MARMARA ÜNİVERSİTESİ YAYINEVİ

ICOVACS 2015

International Conference on
Value Chain Sustainability
12-13 March 2015

Marmara University,
Institutes Building Conference Hall,
Göztepe Campus

www.icovacs.com

PROCEEDINGS



Editors
Gülfem Tuzkaya, Ph.D.
Bahar Sennaroğlu, Ph.D.
Serol Bulkan, Ph.D.

MARMARA ÜNİVERSİTESİ YAYINEVİ

MARMARA
ÜNİVERSİTESİ

E-ISBN: 978-975-400-392-5
Marmara University Publication No: 831

MARMARA ÜNİVERSİTESİ YAYINEVİ

ICOVACS2015

International Conference on
Value Chain Sustainability
12-13 March 2015

Marmara University,
Institutes Building Conference Hall,
Göztepe Campus

www.icovacs.com

PROCEEDINGS

Editors

Gülfem Tuzkaya, Ph.D.

Bahar Sennaroğlu, Ph.D.

Serol Bulkan, Ph.D.

Organizing Institution

Marmara University, Turkey

Supporting Institutions

Izmir University of Economics, Turkey

Yıldız Technical University, Turkey

Tilburg University, The Netherlands

Oklahoma State University, USA

MARMARA ÜNİVERSİTESİ YAYINEVİ

PREFACE

It is a great pleasure to welcome you to the Sixth International Conference on Value Chain Sustainability ICOVACS 2015 in Istanbul at Marmara University, Goztepe Campus, during March 12-13, 2015.

The conference was organized by Marmara University (Turkey) in collaboration with Izmir University of Economics (Turkey), Yıldız Technical University (Turkey), Tilburg University (The Netherlands), and Oklahoma State University (USA).

The theme of ICOVACS 2015, which is the sixth in a conference series that aims to bring researchers in academia, industry and government from various countries together, is "Performance Measurement in Operations Management". The first ICOVACS conference was held in Izmir, Turkey in 2008 with the theme "Integrating Design, Logistics and Branding for Sustainable Value Creation". ICOVACS 2009 was held in Louisville, Kentucky with the theme "Product Design, Branding and Logistics as a Leadership Strategy in a Global Market". The third ICOVACS conference was held in Valencia, Spain in 2010 with the theme "Towards a Sustainable Development and Corporate Social Responsibility Strategies in the 21st Century Global Market". ICOVACS 2011 conference was held in Leuven, Belgium with theme "Sustainable Value Chain Services - Achieving Higher Performance in Health Care". The fifth ICOVACS conference was held in Izmir, Turkey in 2012 with the theme "Value Chain Sustainability through Innovation and Design".

All full papers were peer-reviewed by the reviewers. Accepted full papers were published in ICOVACS 2015 Conference Proceedings USB and their abstracts in ICOVACS 2015 Programme and Abstracts book.

We gratefully acknowledge the support of the sponsors of ICOVACS 2015 for their generous contributions.

The support of keynote speakers Jalal Ashayeri (Professor and Academic Director, Tilburg University, School of Economics and Management, TIAS School for Business & Society, Tilburg, The Netherlands) and Sunderesh S. Heragu (Professor and Head, Donald and Cathey Humphreys Chair, School of Industrial Engineering and Management, Oklahoma State University, Stillwater, OK 74078, USA) are acknowledged.

We would like to thank all the authors as well as scientific, organizing and support committee members, and reviewers for their contributions.

Special thanks go to Büşra Aytekin Şahin, Project Coordinator of DEKON Congress and Tourism.

Gülfem Tuzkaya
Conference Co-chair

Bahar Sennaroğlu
Conference Co-chair

Özalp Vayvay
International Relations Chair

MARMARA ÜNİVERSİTESİ YAYINEVİ

Thank You For Your Support

ARÇELİK A.Ş.

FARPLAS

GOLD BİLİŞİM KURUMSAL HİZ.SAN.VE TİC. A.Ş

IBS SİGORTA VE REASSÜRANS BROKERLİĞİ A.Ş.

İETT İŞLETMELERİ GENEL MÜDÜRLÜĞÜ

KALE ENDÜSTRİ HOLDİNG A.Ş.

VİKO ELEKTRİK VE ELEKTRONİK ENDÜSTRİ SAN. VE TİC. A.Ş.

COMMITTEES

Conference Chairs
Gülfem Tuzkaya
Bahar Sennaroğlu

International Relations Chair
Özalp Vayvay

International Scientific Committee
Timothy Anderson (Portland State University, USA)
Necati Aras (Boğaziçi University, Turkey)
Jalal Ashayeri (Tilburg University, The Netherlands)
Şükran Atadeniz (Yeditepe University, Turkey)
Banu Atrek (Dokuz Eylül University, Turkey)
Birdoğan Baki (Karadeniz Technical University, Turkey)
Nevin Karaarslan Balıkçı (Okan University, Turkey)
Tunçdan Baltacıoğlu (İzmir Ekonomi University, Turkey)
Hayri Baraçlı (İstanbul Metropolitan Municipality, Turkey)
Murat Baskak (İstanbul Technical University, Turkey)
Maria Battarra (Southampton University, UK)
Erkan Bayraktar (Bahçeşehir University, Turkey)
Şakir Bingöl (Marmara University, Turkey)
Semra Birgün (Beykent University, Turkey)
Tunç Bozbura (Bahçeşehir University, Turkey)
Serol Bulkan (Marmara University, Turkey)
Maria Manuela Cruz-Cunha (Polytechnical Institute of Cávado and Ave, Portugal)
Serdar Çelik (Siemens, Germany)
B. Gültekin Çetiner (Marmara University, Turkey)
Atilla Çifter (İstanbul Kemerburgaz University, Turkey)
Emine Çobanoğlu (Marmara University, Turkey)
Tuğrul Daim (Portland State University, USA)
Meltem Denizel (Özyeğin University, Turkey)
Özlem İpekgil Doğan (Dokuz Eylül University, Turkey)
Cem Çağrı Dönmez (Marmara University, Turkey)
Tuğba Efendigil (Yıldız Technical University, Turkey)
Murat Erdal (İstanbul University, Turkey)
Oğuzhan Erdinç (Turkish Air Force Academy, Turkey)
Yasemin Claire Erensal (Okan University, Turkey)

Ahmet Feyzioğlu (Marmara University, Turkey)
Gülçin Büyüközkan Feyzioğlu (Galatasaray University, Turkey)
Orhan Feyzioğlu (Galatasaray University, Turkey)
Patricia Gomes (Polytechnical Institute of Cávado and Ave, Portugal)
Kannan Govindan (University of Southern Denmark, Denmark)
Aslı Göksoy (American University in Bulgaria, Bulgaria)
Kerim Göztepe (Turkish Army War College, Turkey)
Bernard Grabot (École Nationale d'Ingénieurs de Tarbes, France)
Angappa Gunasekaran (University of Massachusetts Dartmouth, USA)
Arif Nihat Güllüoğlu (Marmara University, Turkey)
Mete Gündoğan (Yıldırım Beyazıt University, Turkey)
Güner Gürsoy (Yeditepe University, Turkey)
Joann Halpern (German Center for Research and Innovation, Newyork, USA)
Marta Harničárová (Technical University of Ostrava, Czech Republic)
Sunderesh S. Heragu (Oklahoma State University, USA)
Sergej Hloch (Technical University of Kosice with the seat in Presov, Slovak Republic)
Yuan Huang (University of Southampton, UK)
Zahir Irani (Brunel University, UK)
Melike Demirbağ Kaplan (İzmir Ekonomi University, Turkey)
Gülgün Kayakutlu (İstanbul Technical University, Turkey)
M. Hakan Keskin (University of Turkish Aeronautical Association, Turkey)
Dündar Kocaoğlu (Portland State University, USA)
İlknur Koçaş (Gedik University, Turkey)
Elif Kongar (Bridgeport University, USA)
Julian Lindley (University of Hertfordshire, UK)
Elvira Maeso (Universidad de Málaga, Spain)
Dagmar Magurova (University of Presov, Slovak Republic)
İffet İyigün Meydanlı (Arçelik A.Ş, Turkey)
Margaret Morgan (University of Ulster, UK)
Esther Alvarez De Los Mozos (Deusto University, Spain)
Erdal Nebol (Yeditepe University, Turkey)
Kıvanç Onan (Doğuş University, Turkey)
Vildan Çetinsaya Özkır (Yıldız Technical University, Turkey)
Doğan Özgen (Yıldız Technical University, Turkey)
Ercan Öztemel (Marmara University, Turkey)
Serhat Öztürk (KOSGEB, Turkey)
Carlos Andres Romano (Universitat Politècnica de València, Spain)
Aleda Roth (Clemson University, USA)
Maria Jesus Saenz (Zaragoza Logistics Center, Spain)
Sibel Salman (Koç University, Turkey)

Bahar Sennaroğlu (Marmara University, Turkey)
Ertuğrul Taçgın (Marmara University, Turkey)
Mehmet Tanyaş (Maltepe University, Turkey)
Hakan Tozan (Turkish Naval Academy, Turkey)
Gülfem Tuzkaya (Marmara University, Turkey)
Umut Rıfat Tuzkaya (Yıldız Technical University, Turkey)
Çiğdem Alabaş Uslu (Marmara University, Turkey)
Çağlar Üçler (Özyeğin University, Turkey)
Jan Valíček (Technical University of Ostrava, Czech Republic)
Özalp Vayvay (Marmara University, Turkey)
S. Serdar Yörük (Marmara University, Turkey)
Işık Özge Yumurtacı (İzmir Ekonomi University, Turkey)
Öznur Yurt (İzmir Ekonomi University, Turkey)
Selim Zaim (İstanbul Technical University, Turkey)

International Organizing Committee

Jalal Ashayeri
Tunçdan Baltacıoğlu
Şakir Bingöl
Serol Bulkan
Banu Çalış
Cem Çağrı Dönmez
Tuğba Efendigil
Sunderesh S. Heragu
Melike Demirbağ Kaplan
Bahar Sennaroğlu
Gülfem Tuzkaya
Umut Tuzkaya
Çiğdem Alabaş Uslu
Özalp Vayvay
Öznur Yurt

Support Committee

Mustafa Akdemir
Sinem Bektaş
Ayşe Hande Erol Bingüler
Erhan Bulanık
Tilbe Çelik
Senanur Dicle
Esra Erciyas
Ayşenur Erdil
Volkan Güler
İsmail Gündüz
Fulya İleri
Duygu İnan
Oğuzhan Kalfa
Agah Kalyancuoğlu
Abdullah Anıl Mart
Damla Memigüven
Sarp Nuranel
Büşra Oltekin
Ezgi Özdurak
Özge Özgür
Ceren Parin
Esma Ezgi Sezer
Gülfem Tugay
Merve Tuncel
Seca Nilay Türkçü
Aybüke Ünal
İrem Ünal
Mehmet Yanıt
Marmara Industrial Engineering Society (MieS)

MARMARA ÜNİVERSİTESİ YAYINEVİ



ICOVACS 2015

PROGRAMME OVERVIEW

MARMARA ÜNİVERSİTESİ

March 12, 2015	Thursday			
09:00-10:00	**Registration** Institutes Building Hall, 1st Floor			
10:00-11:00	**Opening Ceremony:** Welcome Addresses by Prof. Dr. Murat Doğruel (Dean, Faculty of Engineering, Marmara University), Gülfem Tuzkaya (Chair of ICOVACS2015), Özalp Vayvay (ICOVACS2015 International Relations Chair) Room: Institutes Building, Conference Room			
11:00-11:30	**Coffee Break**			
11:30-12:00	**Keynote Speaker** Jalal Ashayeri: Enhancing Value through Creating Resilient Supply Chain Room: Institutes Building, Conference Room			
12:00-12:30	**Keynote Speaker** Sunderesh S. Heragu: Deterministic and Stochastic Models for Health Care Systems Room: Institutes Building, Conference Room			
12:30-13:30	**Lunch Break**			
13:30-14:30	**Parallel Sessions**			
	Inventory Management Chair: Serol Bulkan Room: E011	Innovation Management Chair: İrem Düzdar Room: GZES106	Process Managemet Chair: Çiğdem Alabaş Uslu Room: GZES107	Finance and Economics Chair: Cem Çağrı Dönmez Room: GZES113
14:30-15:00	**Coffee Break**			
15:00-16:30	**Parallel Sessions**			
	Quality Management Chair: Özalp Vayvay Room: E011	Operations Management Chair:Banu Çalış Room: GZES106	Sustainability - I Chair: Gülfem Tuzkaya Room: GZES107	Supply Chain Management - I Chair: Hüseyin Selçuk Kılıç Room: GZES113

March 13, 2015	Friday			
10:00-11:00	**Parallel Sessions**			
	Value Chain Management Chair: Çağlar Üçler Room: E011	Brand Management Chair: Gonca Telli Yamamoto Room: GZES106	Enterprise Resource Planning Chair: Batuhan Kocaoğlu Room: GZES107	Forecasting Techniques Chair:Sinan Apak Room: GZES113
11:00-11:30	**Coffee Break**			
11:30-13:00	**Parallel Sessions**			
	Sustainability - II Chair: Tuğba Efendigil Room: E011	Human Resource Management Chair: Oğuzhan Erdinç Room: GZES106	Supply Chain Management - II Chair: Umut Rıfat Tuzkaya Room: GZES107	Technology and Risk Management Chair: Bahar Sennaroğlu Room: GZES113
13:00-14:00	**Closing Ceremony:** Gülfem Tuzkaya, Bahar Sennaroğlu (Chairs of ICOVACS2015), Özalp Vayvay (ICOVACS2015 International Relations Chair) Room: E011			

Detailed Programme Overview

March 12, 2015	Thursday
13:30-14:30	**Inventory Management**
E011	**Chair:** Serol Bulkan
	A Heuristic Approach for Shelf Space Allocation Problem Ayşe Hande Erol Bingüler, Serol Bulkan, Mustafa Ağaoğlu Significant Factors for Selecting The Right Warehouse Management System Samet Gürsev, Can Atalay, Özalp Vayvay Inventory Analysis in a Pharmacy Zeynep Ceylan, Serol Bulkan
13:30-14:30	**Innovation Management**
GZES106	**Chair:** İrem Düzdar
	A Conceptual Framework for Supply Chain Renovation İlknur Yardımcı, Lamia Gülnur Kasap, Özalp Vayvay Constructs of Organizational Innovation for Logistics Industry: An Expletory Analysis for The Impact of ICT for Knowledge Sharing Serkan Gürsoy, Nesli Çankırı Operational Criteria Evaluation for Collaboration of Innovative SMEs İrem Düzdar, Gülgün Kayakutlu, Bahar Sennaroğlu
13:30-14:30	**Process Managemet**
GZES107	**Chair:** Çiğdem Alabaş Uslu
	Performance Evaluation of Projects in Software Development Filiz Çetin, Çiğdem Alabaş-Uslu A Model to Develop a New Smartphone by Using Concurrent Engineering and Quality Function Deployment Methods Barış Egemen Özkan, Gökhan Kalem Program Allocation Process Improvement by An Assignment Model Okay Işık, Muhammet Bilge, Yıldırım Kılıçarslan

13:30-14:30	**Finance and Economics**
GZES113	**Chair:** Cem Çağrı Dönmez
	Complexity of Predictive Market Fluctuations in Econophysics: FTSE, DJIA & BIST-100 Cem Çağrı Dönmez, Tolga Ulusoy ICT and Economic Growth in Eight Islamic Developing Countries (D8) Mahnaz Rabiei, Ali Nezhadmohammad Alarlough Integrate Remanufacturing in The Design Process: Design for Remanufacture (DfRem) Cem Çağrı Dönmez, Rosalba Prisinzano

15:00-16:30	**Quality Management**
E011	**Chair:** Özalp Vayvay
	Performance Appraisals as a Quality Management Tool: Literature Review Zeynep Tuğçe Şimşit, Özalp Vayvay Performance Comparison of Box-Cox Transformation and Weighted Variance Methods with Weibull Distribution Bahar Sennaroglu, Özlem Şenvar Quality Oriented Process Development in Manufacturing Sector: An Application in Textile Firm Ayşenur Erdil, Ahmet Ekerim An Analysis of Statistical Control Charts with Fuzzy Set Theory Zeynep Ceylan, İlayda Ülkü, Özalp Vayvay

15:00-16:30	**Operations Management**
GZES106	**Chair:** Banu Çalış
	An Analytical Approach to Automative Industry İlayda Ülkü, Serol Bulkan, Fadime Üney-Yüksektepe Profit Based Scheduling Using Agent Based Architecture: A Single Machine Problem Banu Çalış Literature Review for Data Mining and Industrial Applications Tuğba Efendigil, İnci Elif Sağlam Does Lean Underpin Sustainable Supply Chains? Ecenaz Demirci, Nevin Balıkçı

15:00-16:30	**Sustainability - I**
GZES107	**Chair:** Gülfem Tuzkaya
	A Descriptive Study on Sustainability Perception: Turkish Logistics Industry Okan Tuna, Aysun Akpolat, Ezgi Uzel, Özlem Sanrı Renewable Energy for a Sustainable Future Koray Altıntaş, Tuğba Türk, Özalp Vayvay Green Marketing and Advertising: A Path to Sustainability Koray Altıntaş, Emine Çobanoğlu High Durable Polymer Electrolyte Membrane for Fuel-Cell Applications Asuman Çelik Küçük, Jun Matsui, Takuji Miyashita

15:00-16:30	**Supply Chain Management - I**
GZES113	**Chair:** Hüseyin Selçuk Kılıç
	Change in Organizational Paradigms in Complex Supply Networks Göknur Arzu Akyüz, Güner Gürsoy Responsive Supply Chain and an Analysis on Manufacturing Industry Murat Bilsel, Semih Özel, Özalp Vayvay Lean, Agile And Leagile Supply Chain Managements: A Review Study Eyüp Anıl Duman, Mete Han Topgül, Hüseyin Avni Es A Supplier Selection and Order Allocation Methodology for Green Supply Chains Gülfem Tuzkaya, Hüseyin Selçuk Kılıç, Canan Ağlan

March 13, 2015	Friday
10:00-11:00	**Value Chain Management**
E011	**Chair:** Çağlar Üçler
	Traveler's Idle Time and The Value Chain At Airports Çağlar Üçler, Luis Martin-Domingo The Effect of Energy Policies in Turkey on Transportation Sector: The Analysis of Energy Related Price and Cost in Road Transportation Celil Durdağ, Ersin Şahin Identification and Ranking e-Commerce Infrastructure e-Readiness Indicators Morteza Mahmoudzadeh, Alireza Bafandeh Zendeh, Masoud Askarnia
10:00-11:00	**Brand Management**
GZES106	**Chair:** Gonca Telli Yamamoto
	Brand Management Benchmarking (BMB) for Global Arena Gonca Telli Yamamoto, Özgür Karamanlı Şekeroğlu, Murat Kaykusuz A Digital Literacy Campaign as a Social Responsibility Project: A Case Study Nejla Karabulut User Satisfaction and Components of Perceived Usability for a Course Management Software Oğuzhan Erdinç, Harun Karga, Ahmet Ürkmez
10:00-11:00	**Enterprise Resource Planning**
GZES107	**Chair:** Batuhan Kocaoğlu
	Routing of Mobile Resources with PSO using Chaotic Randomness (Chaotic-PSO) for Unexpected Delivery Failures in Manufacturing Alper Özpınar, Emel Şeyma Küçükaşçı After Live Stage in Enterprise Software Implementations and Points To Be Considered Batuhan Kocaoğlu R&D Project Selection by Integrated Grey Analytic Network Process and Grey Relational Analysis: An Implementation for Home Appliances Company Umut Rıfat Tuzkaya, Ezgi Yolver

10:00-11:00	**Forecasting Techniques**
GZES113	**Chair:** Sinan Apak
	A Model for Predicting the Consumer Behavior Using Artificial Neural Networks (Case Study: Mobile Phone Subscribers) Alireza Bafandeh Zendeh, Aida Meskarian, Davoud Norouzi Economic Performance Measurement Proposal for Turkish Automotive Sector Sinan Apak, Fulya Taşel, Ebru Beyza Bayerçelik Forecasting patient length of stay in an emergency department by Artificial Neural Networks Muhammet Gül, Ali Fuat Güneri

11:30-13:00	**Sustainability - II**
E011	**Chair:** Tuğba Efendigil
	Money Creation Mechanism Produces Unbridled Debt: Pseudo Relationship Between Production of Goods and Services and the Production of Money Mete Gündoğan, B. Gültekin Çetiner A Review on Social Sustainability and Corporate Social Responsibility Mahmure Övül Arıoğlu Akan, Ayşe Ayçim Selam Sustainable Project Management and Sustainability-Focused Projects: A Brief Summary Ayşe Ayçim Selam, Mahmure Övül Arıoğlu Akan Business Processes as a Source of Competitive Advantage Rıfat Kamaşak, Meltem Yavuz

11:30-13:00	**Human Resource Management**
GZES106	**Chair:** Oğuzhan Erdinç
	Applications of Quick Exposure Check in Industrial Tasks and a Proposed Improvement Oğuzhan Erdinç Relationship Between Empathy Skill Levels and Job Selection: A Study on Business Administration Students A. Güldem Cerit, Ceren Deniz Tatarlar Understanding the Attitudes of the Employees towards Women Managers: A Research in Small Sized Enterprises Duygugül Can, A. Güldem Cerit

11:30-13:00	**Supply Chain Management - II**
GZES107	**Chair:** Umut Rıfat Tuzkaya
	An Investigation for Performance Measurement in Humanitarian Relief Logistics Management Erkan Çelik, Alev Taşkın Gümüş The Effects of Postponement Strategy on Company KPI's and an Industry Application Lütfi Apilioğulları Creating Solutions: Perspectives from Turkey Cansu Yıldırım, Öznur Yurt A Fuzzy Approach for Supplier Selection in a Supply Chain Management Pınar Miç

11:30-13:00	**Technology and Risk Management**
GZES113	**Chair:** Bahar Sennaroğlu
	Multi-objective Optimization of Contingency Logistics Networks with Distorted Risks Esra Dağ, Mehmet Miman Risk Modelling in Health Care Ayşenur Erdil, Ahmet Ekerim, Hikmet Erbıyık Effect of Organic Certifications on Buying Decision for Cosmetics Products in Turkey Oğuzcan Ünver, Emine Çobanoğlu The Future of Mobile Banking Gökçağ Polat

MARMARA
ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ



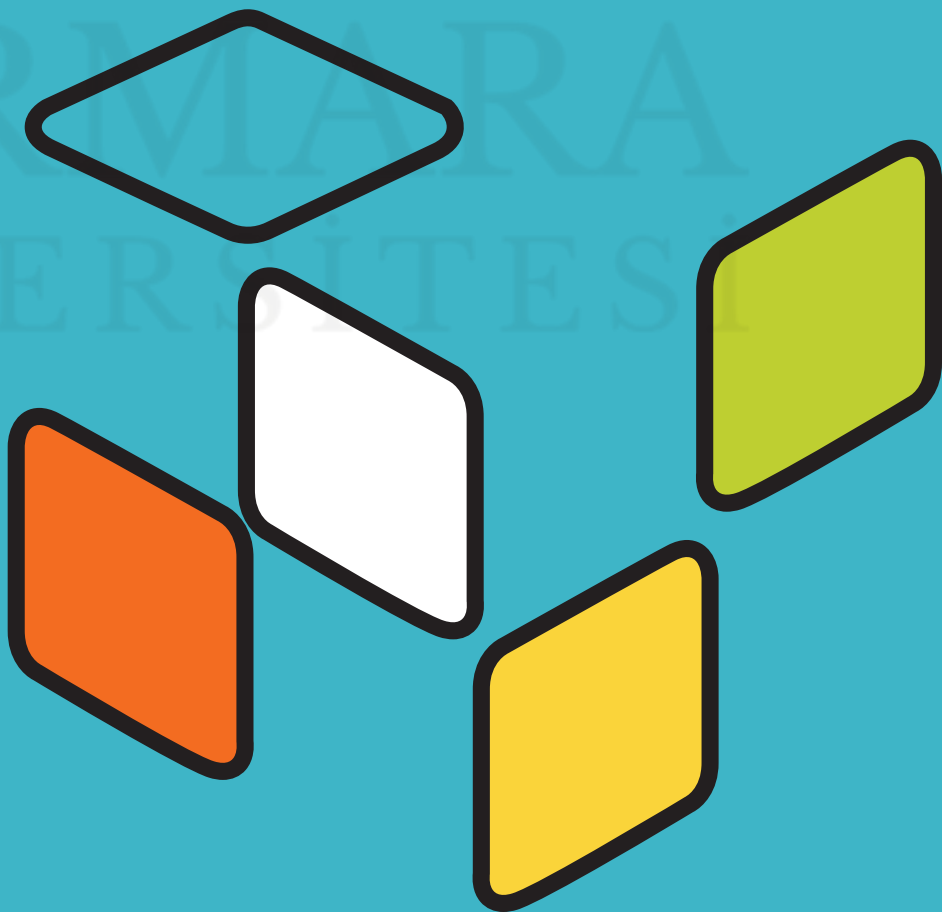
ICOVACS 2015

FULL PAPERS

MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ

INVENTORY MANAGEMENT



MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

A Heuristic Approach for Shelf Space Allocation Problem

A. Hande Erol Bingüler[1], Serol Bulkan[2], Mustafa Ağaoğlu[3]

Abstract

A shelf space allocation problem (SSAP) is a special form of multi-constraint knapsack problem. The main difference between knapsack problem and SSAP is that a knapsack problem has only capacity constraints, whereas an SSAP has some policy constraints in addition. Commercial space management systems use many different heuristic approaches for allocating shelf space due to NP-hard complexity of the SSAP. These heuristics are usually based on simple intuitive rules that could be easily used in practice to implement shelf space allocation decisions. In this paper, a new heuristic is developed to obtain good allocation of shelf space for different products in order to increase profitability under different constraints such as limited shelf space and elasticity factors.

Keywords: Evolutionary Algorithms, Heuristic Methods, Shelf Space Allocation Problem

Introduction

The knapsack problem is a combinatorial optimization problem. Given a set of items, each with a mass and a value, the goal is to determine the number of each item to include in a collection so that the total weight is less than or equal to a given limit and the total value is as large as possible. Different knapsack problems exist in combinatorics, computer science, complexity theory, applied mathematics and optimization.

The knapsack problem has been studied since 1897. Tobias Dantzig was first referred this problem. Dantzig suggested the name that could have existed in myths before a mathematical problem had been fully defined. For all knapsack problems, efficient reduction algorithms have been proposed which enable one to fix several decision variables for objective functions [1]. There are many variations of knapsack problem like multi-objective knapsack problem, multidimensional knapsack problem, quadratic knapsack problem and subset-sum problem.

The multidimensional knapsack problem is similar to the bin packing problem. In this problem, a subset of items can be selected, however, in the bin packing problem, all items have to be packed to certain bins. The concept is that the items have multiple dimensions. This can be seen as a minor change, but it is not equivalent to adding to the capacity of the initial knapsack. This variation is used in many loading and scheduling problems in operations research and polynomial-time approximation scheme.

Despite the fact that the bin packing problem has an NP-hard computational complexity, optimal solutions to very large instances of the problem can be produced with hybrid algorithms. Many heuristics have been developed such as first fit algorithm, tabu search algorithm, genetic algorithm, etc. The goal of this problem, complementary to the minimum makespan scheduling problem, is to schedule jobs of various lengths on a fixed number of machines while minimizing the makespan, or equivalently to pack items of various sizes into a fixed number of bins while minimizing the largest bin size [2].

Shelf space allocation problem (SSAP) then also viewed as a two-dimensional packing problems which was studied by different researches. Gilmore and Gomory (1961) proposed the first model for two-dimensional packing problems, by modifying their column generation approach for one-dimensional packing problems [3]. Beasley (1985) also worked on bin packing problems and formulated an Integer

[1] A. Hande Erol Bingüler, Department of Industrial Engineering,Marmara University, Institute for Graduate Studies in Pure and Applied Sciences, Göztepe 34722, Istanbul, Turkey, hande.erol@marmara.edu.tr
[2] Serol Bulkan, Department of Industrial Engineering, Marmara University, Faculty of Engineering, Göztepe 34722, Istanbul, Turkey, sbulkan@marmara.edu.tr
[3] Mustafa Ağaoğlu, Department of Computer Engineering, Marmara University, Faculty of Engineering, Göztepe 34722, Istanbul, Turkey, agaoglu@marmara.edu.tr

Linear Programming (ILP) model for two-dimensional packing problems [4]. Hadjiconstantinou and Christofides (1995) developed a similar model for this kind of problem [5]. Fekete and Schepers (1998) studied a new bin packing problem based on graph theory [6] and Lodi et.al. (2002) work on the special case of the problem where the products have to be packed by levels [7]. Michael and Moffitt (2013) show that item sizes and the capacity of bins span a vector of values, requiring that a feasible or optimal assignment of the items must satisfy capacity constraints in all dimensions [8].

In logistic field, shelf space is one of the most important resources to interest more consumers. Managing shelf space can not only reduce inventory level but also have stronger wholesaler relationship and higher customer satisfaction [9]. Shelf space, in which products are, is one of the major resources in retail environment [10]. So, the decision of shelf space management is an essential issue in retail operations management.

SSAP is a kind of multi-constraint knapsack problem. The main difference between knapsack problem and SSAP is that a knapsack problem has only capacity constraints whereas an SSAP has some policy constraints in addition. The knapsack model has applications for one dominant resource that manages budget or human resource planning, etc. Commercial space management systems use many different heuristic approaches for allocating shelf space due to NP-hard complexity of the SSAP. These heuristics are usually based on simple intuitive rules that could be easily used in practice to implement shelf space allocation decisions [11]. The concern for practicability and simplicity for these approaches, results in space allocation decisions that reach far from the optimum performance levels. According to the technological growth, the development of optimization approaches to solve SSAP has reached feasible solution to space management systems stage [12].

In retail store, SSAP is used as a decision problem to reach the possibly best objective using some operational constraints. The commercial space management systems use relatively simple heuristic rules to develop operating procedures designed easily to make decisions of shelf space allocation in practice [13]. Space allocation affects store profitability through both the demand function considering main and cross space elasticities together, and through the cost function (procurement, carrying and out-of-stock costs) [14]. Previous researches usually focus on a limited number of brands and only a few shelves [15].

Hwang et.al. (2009) integrated a mathematical model for the shelf space design and item allocation problem to maximize the retailer's profit. They used the shelf space design and allocation problem simultaneously considering location effect and space elasticity on demand. They developed heuristic solution procedures based on Genetic Algorithm [10].

In this study, a model is proposed as a comprehensive optimization model for allocating shelf space. This model used a modifying integer programming model for increasing its applicability in practice. The objective is to determine the best allocation of product items to the available shelf space to maximize objective function adding space elasticity factor. A Simulated Annealing (SA) algorithm is proposed to allocate items to shelf space, subject to given constraints.

Literature Survey

Carvalho (1999) studied arc flow formulation including side constraints for the one dimensional bin packing problem. A branch and price procedure that unifies deferred variable generation and branch and bound is used for the proposed model. OR Library test data sets are used for this research, a strong lower bound is derived and the linear relaxation leads to tractable branch and bound trees for these instances [16].

Lodi et.al. (1999) explored the class of problems arising from all combinations of the requirements that the items are obtained through a sequence of edge-to-edge cuts parallel to the edges of the bin. A heuristic algorithm and a combined tabu search approach adapted to a specific problem by changing the neighborhood [17].

Fekete and Schepers (2001) studied on dual feasible solutions and proposed a simple generic approach for obtaining fast lower bounds of bin packing problems. An asymptotic worst-case performance of 3/4 for a bound that can be computed in linear time for items sorted by size is proved. This study provides a general framework for establishing new bounds [18].

Retailers benefit from the optimum allocation of products into shelves in two ways; they reduce the costs of shelf replenishment and inventory, increase sales. The sales quantity of products depends on many factors such as location of the product within shelf, number of facings of product and adjacent products [15]. Anderson and Amato (1973) show that the companies increase the demand for a product by increasing the display area on the shelf. Table 1 shows research, algorithms and references.

Table 1. Research/Algorithms and references

Research/Algorithm	**References**
Demand model for a product depends on direct elasticity	Corstjens and Doyle (1981) [14]
Dynamic programming solution to a simplified version	Zufryden (1986) [11]
Greedy algorithm	Yang (2001) [12]
Squeaky Wheel Optimization algorithm	Lim et. al. (2004) [19]
Integrated mathematical model on multi-level shelves	Hwang et. al. (2005) [30]
Data mining approach and association rule mining	Chen and Lin (2007) [29]
Developed a model to two local supermarket chains using proprietary data	Fadıloğlu et. al. (2007) [31]
Study the effect of wholesalers pricing on allocation decisions of retailers	Martinez-de-Albeniz and Roels (2011) [32]
Model with elasticities at different aggregation levels	Eisend (2013) [28]

Yang (2001) presented a greedy algorithm to generate good solutions [12]. Lim et. al. (2004) improved Yang's heuristic approach and compared the original as well as the improved heuristics with three metaheuristic algorithms. Their algorithm that incorporates local search found best results [19].

Problem Definition

P_{ijk} is the profit of the product i in the right place of product j on shelf k , X_{ik} is the amount of product i on shelf k, then the objective can be formulated as:

$$Max\ P = \sum_{i=1}^{I}\sum_{j=1}^{I}\sum_{k=1}^{K} P_{ijk} * X_{ik} \qquad (1)$$

Subject to

$$\sum_{i=1}^{I} a_i * X_{ik} \leq T_k \qquad k = 1,2,\dots,K\ (Shelf\ space\ constraint) \qquad (2)$$

$$L_i \leq \sum_{k=1}^{K} X_{ik} \leq U_i \qquad i = 1,2,\dots,I \quad (Lower\ and\ upper\ bound\ for\ each\ product) \quad (3)$$

$$\sum_{k=1}^{K} X_{ik} \in N \cup \{0\} \quad i = 1,2,\dots,I \quad \forall \quad k = 1,2,\dots,K$$

where;
k= 1,2,, …, K the number of shelves
i,j= 1,2, …, I the number of products
T_k : the length of shelf *k*
a_i : the length of product *i*
L_i : the lower bound to allocate product *i*
U_i : the upper bound to allocate product *i*

Simulated Annealing

SA is one of the first available meta-heuristics. Therefore it is not astonishing that it is also the first one to be applied to QAP [20]. SA is a local search which relies on the process of statistical mechanics. Kirkpatrick et.al. (1983) are the first researchers who used the Metropolis algorithm as a heuristic to solve the traveling salesman problem. They proposed an iterative local search method, called SA, for solving combinatorial optimization problems [21].

The methodology between a many-particle physical system and a combinatorial optimization problem show similarities on two facts:

- The states of the physical system are represented by feasible solutions of the combinatorial optimization problem.
- The energy of the states of the physical system is represented by the objective function values.

Kirkpatrick et.al. (1983) proposed a method based on the experimental technique of the *annealing* used by the metallurgists to obtain a "well ordered" solid state, of minimal energy in order to solve NP-hard combinatorial optimization problems. This technique is based on the process of heating a material very fast and then reducing the temperature slowly. The SA method includes two parameters such as *annealing* and *temperature* coefficients [21][22].

The SA algorithm flow chart is shown schematically in the Figure 1. When this algorithm is adapted to the placement problem of components, simulated annealing operates a disorder-order transformation [22].

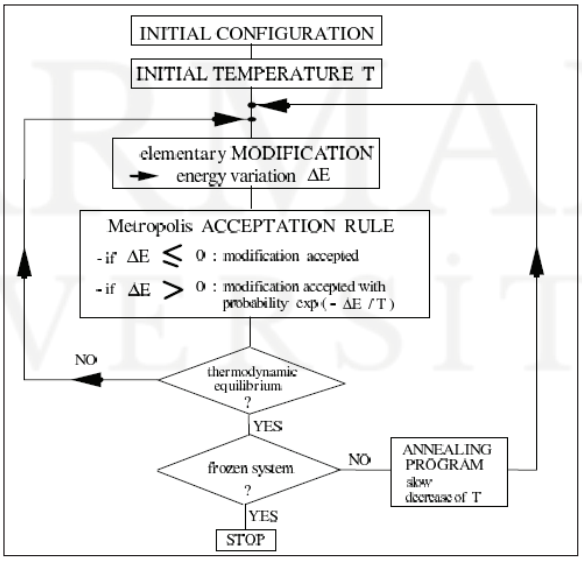


Figure 1. Flow chart of the simulated annealing algorithm [22]

In Figure 2, it is given a general algorithmic outline for SA.

```
procedure Simulated Annealing
generate initial solution s, s_best = s, initial value for T_0,
n = 0,
while outer-loop criterion not satisfied do
while inner-loop criterion not satisfied do
s' = GenerateRandomSolution(s)
s = AcceptSolution(T_n; s; s')
if (f(s) < f(s_best))
s_best = s
end
T_n+1 = UpdateTemp(T_n), n = n + 1
end
return s_best
end Simulated Annealing
```

Figure 2. Outline of a simulated annealing algorithm [23]

SA starts from some initial solution *s* and generates in each step a new solution *s'*. This new solution *s'* is accepted or rejected according to an acceptance criterion. To implement a SA algorithm, some parameters and functions must be specified. Such as a random element of the neighborhood is returned by *GenerateRandomSolution* function and accepted by *AcceptSolution* function [23].

For an SA algorithm, an *annealing schedule* (often also called *cooling schedule*) is very important. In this schedule, T_0 is an initial temperature, new temperature obtains from previous temperature (UpdateTemp), the number of iterations must be performed at each temperature (inner loop criterion) and a termination condition (outer loop criterion) is used [23].

SA is of special appeal to mathematicians due to the fact that under certain conditions the convergence of the algorithm to an optimal solution can be proved. Mathematically, SA can be modeled using the theory of Markov chains. And SA algorithm converges asymptotically to the optimal solution [23].

Burkard and Rendl's motivated simulation procedure for combinatorial optimization problems is one of the first applications of SA to the QAP. It is shown that SA outperforms most of the existing heuristics for the QAP at that time. The corresponding algorithm yields a promising improvement of the trade-off between computation time and solution quality [24]. Thonemann and Bölte propose an improved SA algorithm for the QAP. A metaheuristic closely relates to SA, is also applied to QAP by Nissen and Paul [25].

Burkard and Rendl (1984) develop a general local search heuristic based on simulated cooling process applicable to any combinatorial optimization problem once a neighborhood structure is introduced in the set of feasible solutions [26]. In particular, Burkard et.al. (1998) apply SA to the QAP [27]. Other approaches for the SA apply to the QAP are Bos in 1993, Yip and Pao in 1994, Burkard and Çela in 1995, Peng et al. in 1996, Tian et al. in 1996 and 1999, Mavridou and Pardalos in 1997, Chiang and Chiang in 1998, Misevicius in 2000 and 2003, Tsuchiya et al. in 2001, Siu and Chang in 2002, and Baykaşoğlu in 2004 [25]. These studies differ from each other on implementation of cooling process or the thermal equilibrium.

Advantages of SA method are the flexibility on the evaluations of the problem and the easiness of implementation. On the other hand, the main disadvantages of SA are the difficulty of adjustments of temperature decrease. SA obtained excellent results of big size problems [22].

Simulated Annealing Application

The initial temperature is defined in such a way that the proportion of, the accepted cases to the whole studied cases (γ), in Markov chain has the value of 0.2-0.5 according to different problems. The number of iterations for a specific temperature is proportional to the number of acceptances in an inner loop instead of the number of tries for generation and evaluation. The number of acceptances required for search in the inner loop of the algorithm decreases according to the temperature reduction.

The freezing temperature or convergence condition definition is very important in increasing the speed and accuracy in the search process. If the stop condition of the algorithm is not defined effectively, the algorithm will be stopped sooner which as a result reduces the accuracy or the convergence of the algorithm will be announced by delay which results in the speed reduction. The way of determining the convergence conditions for algorithm is explained in different methods and various criteria are discussed in the literature. The stop condition is defined when in two sequential searches in Markov chain, there is no change in the best obtained (total cost) result.

A kind of a greedy algorithm is used for local search at the end of the SA algorithm. This algorithm gives the final response of the algorithm. For the determination of the negative elements' displacement priority, the *lowest negative element* is selected greedily. The proposed algorithm starts with the initial temperature proportional to 20% of acceptances to the whole situations, ($\gamma = 0.2$) for categories (A) and (B), proportional to 50% of acceptances to the whole situations, ($\gamma = 0.5$) for category (C) and proportional to 40% of acceptances to the whole situations, ($\gamma = 0.4$) for category (D).

The performed operation in the existing loop in defining the initial temperature, is exactly the same operation used in the search engine. This means that it starts with a random variable and after applying the switching operator, the acceptance terms of the algorithm will be checked. In the case of acceptance, the previous generation will be replaced by a new one and the operation will be continued until the Markov chain ends and at the end, it is the ratio of accepted, to the total states that represents the desired ratio. If this ratio is sufficient, the loop will stop, but otherwise, a new ratio will be calculated for the increased temperature by the stepped increase of the temperature and repetition of the above stages. This temperature increase will be continued until the ratio of the accepted states to the total states in a single Markov chain, reaches the ratio defined at the beginning of the algorithm.

In the first inner loop, the iterations is finished when a specific number of acceptances occur related to $A_0=2000n/(1-\gamma)$. In each temperature reduction the number of acceptance reduces with the equation $A_k = 0.8\ (5*A_o)^{1/k}$. More tries are performed in effective temperatures in the search process. The repetition rate reduction is resulted by trial and error.

In the inner loop for producing the new generation, the Switching operator is used. It seems that this operator can find the best possible result. Optimization of process is performed in Java program.

Results and Conclusion

Simulating Annealing algorithm is used for 100 times to evaluate their efficiency and the findings are summarized on Table 2.

Table 2. Comparison of algorithm results

Problem name	Min z	Mean z	Max z	Average run time
Simulated Annealing Algorithm	106.85	162.38	193.85	200.18
Genetic Algorithm (Bilsel, et. al., 2013) [33]	145.95	162.38	176.25	253.13
Greedy (Yang, 2001) [12]	135.90	135.90	135.90	
Greedy with improvements (Ayhan et al., 2007) [34]	146.10	146.10	146.10	

As can be seen from Table 2, the proposed Simulated Annealing algorithm performs better than Yang's and Ayhan et.al.'s heuristics. Its average performance is the same as Bilsel et.al.'s genetic algorithm. However, for the best (max) solution, SA outperforms Bilsel et. al.'s genetic algorithm.

References

[1] **Pisinger, D. (1995)** Algorithms for Knapsack Problems", PhD Thesis, University of Copenhagen, Department of Computer Science, Denmark.

[2] **Watson, T. (2007)** Approximations Algorithms, Scribe: Lecturer: Shuchi Chawla, Topic: Bin Packing and Euclidean TSP, Date: 2/6/2007.

[3] **Gilmore, P.C., Gomory, R.E. (1961)** A linear programming approach to the cutting stock problem, Oper. Res. (9), 849–859.

[4] **Beasley, J.E. (1985)** An exact two-dimensional non-guillotine cutting tree search procedure, Oper. Res. (33) 49–64.

[5] **Hadjiconstantinou, E., Christofides, N. (1995)** An exact algorithm for general, orthogonal, two-dimensional knapsack problems Eur. J. Oper. Res. (83), 39–56.

[6] **Fekete, S.P., Schepers, J. (1998)** New classes of lower bounds for bin packing problems, in: Integer Programming and Combinatorial Optimization (IPCO 98), Lecture Notes in Computer Science, eds. R.E. Bixby, E.A. Boyd and R.Z. Ríos-Mercado, Vol. 1412, Springer, Berlin, 257–270.

[7] **Lodi, A., Martello, S., Vigo, D. (2002)** Recent advances on two-dimensional bin packing problems, *Discrete Applied Mathematics 123 (1–3)*, 379–396.

[8] **Michael, D., Moffitt, M.D. (2013)** Multidimensional Bin Packing Revisited, *Principles and Practice of Constraint Programming*, *Lecture Notes in Computer Science 8124*, 513-528.

[9] **Fancher, L.A. (1991)** Computerized space management: A strategic weapon, *Discount Merchandiser 31 (3)*, 64-65.

[10] **Hwang, H., Choi, B., Lee, G. (2009)** A genetic algorithm approach to an integrated problem of shelf space design and item allocation, *Computers & Industrial Engineering 56* , 809–820.

[11] **Zufryden, F.S. (1986)** A dynamic programming approach for product selection and supermarket shelf-space allocation, *Journal of Operations Research Society 37 (4)*, 413-422.

[12] **Yang, M.H. (2001)** An effective algorithm to allocate shelf space, *European Journal of Operational Research 131*, 107-118.

[13] **Yang, M.H., Chen, W.C. (1999)** A study on shelf space allocation and management, *International Journal of Production Economics 60-61*, 309-317, Elsevier.

[14] **Corstjens, M., Doyle, P. (1981)** A Model for Optimizing Retail Space Allocations, *Management Science 27*, 822-833.

[15] **Dreze, X., Hoch, S.J., Purk M.E. (1994)** Shelf Management and Space Elasticity, *Journal of Retailing 70*, 301-326.

[16] **Carvalho, J.M.V. (1999)** Exact solution of bin-packing problems using column generation and branch-and-bound, Annals of Operations Research, 86 (0), 629-659.

[17] **Lodi, A., Martello, S., Vigo, D. (1999)** Heuristic and Metaheuristic Approaches for a Class of Two-Dimensional Bin Packing Problems, Informs Journal of Computing, 11(4), 345-357.

[18] **Fekete, S.P. and Schepers, J. (2001)** New classes of fast lower bounds for bin packing problems, Mathematical Programming 91(1), 11-31.

[19] **Lim, A., Rodrigues, B., Zhang, X. (2004)** Metaheuristics with local search techniques for retail shelf-space optimization. Management Science, 50(1), 117–131.

[20] **Ji, P., Wu, Y., Liu, H. (2006)** A Solution Method for the Quadratic Assignment Problem (QAP), The Sixth International Symposium on Operations Research and Its Applications (ISORA'06), Xinjiang, China, August 8–12, 106–117.

[21] **Kirkpatrick, S., Gelatt, C., Vecchi, M. (1983)** Optimization by simulated annealing. Science (220), 671–680.

[22] **Dreo, J.; Petrowski, A.; Siarry, P.; Taillard, E. (2006)** Metaheuristics for Hard Optimization: methods and case studies, Springer. ISBN: 354023022X.

[23] **Stützle, T. (1998)** Applying iterated local search to the permutation flow shop problem. Technical Report, AIDA-98-04, FG Intellektik, TU Darmstadt.

[24] **Burkard, R.E., Çela, E. (1995)** Heuristics for bi-quadratic assignment problems and their computational comparison. European Journal of Operations Research 83, 283-300.

[25] **Erol, A.H. (2010)** A heuristic solution algorithm for the quadratic assignment problems. Master thesis, Marmara University, Institute for Graduate Studies in Pure and Applied Sciences, Turkey; Supervisor: Asst. Prof. Dr. Serol Bulkan.

[26] **Burkard, R.E., Rendl, F. (1984)** A thermodynamically motivated simulation procedure for combinatorial optimization problems. European Journal of Operations Research 17(2), 169-174.

[27] **Burkard, R.E., Çela, E., Pardalos, P.M., Pitsoulis, L. (1998)**. The quadratic assignment problem. In P.P. Pardalos and M.G.C. Resende, editors, *Handbook of Combinatorial Optimization*. Kluwer Academic Publishers, Dordrecht, 241-238.

[28] **Eisend, M. (2013)** Shelf space elasticity: A meta-analysis, *Journal of Retailing*, Article in Press.

[29] **Chen, M.C., Lin, C.P. (2007)** A data mining approach to product assortment and shelf space allocation, Expert Systems with Applications (32), 976–986.

[30] **Hwang, H., Choi, B., Lee, M.J. (2005)** A model for shelf space allocation and inventory control considering location and inventory level effects on demand International Journal of Production Economics (97), 185–195.

[31] **Fadıloğlu, M.M.; Karaşan, O.E.; Pınar, M.Ç. (2007)** A Model and Case Study for Efficient Shelf Usage and Assortment Analysis, Annals of Operations Research, Volume 180 (Issue 1), 105-124.

[32] **Martinez-de-Albeniz V., Roels, G. (2011)** Competing for Shelf Space, Production and Operations Management, Vol. 20(1), 32-46.

[33] **Bilsel, M., Ayhan, M.B., Bulkan, S. (2013)** Shelf Space Optimization Using Metaheuristic Algorithms. International Journal of Information, Business and Management. No: 2 (5), 210-217.

[34] **Ayhan, M. B., Bilsel, M., Bulkan, S., Gülcü, A. (2007**) Raf Alanı Optimizasyonu. Yöneylem Araştırması / Endüstri Mühendisliği 27. Ulusal Kongresi, 2-4/07/2007, İzmir, 1105-1110.

Significant Factors for Selecting the Right Warehouse Management System

Samet Gürsev[1], Can Atalay[2], Özalp Vayvay[3]

Abstract

Warehouses are essential components of logistics structure in companies and on one hand they play a crucial role in visibility, speed of whole supply chain system but on the other hand warehouses are cost factors of the company. In order to stay competitive in today's global marketplace all existing cost factors like logistics have to be examined and continuous improvements have to be realized. Today, customers' expectations are increasing rapidly, therefore warehouses need to raise their goals for inventory accuracy, visibility, better information flow, convenient service, personalized order fulfillment, flexible value-added service and responsiveness to special requests. Hence, choosing the right warehouse management system becomes one of major decisions to cover most of these requirements. The research methodology is multi-criteria decision-making (AHP) procedure, where both technical and managerial criteria on software and vendor selection were considered. The algorithm was collected with the preference of specialists' ratings for criteria, and the suitability of warehouse management system alternatives versus the selection criteria were compared to calculate appropriateness indices. Through these appropriateness indices the most suitable warehouse management system was researched. In conclusion, the results were evaluated and some recommendation points were mentioned.

Keywords: Warehouse Design, Warehouse Management System, AHP

Introduction

Warehouses have been part of the most of the production/non-production companies for hundreds years and they have an increasing importance with introduction of supply chain methods and Kaizen strategies. On one hand they are very important elements of the supply chain, but on the other hand they are one of biggest cost factors in the supply chain.

In the past when make-to-stock concept was common the warehouses were generally considered as storage locations to keep goods safely until the delivery is realized. Today, not only diversity and complexity of the goods are increased but also the customer requirements are also much more than what they were in the past decades. In order stay competitive, companies have to work with minimum stocks and realize the shortest delivery time from order taking to shipment. Hence, if usage of warehouses (without value added operations) is inevitable for a company, they have to be managed in a most efficient way to fulfill customer requirements without any schedule delays and with the minimum costs. New methods and tools like automation, layout studies, rack systems and WMS have been put into action for improvements.

WMSs which are similar to current ones have been introduced at the end of 1980's and they are for used executing and managing daily warehouse processes in many modern warehouse concepts. WMS can be described as a part of the supply chain system which is applied for increasing visibility, managing typical daily warehouse processes, resources and inventory in a most efficient and error free way. Typical warehouse processes can include put away/storage, picking, shipping, receiving and inventory adjustment. WMS capabilities can also be increased by integration to existing ERP, TMS systems or hardware like RFID, barcode or AGVs.

[1] Samet Gürsev , Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey
[2] Can Atalay, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey
[3] Özalp Vayvay, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey

The possible benefits from a WMS implementation can be explained as below:

1. Efficient space utilization
2. Increased labor productivity
3. Efficient vehicle/equipment utilization (Forklifts, pallet jack etc.)
4. Increased inventory accuracy
5. Reduced paperwork
6. Better customer service
7. Reporting (Order Monitoring, operator performance, stock information etc.)

Deciding on WMS implementation stand alone is a complex task which requires a detailed cost-benefit analysis. If a WMS implementation accepted then one of the next tasks will be deciding on the right software. Some companies may choose to write their own tailored software for their business requirements but for the others there are many vendors to get the software. Some of these companies are even among the well-known supply chain software suppliers as shown on figure 1.

This study was done to realize which main factors are taken into consideration when deciding on implementation of a WMS. In first step the main criteria are on WMS selection is listed. In the second step the criteria was reviewed by different academicians and specialists from the industry who are experienced in supply chain management and logistics. The criteria were updated based on these reviews. A comparison matrix was prepared for comparing each factor with others with a value scale between 1 and 6 (Figure 1). This matrix was send to responsible who will be taking part in deciding possible WMS software in their current company.

Top 20* supply chain management software suppliers

No.	Supplier	2011 Revenue	URL	SCP	WMS	MES/MRP	TMS
1	SAP	$1.018 billion	www.sap.com	x	x	x	x
2	Oracle	$935.6 million	www.oracle.com	x	x	x	x
3	JDA Software	$368.5 million	www.jda.com	x			x
4	Manhattan Associates	$141.5 million	www.manh.com	x	x		x
5	RedPrairie	$99.7 million	www.redprairie.com		x	x	x
6	Epicor	$92.9 million	www.epicor.com	x	x		x
7	Descartes Systems Group	$87.7 million	www.descartes.com				x
8	Servigistics	$64 million	www.servigistics.com	x	x		x
9	Kewill Systems	$63.7 million	www.kewill.com				x
10	IBS	$58 million	www.ibsus.com	x	x	x	x
11	Totvs	$57.8 million	www.totvs.com	x	x		x
12	Logility	$52.3 million	www.logility.com	x	x		x
13	Lawson Software	$51 million	www.lawson.com	x	x	x	x
14	Retalix	$50.9 million	www.retalix.com	x	x		x
15	IBM	$50.8 million	www.ibm.com	x			
16	Infor	$50.5 million	www.infor.com	x	x	x	x
17	GTNexus	$46.2 million	www.gtnexus.com	x			x
18	HighJump Software	$45.8 million	www.highjumpsoftware.com		x		x
19	Quintiq	$39.5 million	www.quintiq.com	x		x	x
20	Accellos	$35 million	www.accellos.com		x		x
21	Kinaxis	$34.6 million	www.kinaxis.com	x		x	

* Source: Revenue estimates provided by Gartner (www.gartner.com) with the exception of Retalix, which was provided by the company.

Figure 1. Top 20 Supply Chain Management Software

Literature Survey

Inventory control by different parties supply chain implies a significant financial investment to the enterprises. The main reason for inventory control is to foreseen and customer orders. It is known that the inventory may be lost over time. Many enterprises incorporate a safety inventory for work-in-progress. Gattorna and Walters [1]suggested that the inventory requires sophisticated methods of planning and control. Although many software are on the market for particular applications such as ERP and APS systems, they suffer from function restriction and are expensive to implement[4]. Kovacs and Paganelli [2]described that ERP systems mainly provide support for administration and operation of a conventional customer–supplier relationship. These systems are inadequate to cope with the advanced planning of modern manufacturing. Stadtler [3]also showed that the transaction-based ERP systems is not in the area of planning.

Software selection is not a technical operation, a subjective and uncertain decision process selecting a suitable warehouse management system, depends on the assessment of objective, measurable criteria. Software selection decisions cover the simultaneous multiple criteria, including tangible and intangible factors; prioritizing these factors can be challenging. When evaluating and selecting data warehouse software, Kimball, Reeves, Ross, and Thornthwaite [5] suggested that the evaluation should encompass both business and technical requirements. The literature reviewed was limited to software selection applications used by different methodologies and frameworks.

Le Blanc and Jelassi [6] developed a multi-criteria decision methodology for decision support system (DSS) selection Stylianou, Madey, and Smith [7] presented a socio- technical framework and the taxonomy of expert system shells evaluation criteria. Boloix and Robillard [8]proposed a comprehensive framework for software system evaluation. Hluoic and Paul [9] presented a methodology for manufacturing simulation software selection. Beck and Lin [10] researched Automated office system decisions criteria. Seidmann and Arbel [11] presented Office Automation software and used AHP. Zahedi [12] researched Database Management System. Stylianou et al. [13] used Socio-technical framework to show expert system shells properties. Min [14] presented AHP methodology for Logistics Software selection. Sarkis ve Talluri [15] developed goal programming model and AHP model for Supply Chain Software and e-commerce communication systems. Wei et al. [16] presented ERP system criteria. Vlahavas, Stamelos, Refanidis, and Tsoukia`s [17] developed an expert system based on various aspects of the multi-criteria decision aid approach for software evaluation. Kim and Moon [18] researched Workflow Management System. Ngai and Chan [19] developed a multi-criteria decision methodology for Knowledge management tool.

To quantify subjective and vague preferences of decision makers over multiple criteria with linguistic assessments, we calculate the prior weights of decision criteria with a fuzzy analytic hierarchy process (AHP) method. Analytic hierarchy process (AHP) first introduced by Saaty [20] has been a popular approach for supplier evaluation and selection, though it was extended with fuzzy theory to suitably address the ambiguities involved in the linguistic assessment of the data .Kar [21] applied group decision support theory with fuzzy AHP to the supplier selection problem, and extended AHP based on Dempster– Shafer theory to handle uncertainties due to the inability of human's subjective judgment.

Warehouse Processes and Warehouse Management Systems Capabilities

Typical warehouse processes and how they can be supported or managed by a WMS system are listed below:

1. Receiving: The goods receipt process is the movement of the products from the production area or from an external source like supplier. The warehouse inventory records and inventory tracking also start with goods receipt process. An EDI (Electronic Data Interchange) capable WMS system will lead to efficient resource planning like calculating required racks/area, manpower, forklifts etc. on the

arrival time. WMS can also be used on receiving process monitoring by defining deliveries as open deliveries, already processed deliveries and so on.

2. Put away: Material movement from warehouse receivable point to the stock area can be defined as put away. WH staff can be informed through WMS to the pre-defined storage locations on goods receipt. The box/bin management can also be done by WMS.
3. Quality Inspection: Inspection of the received goods can be mandatory in some companies. Here, WMS can support the business by allowing the WH staff to monitor which parts are being inspected, the inspection process time and inspection intervals, lot sizes required for each part number.
4. Picking: Picking process can be defined as movement of the material from stock location as a part of the order fulfillment. Business strategies like FIFO, LIFO, partial quantity picking can be supported by WMS. Picking list can also be prepared through WMS.
5. Shipment: Shipment process can be defined as movement of the goods to an external source which can be customer or another company location. Shipping process may include packing, goods issue and transportation. Delivery notes, freight documents can also be prepared to WMS. An EDI compatible WMS can also be used in sending ASNs to the customers as the goods leave the warehouse. Open and completed deliveries, wave picking/wave planning operations can also be managed through WMS.
6. Cross Docking: Cross docking can be defined as delivering products from production to the loading dock and delivering them to the customer. Cross docking can be planned by WMS.
7. Return Process: The stock receipt and stock management can be managed through WMS in case of return deliveries from the customer.
8. Inventory Management: Inventory errors may lead to unplanned high costs to the company. WMS can contribute to inventory efficiency by supporting counting procedures like cycle counts and continuous counting. These procedures reduce the need of annual stock counts.

In addition to the mentioned points above WMS can be used in Kanban management, line feeding support, resource planning, reporting and RFID (Radio-frequency identification) device support to support business processes. The mentioned functionalities will be expending with the new technological improvements and changes in business requirements.

Research

We have developed AHP decision making procedure for the selection of a data warehouse system. The approach comprises a nine-step procedure as shown in Fig. 2. The details of the selection procedure are presented in the next section.

Group a committee of decision makers

The first step is to add a project decision makers, experts and senior representatives of user departments. The participation and support of top managers notably influences the success of WMS [22]. We connected academic personnel and experts/specialists from the well-known industrial companies.

Define warehouse management system project characteristics

Different enterprises or organizations may adopt a data warehouse system for completely different reasons. The size of company, internal needs and competitive pressure would also influence the adoption of WMS systems [22] The initial faith or aim for adopting a WMS system affects problem definition, identifying and structuring objectives, measuring the performance of objectives, and other subsequent decision-making activities. The decision makers need to analyze the WMS system selection problem by identifying decision factors such as stakeholders project aims, evaluation criteria, number of alternatives, and other concerns in order to provide the decision making process effectively.

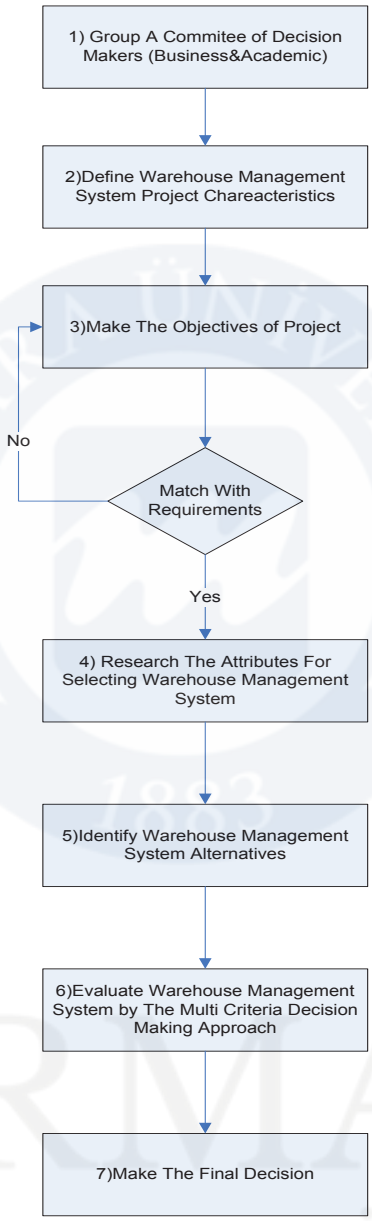


Figure 2. Research flow chart

Determining the Objectives of The Project

The main goal of defining and structuring objectives is to ensure insight for better decisions. The initial list of objectives for a decision problem includes both fundamental objectives and means objectives [23]. Designing the objectives involves organizing them so that the decision makers can describe in detail what an organization wants to achieve, and then incorporate these objectives into the decision model appropriately. For a given decision situation, the overall objective is the same for both the fundamental and means objectives structure. It characterizes the reason for interest and defines the breadth of concern. All relating objectives on different levels of a structure will be derived from the overall objective systematically.

It is important to separate between fundamental objectives and means objectives in the objectives structuring process. Fundamental objectives are those that are important simply because they reflect what the decision

makers are really want to accomplish. However, means objectives are those that help achieve other objectives [24]. Fundamental goals can be organized into hierarchies while means objectives can be organized into networks [24] The upper levels in a hierarchy describe more general objectives, and the lower level objectives explain what is meant by the higher level objectives. A key difference between fundamental objectives hierarchy and means objectives network is that means objectives can be connected to several fundamental objectives, indicating that they help to accomplish these objectives. To separate means objectives from fundamental objectives and to establish their relationships, a guiding question ''Why is that important?'' can be used to complete these tasks for each identified objective, ask, ''Why is that important?'' Two types of answers seem possible. If the answer is that the objective is one of the essential causes for interest in the situation, such an objective is a fundamental objective. If the answer is that the objective is important only because of its implications for some other objective, it is a means objective. [24] provided four techniques to organize fundamental and means objectives further.

Research the attributes for selecting warehouse management system

The decision makers can derive the attributes or criteria to evaluate WMS systems from the created objectives structure. The attributes should involve both quantitative and qualitative measures that satisfy the aims of project and requirements of an organization. Then, these attributes were verified with external professional experts to ensure all attributes were well formulated and properly understood. The final selected attributes will be used to evaluate the WMS systems of the decision model. The decision makers selected two group criteria about WMS; namely software selection criteria and vendor selection criteria.

Software Selection Criteria

a. Compatibility with existing ERP system
b. Compatibility with existing Hardware (Barcode, RFID etc.)
c. Inbound/outbound data transfer capability (EDI etc.)
d. User friendly interface
e. Database support
f. Investment Costs/Indirect Costs
g. Customization capabilities
h. Reporting tools
i. Lead Time Implementation
j. Upgrade possibilities / Future Support
k. Labor Productivity
l. Routing Optimization
m. Equipment Utilization
n. Area Deployment Optimization
o. Compatibility with possible new technologies (like wearable technologies)
p. System stability
q. Kanban, milk-run, line feeding support

Vendor Selection Criteria

a. Vendor reputation
b. Technical and training support
c. Service Quality
d. Number of companies running the Software
e. Experience in WMS field
f. Gartner Group Rating

The first decided above mentioned criteria was then reviewed and it is decided to reduce the points as a very long list might have resulted in complexities for the decision makers. Therefore some of the above criteria

were excluded from the list with the common agreement of the academicals and experts who took part in this study. The final criteria can be seen on the next section.

Evaluate the Warehouse Management Systems by Analytic Hierarchy Process

Analytic hierarchy process (AHP) is a multi criteria rank method developed by Saaty [25]The AHP is a method based on the hierarchical analysis of a certain problem in elements of hierarchy that are structured in levels. The AHP method provides that problem is hierarchically decomposed and partially solved, and then those partial solutions are again combined in order to obtain a solution to the initial problem. According to the AHP method, elements of a problem under analysis are circulated in a hierarchical structure from the objective on top of a hierarchical structure, through criteria and sub-criteria on their respective levels, to alternatives on the lowest level. Final result of a problem analysis weight values in relation to the set objective. AHP help decision-makers to structure a complex problem in the form of a simple hierarchy and assess big number of quantitative and qualitative factors in a systematic manner. The application process of the AHP methods is based on the concept proposed by Vinod Kumar and Ganesh [26]:

a) A hierarchical decomposition of the problem to be solved with the aim at the highest level, the criteria and sub-criteria at lower levels, and the alternatives at the lowest level.
b) Comparison of pairs of elements in each level of the hierarchy in relation to the elements of the higher level, through application of the Saaty scale from 1 to 9. The decision-maker determines the value a_{ij}, of the elements i and j, where its $a_{ij}=1/a_{ji}$, i, j=1,…n and $a_{ij}=1$, i = j.
c) Setting priorities for each element in relation to a higher authority – w_{ij} is a priority of the alternative i in relation to the criteria j, where it is i=1,…,m, j=1,…,n, m is the number of alternatives, and n is the number of criteria.
d) Synthesis for all values of priorities so as to obtain the priority of each element in relation to the objective.

W_i is the alternative priority i and it is determined as:
where, c_j is the criteria priority j, and w_{ij} is the alternative priority i in relation to criteria j.

$$W_i = \sum_{j=1}^{n} c_j w_{ij}$$

Saaty's method is used at each level of hierarchical structure. Using the Saaty's method is assigned to each part of the quantitative characteristics reflecting their importance. The part with the highest priority is obtained by synthesis of these evaluations[27]. The decision maker focuses on them to obtain a solution of the decision problem. When solving the decision-making problem, it includes more experts. It has between the objective and criteria and the level of evaluators (experts), theirs evaluations (weights) indicate the degree of their soundness[28].

For the determination weights of criteria, Saaty's method has been chosen. This method takes into account the different preferences between the criteria and a wide point scale is determined for evaluation (Formula 1). It is therefore possible to detect even slight differences in preferences between the criteria, which are into account then in the process of setting the weights:

$$(S_{ij})=\begin{cases} 1\text{-i and j are equivalent;} \\ 3\text{-i is mildly preferred to j;} \\ 5\text{-i is strongly preferred to j;} \\ 7\text{-i is very strongly preferred to j;} \\ 9\text{-i is absolutely preferred to j} \end{cases}$$

Values 2, 4, 6, 8 are intended to evaluate intermediate stages. This method compares each pair of criteria i and j. Their evaluation is written to the Saaty's matrix (Formula 2) according to the following rules:

$$S = \begin{pmatrix} 1 & s_{12} & \dots & s_{1k} \\ 1/s_{12} & 1 & \dots & s_{2k} \\ \dots & \dots & \dots & \dots \\ 1/s_{1k} & 1/s_{2k} & \dots & 1 \end{pmatrix}.$$

This method involves 5 steps (Saaty 1980), which includes calculation of the weights using normalized geometric average of lines in Saaty matrix:

1. First, Saaty's matrix was filled so that the diagonal values are equal to one (sij = 1), If the "ith" criterion is preferred to "jth" criterion, then the suitable value of Saaty's point scale has to be selected. If the" jth" criterion is preferred to" ith" criterion, inverse values has to be written: sij=1/sij
2. For every i, the value

$$s_i = \prod_{j=1}^{k} s_{ij},$$

was calculated

3. For every i, the value

$$R_i = \sqrt[k]{s_i}$$

was calculated

4.In the next step, the value

$$\sum_{i=1}^{k} R_i$$

was calculated

5.In the last step of the method is determined weights of criteria according to the following formula:

$$v_i = \frac{R_i}{\sum_{i=1}^{k} R_i}.$$

Table 1. Software selection AHP Calculations

Category	Priority	Rank
Compatibility with existing ERP system	23,30%	1
User friendly interface	14,00%	2
Inbound/outbound data transfer capability (EDI etc.)	13,20%	3
System stability	10,60%	4
Investment Costs/Indirect Costs	9,90%	5
Compatibility with existing Hardware (Barcode, RFID, AGVs etc.)	9,10%	6
Lead Time Implementation	7,50%	7
Upgrade possibilities / Future Support	7,30%	8
Area Deployment Optimization	5,10%	9

	1	2	3	4	5	6	7	8	9
1	1	3.00	2.00	3.00	4.00	3.00	3.00	2.00	1.00
2	0.33	1	0.50	1.00	2.00	1.00	1.00	2.00	0.50
3	0.50	2.00	1	1.00	2.00	2.00	2.00	2.00	1.00
4	0.33	1.00	1.00	1	2.00	2.00	2.00	4.00	2.00
5	0.25	0.50	0.50	0.50	1	2.00	2.00	2.00	2.00
6	0.33	1.00	0.50	0.50	0.50	1	1.00	2.00	1.00
7	0.33	1.00	0.50	0.50	0.50	1.00	1	2.00	1.00
8	0.50	0.50	0.50	0.25	0.50	0.50	0.50	1	0.50
9	1.00	2.00	1.00	0.50	0.50	1.00	1.00	2.00	1

Figure 3. Decision Matrix of Software Selection

As it can be seen on the fig xx, "compatibility with existing ERP system" has far the highest priority in the software selection AHP calculations (Table 1). This is not very surprising as it was also expected in the beginning of this study. This criteria is followed by "user friendly interface" and "inbound/outbound data transfer capability", the priority difference between these two criteria is relatively small. Most surprising finding in this calculation is "investment costs/indirect costs" criteria are not within the top three rankings.

Table 2. Vendor Selection AHP Calculation

Category	Priority	Rank
Technical and training support	24,30%	1
Experience in WMS field	24%	2
Service Quality	22,80%	3
Number of companies running the Software	10,70%	4
Vendor reputation	9,20%	5
Gartner Group Rating	9%	6

	1	2	3	4	5	6
1	1	0.33	0.50	1.00	0.33	1.00
2	3.00	1	1.00	3.00	1.00	2.00
3	2.00	1.00	1	3.00	1.00	2.00
4	1.00	0.33	0.33	1	0.50	2.00
5	3.00	1.00	1.00	2.00	1	3.00
6	1.00	0.50	0.50	0.50	0.33	1

Figure 4. Decision Matrix of Vendor Selection

The results of the AHP calculation(table 2) on vendor selection criteria showed close results in top three rankings; "Technical and Training Support" (1st) , "Experience in WMS field" (2nd), "Service

Quality" (3rd). Gartner which is one of the world's leading information technology research and advisory company. It is rating is the lowest, which was not expected (figure 4).

Conclusion

This study was aimed at choosing the most important criteria on WMS selection. Although it was planned to apply only one AHP calculation, it is decided to make two different AHP calculations as there were many indispensable criteria which were classified in two main groups, namely "software selection" and "vendor selection". As mentioned in the introduction part, the evaluation criteria were decided by a group of academicals and experts from different industrial areas. These criteria were then evaluated by these academicals and experts individually, with these evaluations the AHP results calculated with below Consistency ratios: AHP Calculation on Vendor Selection: 2,0%, AHP Calculation on Software Selection: 5,3%

Normally it is not usual to apply two AHP calculations in such studies but we found it necessary to analyze the criteria in two main classification fields as “software selection" and "vendor selection". The most important criteria on software selection based on AHP calculation is "compatibility with existing ERP system". It is obvious that every company wants a seamless integration of a possible WMS system with the existing systems and applications. Therefore the candidate WMS system should be in capable of fitting to existing ERP system or being able to modified to fit to the existing ERP system. The second important ranked criteria is user friendly interface. In most of the companies the warehouse staff is generally not too qualified, so the WMS should be easy to learn and operate. The daily routine tasks should be easily completed through WMS menus, transactions and screens. Inbound and outbound data transfer capability is also very important as the data transfer in electronic form is the most fast and accurate way of the information flow. Either WMS or existing ERP system should be capable of inbound/outbound data transfer to help the company to keep competitive in the global environment.

The most important criteria on vendor selection based on AHP calculation is "technical/training support." Technical support is vital on integrating the new system to existing one(s), system modification and fulfilling possible future requirements due to system changes, internal/external customer requirements and future business adaptations. A good training is a must in order to use a system in an error free and efficient way. Experience in WMS field is the second important criteria. Experience in WMS field will carry the lessons learned from successful and not successful implementations.

Recommendation

The WMS supplier company can also bring the best practice in operations, processes, layouts etc. through the experience being worked with several companies. Service quality is ranked as third. The system breakdowns, error can result in operation stops and that lead to big costs due to stopping deliveries and not fulfilling customer demands on time. In addition to loss in terms of money, such problems may affect losing business partners in long term. So a fast and efficient service is a must, therefore online and remote connection possibilities for a fast solution can also be considered.

This study can be used after cost benefit study on deciding to use a WMS system is completed. In the next step the possible vendors and software can be evaluated based on importance criteria given on AHP calculations. This study can be regarded as a basic guide to compare the possible solutions, offers. Such studies will be useful on helping to decide the right system as number of vendors and number of WMS types in the market increase.

References

[1] Gattorna, J.L. and Walters, D.W., Managing the Supply Chain, 1996 (Macmillan Press: Basingstoke).
[2] Kovacs, G.L. and Paganelli, P., A planning and management infrastructure for large, complex, distributed projects—beyond ERP and SCM. Computers in Industry, 2003, 51,165–183.
[3] Stadtler, H., Supply chain management and advanced planning—basics, overview and challenges. Euro. J. Op. Res., 2004, 163, 575–588.
[4] Stamelos, I., Vlahavas, I., Refanidis, I., & Tsoukia` s, A. (2000). Knowledge based evaluation of software systems: A case study. Information and Software Technology, 42(5), 333–345.
[5] Kimball, R., Reeves, L., Ross, M., & Thornthwaite, W. (1998). The data warehouse lifecycle toolkit—expert methods for designing, developing, and deploying data warehouses. NY: John Wiley & Sons.
[6] Le Blanc, L. A., & Jelassi, M. T. (1989). DSS software selection: A multiple criteria decision methodology. Information and Management, 17(1), 49–65.
[7] Stylianou, A. C., Madey, G. R., & Smith, R. D. (1992). Selection criteria for expert system shells: A socio-technical framework. Communications of the ACM, 35(10), 30–48.
[8] Boloix, G., & Robillard, P. N. (1995). A software system evaluation framework. IEEE Computer, 28(12), 17–26.
[9] Hluoic, V., & Paul, R. J. (1996). Methodological approach to manufacturing simulation software selection. Computer Integrated Manufacturing Systems, 9(1), 49–55.
[10] Beck, M. P., & Lin, B. W. (1981). Selection of automated office systems: A case study. OMEGA, 9(2), 169–176.
[11] Seidmann, A., & Arbel, A. (1984). Microcomputer selection process for organizational information management. Information and Management, 7(4), 317–329.
[12] Zahedi, F. (1985). Database management system evaluation and selection decisions. Decision Sciences, 16(1), 91–116.
[13] Stylianou, A. C., Madey, G. R., & Smith, R. D. (1992). Selection criteria for expert system shells: A socio-technical framework. Communications of the ACM, 35(10), 30–48.
[14] Min, H. (1992). Selection of software: The analytic hierarchy process. International Journal of Physical Distribution and Logistics Management, 22(1), 42–52.
[15] Sarkis, J., & Talluri, S. (2004). Evaluating and selecting commerce software and communication systems for a supply chain. European Journal of Operational Research, 159(2), 318–329. Seidmann, A., & Arbel, A. (1983). An analytic approach
[16] Wei, C., Chien, C., & Wang, M. J. (2005). An AHP-based approach to ERP system selection. International Journal of Production Economics,96(1), 47–62.
[17] Vlahavas, I., Stamelos, I., Refanidis, I., & Tsoukia` s, A. (1999). ESSE: An expert system for software evaluation. Knowledge-Based Systems ,12(4), 183–197.
[18] Kim and Moon (1997) Fuzzy sets and fuzzy logic: Theory and applications. NJ: Prentice-Hall.
[19] Ngai and Chan (2005) "Quantitative Risk Assessment in Supply Chains: A Case Study Based on Engineering Risk Analysis Concepts." In Planning Production and Inventories in the Extended Enterprise: A State of the Art Handbook, Vol. 2, Chapter 5. edited by K. G. Kempf, P. Keskinocak, and R. Uzsoy, 105–132. New York: Springer.
[20] Saaty, T. L. 1980. *The Analytic Hierarchy Process*. McGraw-Hill. 287 p.
[21] Arpan Kumar Kar, 2014. Revisiting the supplier selection problem: An integrated approach for group decision support, Expert Systems with Applications 41: 2762–2771
[22] Hwang, H. G., Ku, C. Y., Yen, D. D., & Cheng, C. C. (2004). Critical factors influencing the adoption of data warehouse technology: A case study of the banking industry in Taiwan. Decision Support Systems, 37, 1–21.
[23] Clemen, T. R., & Reilly, T. (2001). Making hard decisions with decisiontools. Pacific Groce, CA: Duxbury
[24] Keeney, R. L., & Raiffa, H. (1993). Decisions with multiple objectives: Preferences and value tradeoffs. NY: Cambridge University Press
[25] Saaty, T. L. 1977. "A Scaling Method for Priorities in Hierarchical Structures." Journal of Mathematical Psychology 15: 234–281.
[26] Vinod Kumar, N., and L. S. Ganesh. 1996. "An Empirical Analysis of the Use of the Analytic Hierarchy Process for Estimating Membership Values in a Fuzzy Set." Fuzzy Sets and Systems 82: 1–16.

[27] BlancoC.,Guzman R.,Medina F.,2014,"An architecture for automatically developing OLAP applications from models"Information Software Technology,Volume 59, March 2015,Pages 1-16

[28] Shqair M.,Altazari S.,Shihabi S."A statistical study employing agent based modeling to estimate the effects of different parameters on the distance traveled in warehouses"Simulation Modelling Practise and Theory, Volume 49,pages 122-135

MARMARA ÜNİVERSİTESİ YAYINEVİ
MARMARA ÜNİVERSİTESİ 1883
MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Inventory Analysis in a Pharmacy

Zeynep CEYLAN[1], Serol BULKAN[2]

Abstract

Pharmacies are vital part of health care systems. There must be enough amount of drug always present in pharmacy stock to prevent any trouble. Furthermore, for a quality service management in a pharmacy, required drug must be supplied continually at correct time. Inventory theory is the area to study efficiently forecasting the continually flow of materials into and out of a process. This theory involves the controlling the transfer of materials in order to prevent the inventory from becoming excess, or decreased to levels that could endanger the operation of the process.

In this work, the annual drug sale data was taken from a medium sized pharmacy that located in Istanbul. The aim of this study was to properly manage the inventory in a pharmacy to balance inventory drug levels to provide patients' needs and customer satisfaction. For this purpose, drugs found in prescriptions were classified and prioritized by using information from Turkey Drug & Medical Device Institution and analyzed using inventory management tools. Moreover, literature review, and interviews with several pharmacists were also conducted during the research to emphasize the importance of inventory management in pharmacies.

Keywords: Drug Inventory Management, Pharmacy

Introduction

The pharmacy is one of the most commonly used therapeutic centers where a large amount of money is spent for purchasing medicinal items [1]. In pharmacies, various drugs are being stored for supporting the therapy of patients. Depending on the illness type and level, the characteristics of the drugs widely varies, from the common and cheap ones, such as antipyretics, to highly specific and expensive ones, such as chemotherapy drugs.

Due to the variety of pharmaceutical items, it is a difficult task to control and manage the quantity of drug. However, for a better and effective service management in a pharmacy, required drug must be provided continually at correct time and quantity to sustain steady in supply. The unavailability of any drug can negatively affect pharmacies image and results in fewer patient visits, conveyance of dissatisfaction with the pharmacy to other people. This can be accomplished by efficient inventory management of pharmacy by providing control on important drugs, and deciding on priorities in purchase and distribution of drugs [2]. Therefore, the inventory management ensures significant improvement for both patient care and optimal use of resources [3], [4]. It improves workflow and enhances customer satisfaction which is ultimately the breaking point of the business. Moreover, "Essential Inventory Management (EIM) is vital for the profitability of the pharmacy, EIM results in better cash flow, good customer service, good relationship with suppliers, good return on investment and accurate prediction of future needs of inventory" [5].

ABC (Always, Better, Control) analysis is a significant and well-known analytical tool in inventory management [6]-[8]. It was first developed in the 1950s and aims to gain managers' interest on the critical few (A-items) and not on the insignificant many (C-items). It divides items into three classes as A, B and C that can be managed and controlled separately [9]-[11]. *A-items* constitute only 10% of all inventory items. They have to be under strict control of higher management as they consume the top 70% of the total inventory consumption value of the company. *B-items* are the interclass items which include 20% of total inventory items. They require moderate control by middle management since they consume 20% of annual consumption

[1] Zeynep CEYLAN, Ondokuz Mayıs University, Engineering Faculty, Department of Industrial Engineering, Samsun, Turkey, zeynep.dokumaci@omu.edu.tr
[2] Serol BULKAN, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, sbulkan@marmara.edu.tr

value, on the contrary, *C-items* need control by lower management, account for 70% of total inventory items and consume 10% of the annual consumption value (Table 1).

The main restriction of ABC analysis is that it depends on price and the percentage of usage of the products. Thus, importance of items cannot be considered entirely. Therefore, it is not enough for efficient inventory management since an item which has low capital investment and consumption may be staminal or life-saving. The criticality (vitality) of an item should also be considered for development of management tool for inventory control [3], [12].

VED analysis is based on priority and importance to patients' health. It divides the items into three categories as Vital (V), Essential (E) and Desirable (D) [13]. Vital (V) class drugs that are life-saving like vaccines, and needed for life support (e.g., some antibiotics, insulins, digoxin, and etc.) must be available in the pharmacy stocks at all times. Essential (E) class drugs, which have lower severity, are efficient for therapy of less life threatening, but still serious diseases (e.g., antibiotics, ranitidine, chloroquine, phenytoin and etc.) may be available in the pharmacy stocks. The remaining drugs with lowest severity, which are used for therapy of slight diseases, are included in Desirable (D) class drugs. The absence of these drugs isn't fatal to the health of the patients (e.g., Vitamin E capsules, sun screen lotions and etc.) [14].

Effective and efficient inventory control can be accomplished on the items by considering both VED analysis and ABC analysis. Therefore, ABC-VED matrix analysis is created, by combining the ABC and VED analysis. ABC-VED matrix provides more meaningful control over the material supplies and divides items into three main categories: Category I, Category II, and Category III. Category I items are vital and expensive, consist of six subcategories (AV, BV, CV, AE, and AD), and need control by top of management. Category II includes essential with low cost items (BE, CE, BD). Category III consists of the desirable with least cost items (CD) [4], [12].

Table 1. Several Studies on Drug Inventory Management

Reference/ Year	Name of the Study	Application Area	Methodology
[13] / (2007)	ABC and VED Analysis in Medical Stores Inventory Control	Hospital	ABC,VED, and ABC-VED matrix
[4] / (2008)	A Study of Drug Expenditure at a Tertiary Care Hospital: An ABC-VED Analysis	Hospital	ABC,VED, and ABC-VED matrix
[12] / (2010)	ABC and VED Analysis of the Pharmacy Store of a Tertiary Care Teaching, Research and Referral Healthcare Institute of India	Pharmacy	ABC,VED, and ABC-VED matrix
[15] / (2010)	Applying Management Techniques for Effective Management of Medical Store of A Public Sector Undertaking Hospital	Medical Store	ABC,VED, and ABC-VED matrix
[16] / (2011)	Classification of Hospital Pharmaceutical Drug Inventory Items by Combining ABC analysis and Fuzzy Classification	Hospital	ABC analysis, and Fuzzy –ABC Classification
[3] / (2012)	Medical Store Management: An Integrated Economic Analysis of a Tertiary Care Hospital in Central India	Hospital	ABC,VED, and ABC-VED matrix
[10] / (2012)	Analysis of Inventory of Drug and Pharmacy Department of a Tertiary care Hospital	Pharmacy	ABC,VED, and ABC-VED matrix
[1] / (2012)	Inventory Management: A Tool of Identifying Items That Need Greater Attention for Control	Pharmacy	ABC analysis
[2] / (2013)	Multi-Unit Selective Inventory Control- A Three Dimensional Approach (MUSIC -3D)	Pharmacy	ABC, VED, and SDE analysis
[7] / (2013)	Inventory Control Techniques in Medical Stores of a Tertiary Care Neuropsychiatry Hospital in Delhi	Medical Store	ABC,VED, and ABC-VED matrix
[8] / (2014)	ABC-VED Analysis of Expendable Medical Stores at a Tertiary Care Hospital	Medical Store	ABC,VED, and ABC-VED matrix

In this study, ABC, VED, and ABC-VED matrix analysis of the pharmacy in İstanbul was carried out to determine and organize the categories of drugs for providing better management. The main objectives of this study were to: (1) analyze the annual drug expenditure (ADE) of pharmacy for the year 2013-2014, (2) improve priority system of drugs to provide the supervisory monitoring plan for the pharmacy. Several studies which include topics of inventory managements of drugs are listed in the Table 1.

Materials & Methods

The annual drug consumption and expenditure on each drug were collected from a pharmacy in İstanbul, Turkey. The taken dataset included 1552 prescribed drugs between 01/01/2013 and 01/01/2014, and it was stored in MS Excel spreadsheet format for quantitative calculations. Database provided 5 features (attributes) which are prescription number, date of prescription, commercial name of prescribed drug, quantity of prescribed drug and price.

ABC Analysis

In the initial stage, the annual drug expenditure (ADE) of all the drugs was calculated by multiplying the number of packages consumed in 2013 times the price per package. The total cost of all the drugs, cumulative percentage of expenditure and the cumulative percentage of drugs were also calculated. The drugs were assigned to a class (A, B and C) according to total cost consumed 70%, 20% and 10%, respectively (Table 2).

Table 2. ABC Analysis

Item	Items (%)	Total Cost (%)
A	10	70
B	20	20
C	70	10

VED Analysis

The ABC analysis depends on cost (annual drug expenditure) and is not enough for inventory management. Therefore, the criticality of a drug (Vital, Essential and Desirable analysis) should also be considered for improvement of management. Thus, criticality analysis of all the drugs in the pharmacy store was conducted and then these drugs were classified based into three groups (V, E, and D). The VED categorization of each drug was arranged by using information from Turkey Drug & Medical Device Institution and group of pharmacist.

ABC-VED Matrix Analysis

ABC-VED matrix analysis is combination of ABC and VED analysis. By cross-tabulating of these analysis nine different subcategories (AV, AE, AD, BV, BE, BD, CV, CE, and CD) were obtained. This nine subcategories are grouped into three main categories as Categories I, II and III. Category I includes items belonging to AV, AE, AD, BV and CV subcategories. The BE, CE and BD subcategories constituted category II and the remaining items in the CD subcategory constituted category III [12]. Table 3 shows ABC-VED matrix analysis format.

Table 3. ABC-VED Matrix Analysis Format

<table>
<tr><td colspan="2"></td><td colspan="3">VED Analysis</td></tr>
<tr><td colspan="2"></td><td>V</td><td>E</td><td>D</td></tr>
<tr><td rowspan="3">ABC Analysis</td><td>A</td><td rowspan="3">Category I</td><td colspan="2" rowspan="2">Category II</td></tr>
<tr><td>B</td></tr>
<tr><td>C</td><td>Category III</td></tr>
</table>

In Table 3, the first letter in the categories represents the drug class in ABC analysis while the second letter denotes drug class in VED analysis.

Results

In 2013, the number of drugs sold was consisting of 1552 items. The total ADE of the pharmacy on drugs was calculated about ₺589917.17.

ABC Analysis Results

ABC analysis results revealed that, 10.31% (160) of drugs in A class and 21.78% (338) of drugs in B class constituted 89.98% of the total pharmacy expenditure. The remaining 67.91% (1054) of drugs which are in category C, constituted only 10.01% of the ADE, as seen on Table 4.

Table 4. ABC Analysis of Drug

Analysis Parameter	Category			TOTAL
	A	B	C	
Total Annual Consumption (%)	69.96	20.02	10.01	100
Value of Annual Consumption (₺)	412728.29	118119.63	59069.25	589917.17
Number of drugs	160	338	1054	1552
Cumulative % of drugs	10.31	21.78	67.91	100

The results were also displayed in Figure 1.

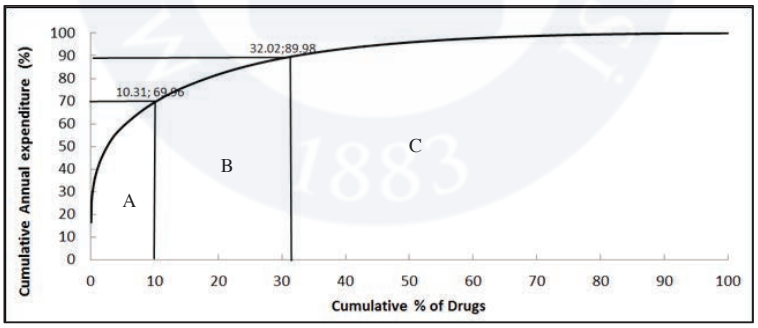


Figure 1. ABC Analysis Cumulative Curve (2013-2014)

The percentage of drugs in the increasing order against the ADE was also calculated. As seen Table 5, the ADE for first 10 % of drugs is ₺409513.46 (69.42 %) while only ₺924.11 (0.157 %) for last 10 % of the drugs.

Table 5. Percentage of Drugs Versus ADE

Percentage of Drugs	Number	ADE (₺)	ADE (%)
10	155	409513.46	69.42
20	310	72795.88	12.34
30	466	42078.30	7.133
40	621	25510.82	4.324
50	776	16067.73	2.724
60	931	10427.70	1.768
70	1086	6481.37	1.099
80	1242	3916.61	0.664
90	1397	2201.19	0.373
100	1552	924.110	0.157

VED Analysis Results

VED analysis results revealed that, 10.67% (167) of drugs in V class and 45.49% (706) of drugs in E class constituted 79.16% of the total pharmacy expenditure. The remaining 43.75% (679) of drugs which are in category D, constituted 20.84% of the ADE, as seen on Table 6.

Table 6. VED Analysis of Drugs

	Analysis Parameter			
Drug Category	**No of Drugs**	**% of Drugs**	**Value of Annual Consumption (₺)**	**Total Annual Consumption (%)**
Vital (V)	167	10.76	137529.70	23.31
Essential (E)	706	45.49	329451.16	55.85
Desirable (D)	679	43.75	122936.31	20.84
Total	1552	100.00	589917.17	100.00

ABC-VED Matrix Analysis Results

Table 7 shows combination of ABC and VED analysis (ABC-VED matrix analysis). Nine different subclasses were studied using this analysis. These nine were then grouped into three main categories (I, II and III).

Table 7. ABC-VED Matrix Analysis

		VED Analysis					
		V		E		D	
		No	**% of Drugs**	**No**	**% of Drugs**	**No**	**% of Drugs**
ABC Analysis	**A**	AV (57)	3.67	AE (63)	4.06	AD (40)	2.58
	B	BV (58)	3.73	BE (167)	10.76	BD (113)	7.28
	C	CV (52)	3.35	CE (476)	30.67	CD (526)	33.89

Table 8 showed that 17.04% (270) drugs belong to category I and constituted about 79% of the ADE of the pharmacy. Category II consisted 33.9% (526) of drugs, which accounts for 17.3% of the ADE of the pharmacy. The remaining 33.9% (526) drugs are in category III, accounts for only 2.57% of the total drug expenditure.

Table 8. ABC-VED Matrix Analysis

ABC- VED Matrix Classification				
Category No	**No of Drugs**	**% of Drugs**	**Value of Annual Consumption (₺)**	**Total Annual Consumption (%)**
Category I	270	17.40	443924.4	75.25%
Category II	756	48.70	130820.15	22.18%
Category III	526	33.90	15172.62	2.57%
TOTAL	1552	100.00	589917.17	100.00%

Drugs in Category I (AV, AE, AD, BV and CV) should be seriously managed. The consumption and stock level should be monitored continuously by the top management. AV, AE and BV subgroups of category I consist of 178 expensive drugs which consists 11.46% of total drugs and 62.41% of ADE. Since, they are either vital or essential and their being out of stock inadmissible. CV subgroup (52, 3.35%) consists of low cost but high criticality drugs and consumes only 0.81% of ADE of the pharmacy. These drugs can be

supplied once a year as ADE is negligible. Drugs in Category II (BE, CE, BD) are essential and have average cost. They should be managed with moderate control by the middle level management, but their consumption should also be controlled. Category III (CD) consists of drugs that are desirable and inexpensive. They should be ordered periodically and controlled by lower level of management. The comparison of this study results with similar studies in the literature was shown in Table 9.

Table 9. Comparison of Analysis Results with Different Studies in Literature [13]

	Category	Several Studies in Literature				
		[12]	[4]	[13]	[14]	Present Study
ABC analysis	A	13.78	12.93	14.46	10.76	10.31
	B	21.85	19.54	22.46	20.63	21.78
	C	64.37	67.53	63.08	68.61	67.91
VED analysis	V	12.11	12.36	7.39	23.76	10.76
	E	59.38	47.12	49.23	38.12	45.49
	D	28.51	40.52	43.38	38.12	43.75
ABC-VED analysis	I	22.09	22.99	20.92	29.15	17.40
	II	54.63	41.67	48.92	41.26	48.70
	III	23.28	35.34	30.16	29.59	33.90

Conclusion

Inventory analysis plays important role in the management of pharmacies. The usage of inventory control techniques in the healthcare provides significant improvement in patient care, customer relationships and optimal use of resources. Pharmacy spends a large amount of money for buying pharmaceutical items. Therefore, pharmacy management requires planning, designing and organizing of the medical stores. However, effective inventory management by keeping a close supervision may sometimes be challenging, due to huge variety items and traffics in the pharmacy.

To address this issue, this study aims to examine inventory management practices in a pharmacy. The study analyzed drugs inventory of pharmacy for the year 2013-2014 according to their cost and criticality properties. Three important methods regarding inventory management practice was studied such as ABC analysis, VED analysis, and ABC-VED matrix analysis. ABC analysis is an important and widespread tool used for ensuring decrease in expenditures and increase in effectiveness of drug utilization. However, it is not enough for efficient inventory management as ABC analysis is that it is depends on price and the rate of consumption of the item. A drug can be inexpensive and vital or life-saving. Thus, to overcome the limitation of ABC analysis, VED analysis was applied. VED analysis classifies drugs according to criticality and importance on patient's heath. However if we only consider VED analysis or ABC analysis alone, effective control cannot be accomplished on the items inventory. Therefore, the ABC-VED matrix was obtained with combination of ABC and VED analysis. ABC-VED matrix analysis provides strict controlling the drugs for optimal usage of budget and preventing out-of-stock conditions in the medical stores.

References

[1] Dwivedi S., Kumar A., Kothiyal P., 2012, Inventory management: A tool of identifying items that need greater attention for control, *The Pharma Innovation*, 1(7), 125-9.

[2] Girija, V.R., Bhat, M.S., 2013, Multi Unit Selective Inventory Control- A Three Dimensional Approach (MUSIC - 3D), *CVR Journal of Science and Technology*, 5, 98-104.

[3] Mahatme, M.S., Dakhale, G.N., Hiware, S.K., Shinde, A.T., Salve, A.M., 2012, Medical Store Management: An Integrated Economic Analysis of a Tertiary Care Hospital in Central India, *Journal of Young Pharmacists*, 4(2), 114-118.

[4] Vaz, F.S., Ferreira, A.M., Kulkarni, M.S., Motghare, D.D., Pereira-Antao, I., 2008, A study of drug expenditure at a tertiary care hospital: An ABC-VED analysis. *Journal of Health Management*, 10, 119-127.

[5] Alexandria, V.A., 2008, Managing the Pharmacy Inventory, *National Community Pharmacists Association* (NCPA) Digest. http://www.ncpanet.org/

[6] Yu, M.-C., 2010, Multi-criteria ABC analysis using artificial-intelligence-based classification techniques, *Expert Systems with Applications*, 38 (4), 3416–3421.

[7] Khurana, S., Chhillar, N., Gautam, V. K., 2013, Inventory control techniques in medical stores of a tertiary care neuropsychiatry hospital in Delhi, *Health*, 5, 8-13.

[8] Kumar, M.S., Chakravarty, B.A., 2014, ABC–VED analysis of expendable medical stores at a tertiary care hospital, *Medical Journal Armed Forces India*, http://dx.doi.org/10.1016/j.mjafi.2014.07.002.

[9] Guvenir, H.A., Erel, E., 1998, Multi-criteria inventory classification using a genetic algorithm, *European Journal of Operational Research*, 105(1), 29-37.

[10] Millstein, M.A., Yang, L., Li, H., 2014, Optimizing ABC inventory grouping decisions, *International Journal of Production Economics*, 148, 71-80.

[11] Manhas, A.K., Malik, A., Haroon, R., Sheikh, M.A., Syed, A.T., 2012, Analysis of Inventory of Drug and Pharmacy Department of a Tertiary care Hospital, *JIMSA*, 25(3), 183-185.

[12] Devnani, M., Gupta, A.K., Nigah, R., 2010, ABC and VED Analysis of the Pharmacy Store of a Tertiary Care Teaching, *Research and Referral Healthcare Institute of India, Department of Hospital Administration*, 2, 201-205.

[13] Gupta, R., Gupta, K.K., Jain, B.R., Garg, R.K., 2007, ABC and VED analysis in medical stores inventory control, *Medical Journal Armed Forces India*, 63, 325–327.

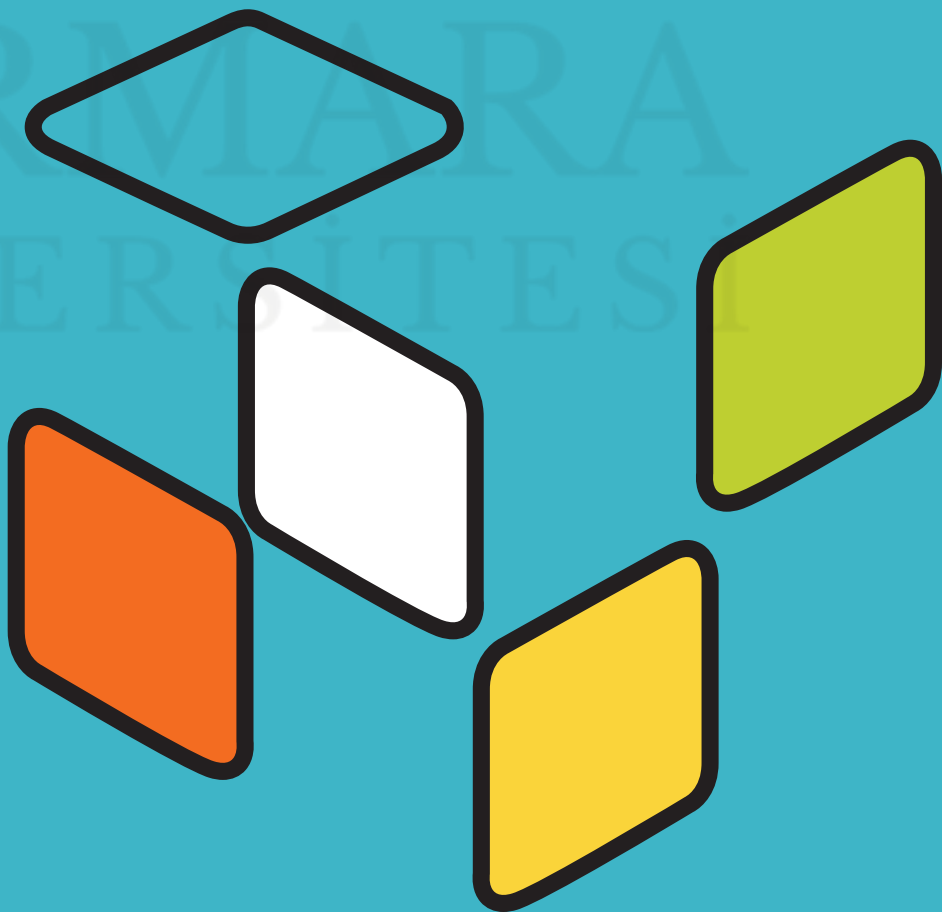
[14] Thawani, V.R., Turankar, A.V., Sontakke, S.D., Pimpalkhute, S.V., Dakhale, G.N., Jaiswal, K.S., 2004, Economic analysis of drug expenditure in Government Medical College Hospital Nagpur. *Indian Journal Pharmacol*, 36, 15–19.

[15] Roy, R.N., Manna, S., Sarker, G.N., 2010, Applying management techniques for effective management of medical store of a public sector undertaking hospital. *Indian Journal of Preventive and Social Medicine*, 41(1, 2), 11-14.

[16] Mahendrawathi, E.R., Nurul Laili, E., Kusumawardani, R.P., 2011, Classification of hospital pharmaceutical drug inventory items by combining ABC analysis and fuzzy classification, *Proceedings of the 2011 International Conference on Advanced Computer Science and Information Systems (ICACSIS 2011)*, Jakarta, Indonesia, 215-220.

MARMARA ÜNİVERSİTESİ YAYINEVİ

INNOVATION MANAGEMENT



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

A Conceptual Framework for Supply Chain Renovation

İlknur Yardımcı[1], Lamia Gülnur Kasap[2], Özalp Vayvay[3]

Abstract

As a requirement of today's competitive environment, companies want to renewthemselves in a changing world. Renovation is a new norm for renewing firms and supply chains. For successful renovation and development, it is needed supply chain reengineering methodology which is about analyzing the existing organization of supply chain, planning improvements tools and designs and then putting these improvements into practice. In this context, business process re-engineering is the key to the successful implementation of effective management which has become a potentially valuable way of securing competitive advantage. The summary is to show through a combination of these methods how the performance of the supply chain can be improved with the renovation and integration of processes at various tiers in the chain. In this study, information is given about supply chain renovation concept and requirements of this concept have been defined and a detailed literature review was conducted. With the results of the literature study, the deficiencies of new concepts were identified and described. Business benefits, challenges and solutions in supply chain management are examined for future researches.

Keywords: Innovation Management, Re-Engineering, Renovation, Supply Chain Management

Introduction

A supply chain is the set of business processes and resources that transforms a product from raw materials into finished goods and delivers those goods into the hands of the customer. Supply chain management (SCM) has been defined as "the management of upstream and downstream relationship with suppliers, distributors and customers to achieve greater customer value-added at less total cost" (Wilding, 2003). The goal of SCM is to integrate both information and material flows seamlessly across the supply chain as an effective competitive weapon (Childhouse and Towill, 2003). It has often been claimed that in the modern world the competition is no longer between single companies but between supply chains (Trkman et al., 2007).

Recent business development in the light of increased competition has caused many companies to explore new drivers in order to remain competitive. In this context, renovation is the key to the successful implementation of effective supply chain management which has become a potentially valuable way of securing competitive advantage (Groznik and Maslaric 2010). A new business processes are gained by renovation of current business practice in order to fully realise the benefits of improved information quality and share.

[1] *İlknur Yardımcı, Marmara University, Faculty of Engineering, Department of Industrial Engineering, iyardmc@gmail.com*
[2] *Lamia Gülnur Kasap, Marmara University, Faculty of Engineering, Department of Industrial Engineering,lamiagulnur@gmail.com*
[3] *Özalp Vayvay, Marmara University, Faculty of Engineering, Department of Industrial Engineering, ozalp@marmara.edu.tr*

Why Chains Must Be Renovated?

After successful strategy preparation, companies have to identify areas of possible improvement in quality of product or service, lead times or operational costs. This step takes an integral view of all organisations involved into the supply chain in order to renovate their operations towards supply chain excellence. Business Renovation (BR) or business process renovation and informatisation efforts integrate the radically strategic method of Business Process Re-engineering (BPR) and more progressive methods of Continuous Process Improvement (CPI) with appropriate IT infrastructure strategies. BPR seeks improvements by elevating efficiency and effectiveness of the business process that exist within and across organizations. On the opposite, CPI refers to minor and specific changes that one makes in an existing business process (Harmon, 2003). CPI relies on building a fundamental understanding of customers‟ requirements, process capability, and the root cause of any gaps between them by developing culture of continuous improvement in the areas of reliability, process cycle times, costs in terms of less total resource consumption, quality, and productivity. Six Sigma and Total Quality Management (TQM) are examples of approaches to CPI (Trkman and Groznik, 2009). According to Jacobson (Jacobson, 1995), we view business renovation as an umbrella concept for strategic IS planning, and both BPR and CPI since thorough and effective renovation should combine both, radical shifts (BPR) with those that permanently increase business efficiency and effectiveness (CPI).

From the literature sources of discontent in the supply chain that give rise to the need for reengineering can be summarised as follows:

1. incongruent objectives
2. disintegrated performance measures
3. unsynchronised decision-making
4. information asymmetry
5. misaligned incentives
6. fragmented business processes (Simatupang and Sridharan, 2005).

As can be seen from this list, problems are mostly collaboration and communication oriented which calls for a common reference framework for both supply chain management and SCRE. As precisely put by Tummala et al., ‘by evaluating and mapping a specific supply chain, a company is able to find and reduce system redundancies while improving reliability and flexibility of a system (Tummala et al., 2006).

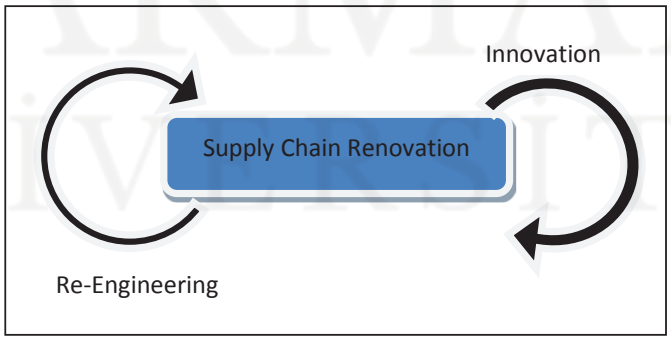


Figure 1.Supply Chain Renovation Elements

As shown in Figure 1 renovation occur from two elements. From that reason we examine literature in two part, re-engineering and innovation. Innovation starts after real time information flow ,and this information flow can be provided with re-engineering activities on business processes.

Supply Chain Renovation Model

Necessarily steps to create a new model are:

1. **Have a real time information system**- Supplying informatin is the most important part of supply chain management.
2. **Measure the current supply chain performance**- If you can not measure you can not improve a system
3. **Analyse the current system**
   3.1. Analyse customer demands and expectations –inward and outward
   3.2. Product, Process –with an innovative look
   3.3. Market trends
4. **Defign the Gaps**
5. **Renovate-** innovation with new mwthodolgy and tools
6. **Act new model**
7. **Control the results**

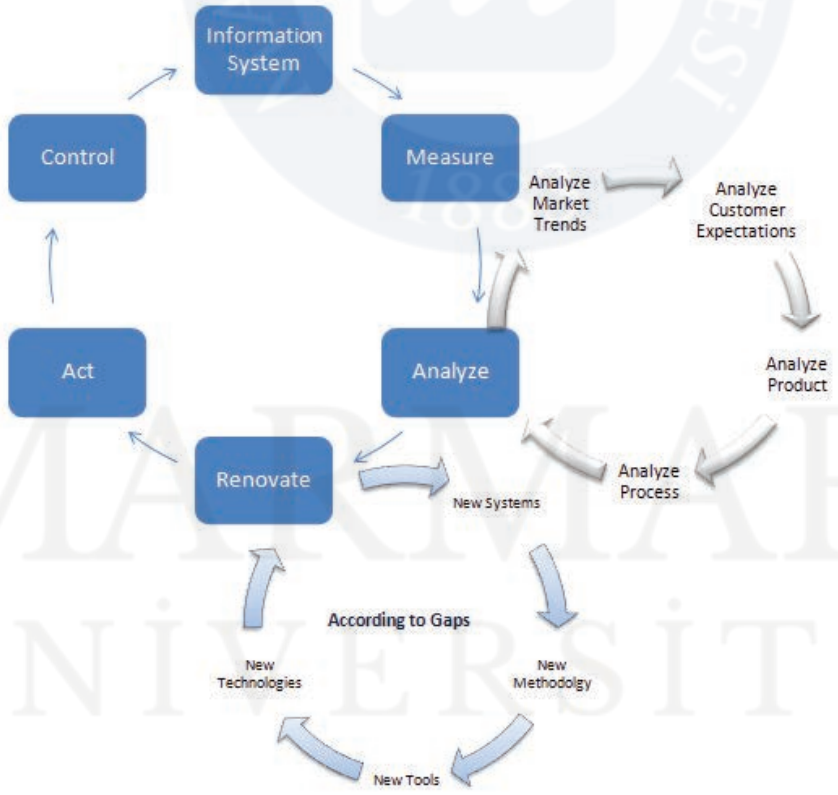


Figure 2: Renovation Model Progress Cycle

The model starts with the main purpose of the supply chain renovation problem which is to improve the performance of the supply chain; if you cannot measure you cannot improve. The idea of using performance management frameworks for greater purposes other than pure performance management is not novel. Indeed for instance, in their article titled Using the balanced scorecard as a strategic management system, Kaplan and Norton (1996) propose a four step (translating the vision, communicating and linking, business planning, feedback and learning) spiral mechanism to manage a company strategically. Cuthbertson and Piotrowicz (2008) have found through a literature review that supply chain measures can be applied in decision-making process, helping to define, test and implement new strategies, and other improvement opportunities. SCRM built on pillars which strategic, tactical, and operational aspects of the supply chain.

Current System occur from cultures, ideas, information, current, method and model process with new cases, circumstances, conditions, facilities and constraints. After these renovation process new culture, ideas, etc. will be formed. This new information, now we can call it knowledge, will return to our current information. And the cycle will start again. For that reason the firms that dominate the most of the market too, have to renovate their systems.

$$Current\left\{\begin{matrix}Culture\\Ideas\\Information\\Theory\\Model\\Method\end{matrix}\right\}\left(\begin{matrix}+*\\-\\/\end{matrix}\right)New\left\{\begin{matrix}Cases\\Circumstances\\Processes\\Conditions\\Facilities\\Constraints\end{matrix}\right\}=New\left\{\begin{matrix}Culture\\Ideas\\Information\\Theory\\Model\\Method\end{matrix}\right\}$$

Figure 3 (Özen S,Maltepe University,Lecture Notes, Social Responsibility in Corporations 2014 ,Page 55)

Literature Review

Bevilacqua M. et al., 2009 used the business process reengineering (BPR) approach to create a computer-based system for the management of the supply chain traceability information flows. In this paper, they focus on the process modelling technique used by some of the leading tools in the field of business process engineering. Process models made with this technique are called event-driven process chains (EPCs). EPCs are used in tools such as SAP R/3 (SAP AG), ARIS (IDS Prof. Scheer GmbH), LiveModel/Analyst (Intellicorp Inc.), and Visio (Visio Corp.). They developed this traceability system for the supply chain of a company situated in the Tronto valley in central Italy. During reengineering process key elements were: (1) modelling ‘‘by production lots”, (2)

the correlation between the information flow and the production flow. They solve four main problem of supply chain with "traceability" activities (Bevilacqua M. et al., 2009).

Groznik A. and Maslaric M., 2010 investigated the potential of using BPR for improving supply chain performances and competiveness. A definition of SCM, BPR and relevant issues was presented, together with an overview of the role of IT in supporting BPR. There followed a brief overview of business process modeling methods, with a case study providing an example of its use in oil downstream supply chain in one developing country. From this case is clear that this renovation project is justifiable from the cost and time perspective. The results in table and figure at below it's shown that a full improvement and effective supply chain management are only possible in the case of implementing both IT which enables efficient information sharing and the re-engineering of business processes. The mere implementing of IT without structural and organizational changes in business processes would not contribute to realizing the full benefit (Groznik A. and Maslaric M.,2010).

Transaction	Number	Average lead-time (h)	Average work (h)	Average wait (h)	Average costs (€)
Yes (AS-IS)	46	33.60	11.67	21.93	60.10
No (AS-IS)	17	8.43	2.40	6.03	8.47
Yes (TO-BE 1)	46	27.12	10.26	16.86	56.74
No (TO-BE 1)	1489	0.00	0.00	0.00	0.00
Yes (TO-BE 2)	46	12.85	4.88	7.98	32.54
No (TO-BE 2)	1489	0.00	0.00	0.00	0.00

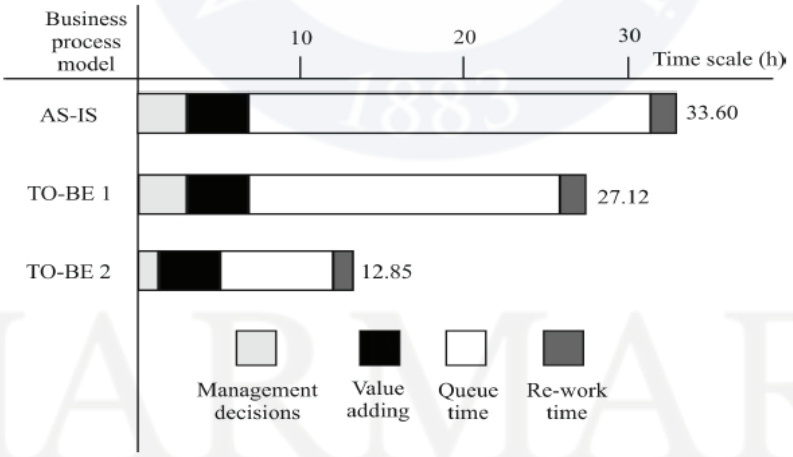


Figure 4: Output of new Model

Trkman P. and Groznik A., 2009 reviews latest findings in the most relevant areas, namely the importance of a proper supply chain strategy that is a pre-condition for business process renovation and mitigation of supply chain connected risks. The paper has tackled a vital challenge to provide a comprehensive review of several inter-connected challenges in supply chain management. Only continuous efforts in each of the mentioned areas assure efficiency and success. Nevertheless, optimal decision making is not possible since the choice set is too complex and generally unknown, due to the large number of possibilities and uncertainties (Trkman P. and Groznik A., 2009).

JDA Software has a case study about IKEA in 2010. IKEA was looking to change its supply chain strategy by cutting back on suppliers and focusing on those located in low-cost countries. IKEA discovered that this transition would mean enduring longer lead times that would force higher demands on the planning process. It would also prevent the retailer from quickly adjusting to changes and put extra pressure on IKEA's entire supply network. A global and regional supply planning system component would make it possible to coordinate sales, capacity and distribution planning, as well as link them directly to replenishment. The solution would also provide IKEA with visibility into the order-management process (URL 1, 2010).

Turhan D. and Vayvay Ö., 2011 presented a decomposition-based decision-making tool incorporating supply chain balanced scorecard performance measures for supply chain reengineering in this paper. Following a literature review on supply chain performance measures and reengineering models, various dimensions and approaches to supply chain reengineering are explored. Based on the insights gained, using the axiomatic design technique, a performance-based supply chain reengineering model is developed. In line with literature, the study conveys that there is still a large room for improvement for developing balanced supply chain measures that address different parts of the supply chain (Turhan D. and Vayvay Ö., 2011).

Stephens S. et al., 1997 explained the challenges in supply-chain reengineering and offer insight into the shape of future large-scale reengineering projects. Admittedly, no one has all the answers, but those who get supply-chain reengineering right will be winners in their markets. Supply-chain reengineering is the next hurdle in improving competitive position. Like many of today's technologies, the half-life of a reengineered process is short. This means that supply-chain reengineering will become an ongoing process requiring a continuous effort by all partners in the Supply chain (Stephens S. et al., 1997).

Groznik A. and Trkman P., 2007 showed the combination of the business process modeling and simulation methods how the performance of the supply chain can be improved with the renovation and integration of processes at various tiers in the chain and the sharing of information between companies. This combination of the methods enables an estimation of changes in lead times, process execution costs, quality of the process and inventory costs. The purpose of the case study is to show how the benefits of the supply chain process renovation and integration can be assessed by using the proposed combination of business process modelling and simulation. The case study presented in this paper deals with the fulfilment/procurement process in an SC that contains a petrol company (with multiple petrol stations at different locations) and a supplier which transports the petrol to the petrol stations from a few large warehouses (Groznik A. and Trkman P., 2007).

The purpose of the simulation is to estimate the optimal reorder point and the level of costs for this point for each simulation.

Three different situations were studied:

- the current situation in the AS-IS model (the level of petrol is checked once a day);
- the TO-BE model with the same number of orders (the level of stock is checked automatically every hour); and
- the TO-BE model with twice the number of current orders.

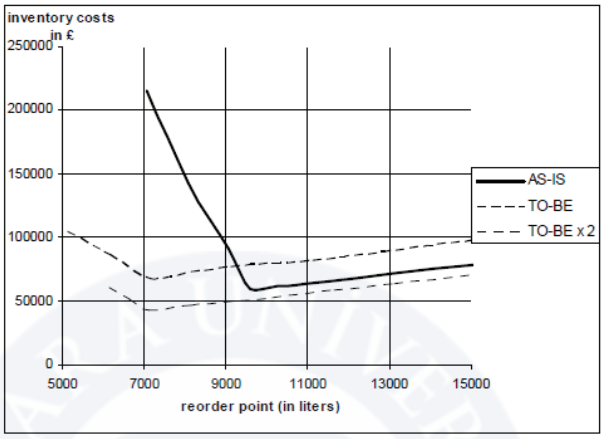


Figure 5: Total inventory costs in relation to reorder point (Groznik A. and Trkman P., 2007).

Groznik A. and Trkman P., 2009 had a case study of Slovenia about upstream supply chain management in e-government. The paper's main focus is the identification of the problems posed by ignorance of the supply chain management principles in e-procurement projects. The case study of the somewhat unsuccessful informatization of Slovenian public procurement demonstrates that the main challenges are not on the technological side but are instead connected with business process renovation, project management, unclear goals and responsibilities, and difficult coordination among various ministerial and governmental bodies. This paper substantiates the thesis that e-government should be viewed as a supply chain providing services to customers on the downstream side while integrating suppliers on the upstream side of the supply chain (Groznik A. and Trkman P., 2009).

Sweeney E., 2000 provides a basis for achieving world class standards for supply chains operating in all types of industry. There is a logical and systematic way of addressing the task of supply chain reengineering. This logical and systematic approach is referred to as the systems approach. The approach involves considering the whole supply chain and avoiding a situation where subsystems are optimized but whole supply chain is suboptimal. The process of supply chain analysis and improvement is complex; it requires total management commitment and dedicated resources. With this commitment and the necessary resources, the use of systems approach can result in significant improvements in supply chain performance (Sweeney E., 2000).

Table 1: Used methods and improvements of Supply Chain Renovation Studies

RESEARCHERS	METHODS	IMPROVEMENTS
Bevilacqua M. et al., 2009	Process Modeling Technique _ eEPC and eERM Logic	Quality improvement, improved promotion management and dynamic pricing, improvement of supply, logistics/distribution management, and an increased customer service level.
Groznik A. and Maslaric M.,2010	Process Modeling Technique _ Simulation of TO_BE and AS-IS models	Reduce lead time, eliminating waste and trimming process (Management decisions, Value. adding, Queue time, Re-work time)

Trkman P. and Groznik A., 2009	SCOR Model	Improvement in the area of reliability, process cycle time, costs in terms of less total resource consumption, quality, and productivity.
JDA Software, 2010	A global and regional supply planning system component	Quickly adjusting to changes, coordinate sales, capacity and distribution planning, as well as link them directly to replenishment.
Turhan D. and Vayvay Ö., 2011	Axiomatic design, SCRED model	Reduce waste and ensure efficient use of resources, reduce cost, faster delivery, improve quality. (include security, sustainability, resilience and innovation)
Stephens S. et al., 1997	3 stage engineering management and report cards on reengineering	Reduce costs and early morning shelf-stocking, improved competitive position, customer service, and cost effectiveness.
Groznik A. and Trkman P., 2007	Process Modeling Technique _ TO_BE and AS-IS models	Reduce operating costs, Shorten lead times, improve stock-out management
Groznik A. and Trkman P., 2009	e-Government, Critical Success Factor (CSF), SCOR Model, Development of an Upstream SC	Improve delivery performance, heterogeneous user groups, monitor costs, time and desired outcomes.
Sweeney E. ,2000	System Approach Methodology	Improvements in supply chain performances (Subsystems are optimized but the whole supply chain is sub-optimal)

Benefits Of Supply Chain Renovation

- The Big 3 auto makers strive to turn their suppliers into systems suppliers – not component makers. The outsourcing of key components reduces costs, but leads to strikes and plant shutdowns.
- Proctor and Gamble reports saving $1.6 billion over five years and expects to save even more in the future through more efficient supply-chain management.
- Microsoft teams with Net Logistics to launch a zero cost Web site for conducting shipping transactions in a standard format.
- A coffee chain consolidates non-coffee product (muffins and other extras) delivery to reduce frenetic early morning shelf-stocking by multiple vendors.
- Improved global view of the business and Company
- Cost savings accrued from long-term commitments
- Reduced risk of imbalance between commitments and demand
- More efficient management system
- Market Improvement
- Strengthening Supply Chain Systems
- An estimation of changes in lead times, process execution costs, quality of the process and inventory costs.

Conclusion and Recommendations

- Most of the papers are focused on mathematical methods for supply chain optimization instead of an overview of business-related challenges connected to supply chains.
- The literature is rich in theoretical approaches to supply chain performance measurement, but at the same time there is a lack of empirical research, both qualitative and quantitative.
- In the literature, additional simulations are used to estimate changes in the quality level and costs of stock. It allows a deeper understanding of the consequences of introduced new technologies and intraorganizational IS as enablers of process and organizational changes.
- Business process renovation and integration should not be considered as a one-time project, as a permanent process performance measurement, analysis and a continuous improvement of supply chain processes.
- When problems are tied to the identification of users' needs, the connectivity with suppliers and the renovation of internal business processes, it become impossible without business process modeling and renovation.
- Bullwip Effect; One changing on one element of supply chain has large impact on all supply network. The renovation issues, Figure 5, has shown areas that can be affected by each other.

- ✓ **Human resources** - training and organization value development.
- ✓ **Project management -** communication and lack of management tools. Failure to assess project performance.
- ✓ **Management support -** goal-setting, sponsorship, continuity of involvement.
- ✓ **Change management** - addressing organizational resistance.
- ✓ **Tactical planning -** resource commitment and financial justification.
- ✓ **Process delineation** - measurable goals, scoping of process, scoping of effort, and incrementalism.
- ✓ **Strategic planning -** alignment with strategy and business vision for the project.
- ✓ **Time frame** - timeliness of implementation, ability to assure schedule performance.
- ✓ **Technological competence -** capabilities in technical areas of the project.

Figure 5: Renovation Issues (Stephens,Gustin,Ayers,1997)

References

[1] Wilding R (2003). The 3Ts of highly effective supply chains. Supply Chain Practice 5(3): 30-39
[2] Childhouse P, Towill DR (2003). Simplified material flow holds the key to supply chain integration. Omega-Int. J. Manage. S. 31(1): 17-27.
[3] Trkman P, Stemberger MI, Jaklic J, Groznik A (2007). Process approach to supply chain integration. Supply Chain. Manage. 12(2): 116-128
[4] Groznik A, Maslaric, (2010). Achieving competitive supply chain through business process re-engineering: A case from developing country, African Journal of Business Management Vol.4 (2), pp. 140-148.
[5] Simatupang TM, Sridharan R (2005) Supply chain discontent.Bus Process Manag J 11(4):349–369
[6] Trkman, P., & McCormack, K. (2009a). A conceptual model for managing supply chain risk in turbulent environment. International Journal of Production Economics, 119(2), 247-258.

[7] Trkman, P., & McCormack, K. (2009b). Estimating the benefits and risks of implementing e-procurement IEEE Transactions on Engineering Management, In press.
[8] Tummala, V.M.R, Phillips, C.L.M. and Johnson, M. (2006) 'Assessing supply chain management success factors: a case study', Supply Chain Management, Vol. 11, No. 2, pp.179–192.
[9] Özen S,Maltepe University,Lecture Notes, Social Responsibility in Corporations 2014 ,Page 55
[10] Stephens, Gustin, Ayers,1997.Reengineering the Supply Chain-The Next HurdleScott, The Executive's Journal:13-18
[11] Groznik A, Trkman P (2009), Upstrean supply chain management in e-government: The case of Slovenia, Govenment Information Quarterly, 26(2009) 459-467
[12] Sweeney E (2000), The system approach to supply chain, Marketing News: the journal of the marketing institute of Ireland, Vol.12, 13, page 14-15
[13] Bevilacqua M. Ciarapica F.E., Giacchetta G. (2009), Business process reengineering of a supply chain and a traceability system: A case study, Journal of Food Engineering, Vol 93, page 13–22
[14] Trkman P., Groznik A. (2009) Current Issues And Challenges Of Supply Chaın Management, European and Mediterranean Conference on Information Systems, April 12-13 2009, Abu Dhabi, UAE
[15] Turhan D., Vayvay Ö. (2011) A performance-based decision-making tool for supply chain reengineering, Int. J. Business Excellence, Vol. 4, No. 3, page 298-320
[16] URL 1, JDA Software (2010), IKEA Revamps Supply Chain Strategy with Demand and Fulfillment Solutions from JDA Software, http://www.jda.com/company/display-collateral.html?did=226

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Constructs Of Organizational Innovation for Logistics Industry: An Explotory Analysis for the Impact of Act for Knowledge Sharing

Serkan Gürsoy[1], *Nesli Çankiri*[2]

Abstract

Global dynamic economy forces many firms to generate continuous innovation to sustain their competitive advantage. Advancement in information and communication technologies opens new eras and opportunities in global supply chain and enables firms to have better services for customers in logistic sector. The purpose of this study is to understand and to shed organizational innovation facilitators in the logistic service providers. Throughout the analysis on 120 samples, exploration of latent and sub constructs of these facilitators is stated on the theoretical bases of the enablers in organizational innovation. This work presents some sort of potential facilitators of each constructs and their relationships with the knowledge sharing setting of an organization.

Keywords: Organization Innovation, Logistics

Introduction

One of the popular words of today is innovation, mostly known as the new products or process available for new markets. As a result of investing in research and development; it may also be regarded as a primary way of having competitive advantage (Freeman and Soete, 2004). Although literature offers various explanations about innovation, the Oslo Manual published by OECD (1997) considers innovation in such categories which are derived from Joseph Schumpeter, mostly known as the first economist explaining the path of innovation in 1930s. Schumpeter's five different types of innovation can be listed as: (1) product innovation (introduction of a new product or a qualitative change in an existing product), (2) process innovation, (new production methods), (3) marketing innovation (the opening of a new market), (4) managerial innovation (development of new sources of supply for raw materials or other inputs), and finally (5) organizational innovation (changes in industrial organization). In line with these classifications, innovation refers two main aspects. These are technical and non-technical aspects of innovation. The former one refers new or improved products and new or improved production methods while the latter one refers mostly the adaptation of new including new markets, new forms of organization and etc. Even though the existence of widely agreed definitions and measurement techniques by focusing inputs and outputs of technical innovations (Roger, 1998; European Innovation Scoreboard, 2008), there are insufficient conceptual and methodological techniques for measuring nontechnical side especially for organizational innovation.

The critical importance of organizational innovation for having competitive advantage is still ongoing debate in sense of the ways and constructs enabling competitive strategy. However, it is known that the basic links about innovation and competitiveness relies on four factors: innovations are hard to imitate by rivals (Porter, 1995), innovations reflects market realms (Porter, 1995), innovations enable firms to exploit knowledge and technology and it make firms to access new capabilities (Miller, 1992). On the other hand, selecting competitive strategy forces firms to have a successful innovation. Utterback and Abernaty (1975) explain that cost minimizing strategies make firms to work on process

[1] Serkan Gürsoy, Beykoz Vocational School of Logistics, serkangursoy@beykoz.edu.tr
[2] Nesli Çankiri, Beykoz Vocational School of Logistics, neslicankiri@beykoz.edu.tr

innovation to decrease total cost of production and to increase productivity. Studies about the impact of organizational innovation on competitiveness mostly suggest organizational innovation as a result of process innovation enabled by efficient use of technologies (Acemoglu et al, 2006; Caroli and Van Reenen, 2001) and optimized organizational structure. Moreover, organizational innovation provides competitive advantage since it has significant impact on productivity, flexibility and quality. In order to keep their competitive advantage, organizations need to adapt increasing complexity and rapid changes in markets. In today's world of business, the age of knowledge economy, logistic service providers try to make themselves to adapt new situations by transforming their organizations from labor-intensiveness into knowledge intensiveness. Within the context of this adaptation processes, they also try to create and use knowledge for not only for having competitive advantage, but also promote their competencies to gain innovative products. Chapman et al. (2003) states knowledge as crucial need for having innovation capability. Moreover, authors mention that effective managing of knowledge within the organization and among the organizations is the key factor to develop new ideas and products. Autry and Griffis (2008) find positive and significant relationship between knowledge and logistics innovation in their recent works on supply chain capital. Besides the positive relationship between logistics and innovation, Flint et al. (2008) also proposed a positive correlation between supply chain learning and logistics innovation. To utilize knowledge within the organization force logistic firms to develop their internal/external knowledge networks, to invest in knowledge sharing infrastructure for better acquisition of knowledge (Wagner, 2008). As a derived implication, one of the fundamental breakthrough of this adaptation processes is to implement information and communication technologies and automation technologies in their business processes. Investing in information and communication technologies (ICT) used for knowledge sharing within organizations provides new abilities, new skills and new organizational and industry structures as a major driver of the change (Brynjolfsson and Hitt, 2014). Together with the complementarities between ICT and organizational change, there are some evidences that the use of ICT has also positive impact on product and process innovation as well as productivity (Leeuwen, 2008). Finding these kinds of positive correlations between ICT and innovation caused by organizational change may not be proof of the positive relationship between all constructs of ICT and the constructs of organizational innovation. Having ICT investment might be insufficient to have positive impact on organizational innovation performance but conceptually, adaptation of these technologies, in other words the use of these technologies bring organization to have success in the process of change.

This study copes with the characteristics of organizational innovation and the impact of ICT on these characteristics. By exploring the constructs of today's online ICT applications and constructs of today's organizational innovation, this research aims to specify the impact of each constructs of ICT on each constructs of organizational innovation. Within these bases, the study focuses on (1) the use of **ICT for knowledge sharing** and (2) constructs of the structural characteristics of organizational innovation. The first section, literature review, focuses on the theoretical basis of the concepts; ICT and organizational innovation. This part covers these concepts in an organizational context of knowledge sharing by presenting basics and ongoing debates about the relationships among ICT and organizational innovation. It represents the elaborated review for accessing the constructs enabling empirical settings used in the study. Then, the study ends with an overview of the study and the empirical research suggestions about the matters.

Literature review

One of the most popular trends in today's business is to shift their innovation capabilities by investing in knowledge based assets and investing in ICT applications as a tool for knowledge sharing activities. Since 1990s, ongoing emphasis on innovation capability has been known as the importance of

knowledge sharing and research networks affecting the organizational performance (Baum and Ingram 1998). Having an ability to share and diffuse knowledge resources helps organizations to create opportunities for having better problem solving mechanisms, having more efficient learning environment and openness for innovation and etc. Nonaka (1994) states that knowledge is created and managed by individuals within the organization. Within this scope, knowledge sharing can be defined as a social interaction culture, involving the exchange of employee knowledge, experiences, and skills through the whole department or organization (Lin, 2007). On the other side, knowledge can be shared not only between individuals but also between organizations. Within this sense, knowledge sharing means that organizations must capture, organize, explore, exploit and diffuse knowledge (especially experience-based knowledge aka tacit knowledge) which resides within organization. For both individual and organizational level of knowledge sharing, ICT applications and network systems motivate its users to share their knowledge (Nonaka 1994) and also to facilitate the codification, integration, and dissemination of organizational knowledge (Song, 2002). This section of the study offers literature review about the constructs of organizational learning the constructs of online ICT application used for knowledge sharing within organizational context.

Organizational Innovation and Organizational Structure

Basically, it can be defined as the creation or adoption of an idea or behavior new to the organization (Damanpour, 1996) by building of valuable assets for having new products or process within the organizational context (Woodman et al, 1993). Despite the fact that wide range of literature suggest organizational innovation as a factor having positive impact on organizations' competitiveness and performance, the terms of organizational innovation is still diverse and scattered (Lam, 2004). Thus, organizational innovation has variety of interpretations but it can be broadly classified into three different streams (Lam, 2004). These streams can be grouped as (1) organizational structures enabling organizational innovation, (2) organizational cognition, enabling organizational innovation and finally, (3) organizational change enabling adaptation. While the first strand of research focus on identification of structural characteristics resulting product or process innovation (Teece, 1998), the second strands focus on cognitive characteristics of organizational learning and knowledge creation processes resulting new products or processes (Nonaka, 1994). The last strand mainly focus on relational characteristics of organization with environmental factors forcing them to change and to develop capabilities for responding this demand (Tushman and Nelson, 1990).

All these strands claim that organizational innovation cause technical innovation by enabling organization to adapt changing conditions such as technology, market and etc. On the other hand, it is difficult to separate these strands because of the overlapping results on innovativeness and competitiveness. However, each dimension of these strands may provide different results in sense of the impact of ICT applications. Beyond these research strands, there are also some fragmented research about the relationship between organizational innovation and competitive performance (Womack et al, 1990; Hammer and Champy, 1993; Goldman et al, 1995).

Besides these approaches, Lin (2006) argues that different types of innovation stress some distinctive determinants of innovation in terms of understanding organizations' adaptation behavior. The author conducts on technical and administrative innovation. While the former one refers to product, services and process innovation, the latter one refers organizational structures and administrative processes. Lin (2006) classifies administrative innovation in three matters as: Supply Chain Management (SCM), Customer Relationship Management (CRM), and knowledge management. The last one, knowledge management, is defined by author as the techniques deal with how knowledge is created or acquired, disseminated, and used within organizations. Thus, it deals with the information infrastructure, tools,

and content. It also involves exploration and exploitation of knowledge. This conceptualization brings the topic to the intersection between resource based view and knowledge based view on competitiveness of organizations in sense of having innovative capability. Knowledge sharing which is addressed in strategic management literature in accordance with resource based theory is the realization of competitive advantage in sense of establishing conditions which enable the sustainability (Grant, 1991). Resource based view characterizes firm's resources as strategic assets and states resource asymmetries between firms as source of organizational rent (Winter, 1987). However, the knowledge based view states the assumption that organizational knowledge is a main strategic resource to sustain competitive advantage by enabling knowledge creation and application in other words exploration and exploitation). General implications derived from literature imply that firms must be effective both in exploration and exploitation in order to innovate. While necessity to survive in long term requires exploration in sense of development of new capabilities, necessity of survive short term requires exploitation in sense of efficient use of current capabilities. Combining both behaviors in a process seems problematic because of that exploitation generally requires preservation of stable organizational structure in firm's assets and capabilities, however, exploration needs changes in structure for new configurations for shifting new standards from existing ones (Noteboom, 2004). In line with methodology followed by Daugherty et al. (2011), it can be framed that the components of organizational structure are linked with organizational capital – formalities or informalities, controlling, coordinating - (Barney, 1991) or organizational resources (Grant, 1991). The more examples can be found in the literature suggesting that organizational structure as a business resource is contributor of having sustainable competitive advantage. Because of the purpose of this study intending to explore the relationship between ICT constructs and constructs of organizational structures, the other fragmented research streams (skill biased change, imitability of resources and etc.) are excluded together with the popular strands of organizational cognition – cognitive characteristics- and organizational change – relational characteristics-.

By following Damanpour (1996) who provides comprehensive analysis of organizational innovation in his work claiming the effects of determinants and moderators of innovation, this study use organizational structuring variables as the dimensions of organizational structure through organizational innovation. Because of the changing complexity through more dynamic structures and advances in ICT applications effects structure related decisions of the organization (Olson et al, 2005). Daugherty et al. (2011) analyzed Grant's (1996) theoretical argument by empirically testing the relationships between organizational structure and organizations innovativeness. They confirmed that organizational structure may contribute to its organizational innovation capability. Grant (1996) explains two critical implications as the role of hierarchy and the location of decision making. Similarly, Damanpour (1996) posits structural complexity as the number of locations at which work is performed, as the number of jobs or services performed, or as the number of hierarchical ranks performing different tasks. Daugherty et al. (2011) follows both directions and they state three dimensions of organizational structures effecting organizational innovation; **decentralization (vs. centralization)**, **formalization** and **specialization**. According to them, the significant and positive relationship between decision-making decentralization and logistics service innovation depends on organizations' efforts on formalization including flexibility and autonomy. However, they found a negative relationship between formalization and logistics service innovation while Damanpour (1996) founds positive. The difference between these two results is resulted by the effect of efficiency (Daugherty et al., 2011) in formal or informal structures. Finally, they found positive (similar with Damanpour) but insignificant relationship between specialization and organizational innovation because of the integrative nature of current supply chain management which requires extensive interaction and collaboration among employees (Daugherty, 2011). Authors gives some definitions for

these three dimensions. According to them centralization refers to the extent that decision authority is closely held by top managers while decentralized and delegated management is held by middle- and lower-level managers (Olson et al., 2005 cited in Daugherty, 2011). Formalization is defined as the extent to which rules, procedures, instructions, and communications are written (Pugh et al., 1968 cited in Daugherty, 2011). Specialization is the degree to which tasks and activities are divided in the organization and the degree to which workers have control in how the tasks are conducted (Olson et al., 2005 cited in Daugherty, 2011). Since this study is designed for explorative research on significant correlations on its previous bases, the constructs of specialization is postponed for future work especially for observing and finding new significant determinants.

Decentralization: The continuous changes in technology and market force organizations to respond this rapid and fast movement by adapting their assets and organizational architectures. When they have improvement in their adaptation process, decentralized workplace organization provide productivity with the more contribution of information technology (Bresnahan, Brynjolfsson and Hitt, 2000). Therefore, most of the organizations try to shift their competencies through the better utilization of decentralized authority, teamwork, and incentives (Hitt and Brynjofolsson, 1997). This shift can be explained as teamwork, incentives, and increased use of skills and training. Hitt and Brynjofolsson (1997) classify these matters in such areas as: (a) decision authority referring teams and individual decision rights, knowledge work and skills, (b) training and supporting practices (incentives for training and education, preemployment screening) and (c) incentives, which includes various aspects of performance-based pay increases and promotions. They also claim that information technology is complementary to decentralized authority because valuable specific knowledge may not able to transfer, or information overload may create potentially binding constraint on central decision makers. At their work, they capture such aspects of decentralization as self-managing teams, employee involvement groups, the allocation of individual decisions and pace or method of work. Similarly, some other critical contributions (Tidd et al., 1997; Lam,2004) based on Mintzberg's (1983) structural archetypes and their innovative potentials (simple structure, machine bureaucracy, professional bureaucracy, divisionalized form, adhocracy) defines features of innovative organizational structure. Highlights of these features are entrepreneurial behaviors are often highly innovative, low level of standardization or flexibility are beneficial for problem solving, high degree of autonomy may limit innovative capability, capability of learning provide high level of innovative capability (Lam,2004). In line with Mintzberg's (1999) way and the purpose of this study consider decentralization as dispersion of formal authority. In the light of other contributions in the literature, it can be specified as **the level of delegation** of power and **the degree of authority**.

Formalization: It refers a work style of an organization regulating its activities by creating and announcing written rules also known as procedures. The intention is to reduce mistakes and risk as long as variability in acts. Even though it has some advantages especially for having standardized products and services, it may impede innovation capability because of that it tend to be more bureaucratic and lower ability to change. In order to highlight the role formalization versus innovativeness, the behavior of individual (it can be called as practitioner here) within the organization (it can be called as community here) must be taken into consideration. Communities of practices have been described as "groups of people informally bound together by shared expertise and passion for a joint enterprise" (Wenger and Snyder 2000). They are different from teams and functional units as they are self-organizing systems whose lifespan is determined by its members, based on the intrinsic value that membership brings. Such communities are not constrained by time and space and therefore can span organizational boundaries (Wenger 1998). Steinmüller (2004) highlights the communities of practitioners as the social networks which are influenced by (and influence) the utilization of

information and communication technologies, economic performance at various levels of aggregation and the localization and globalization of knowledge creation and exchange. These communities are able to retain dynamic and evolving knowledge within a real-time process that adds context to existing static repositories. In line with these explanation, this study consider formalization **the lower level of rigidity** and **the lower level of flexibility** announced by organizations.

Information and Communication Technologies

Especially in the last decades, the skills and capabilities of individuals have been increasingly noticed in terms of their ICT competencies. The skills conducted here are not only technical, but - more importantly – informational: skills that enable individuals to access, to process and to interpret information in useful ways. In this frame, there is a growing attention to the fundamental impact of ICT on the structure (Blanchard and Horan, 2000; Hampton and Wellman, 2003; Quan-Haase and Wellman, 2004; Huysman and Wulf, 2006; Ellison et al., 2007). This attention to the impact of ICT on knowledge creation and skill diffusion makes clear that the ability to create, share and utilize knowledge is continuously upgraded by the advancement of ICT. In parallel with these advancements in organization, ICT introduces some other opportunities for organizations in the sense of having and managing their social assets (Millen and Patterson, 2003). Use of ICT in a virtual environment, including online communities, builds social norms and assets in organizations. Nowadays, instead of only a tool for interaction, ICT should be assumed as an actor of exchanging, codifying, storing, retrieving and delivering (Wang, 2012). This section explores online communities as a place for exchanging knowledge in an organizational context.

Online Tools for Knowledge Sharing

Within the existence of insufficient research attempts, there are some commonly accepted results about the relationship between ICT and knowledge sharing.

Huysman and Wulf (2005) expect that distributed communities with a high cognitive ability (i.e. a shared frame of reference) and motivations to share knowledge (e.g. a shared purpose), but with low structural opportunities will be in need for communication tools since, it is expected that the level of density will increase over time (Brown and Duguid, 2001 cited in Huysman and Wulf, 2006). With regard to the dimensional approaches, Pigg and Crank (2004) consider the functions of ICT supporting both communication in various forms as well as information storage, retrieval, analysis and sharing. Bolisani and Scarso (1999) point that ICT facilitates knowledge transfer through the exchange of data. Nonetheless, this requires a double transformation process from knowledge to information and then to data, and back from data to information and finally, to knowledge. They also claim that the transfer of knowledge (especially the tacit form) often requires proximity between the transmitter and the receiver. In line with these explanations, considering ICT in two forms as **information functioning tools** and **communication functioning tools** may become necessary especially because of the fact that it is built upon “instrumental” and “expressive” information forms (Briggs, 2003 cited in Pigg and Crank, 2004). Pigg and Crank, (2004) differentiate between the information and communication functions. **The information function** is complex because Internet-based information transfer can take place using a variety of features of the network (Pigg and Crank, 2004). Information transfer can be “active” in that people share information using various communication features of the online networks including e-mail and video conferencing, or it can be “passive”, based on one person’s searching for resources on the Internet and using, for example, its archiving or knowledge management capabilities. Pigg and Crank, (2004) also offer that **the communication function** is multi-faceted and interactive, including text, audio and video, as well it may be real-time (as in VOIP) or asynchronous or

archival/historical. According to them, the communication function refers to the acts of transmitting information of different types, e.g., ideas and feelings, from one person to another. Based on these challenges for classifying ICT in sense of its format and the role in users' relations, Yuan et al., (2013) considers the role of ICT tools for knowledge sharing. For that reason, they collect ICT in three groups such as **Social media tools** –as a generator of knowledge sharing among community members-, **communication tools** –as a channel for knowledge sharing-, long standing tools[3]. They state that social media can better address challenges to knowledge sharing because using social media helps users to develop better awareness of both other users' expertise (e.g., from employees′ profiles) and their personal lives (e.g., from status updates). On the other hand, communication tools connect users (transmitter and receiver) directly and they are very informative and more importantly, most efficient in providing up-to-date information. Besides, they may help build stronger connections between them and thereby make providers more motivated to share knowledge (Yuan et al., 2013). Based on the given discussion, as a knowledge sharing platform, social media tools and the communication tools may lead to basic changes in users' opportunities, motivations and abilities in sense of building, maintaining.

Communication tools: According to Boase et al. (2006) communication tools are going to emerge mostly as a synchronous messaging which are integrated with other knowledge sharing tools (web-based platforms). The means of online communication are many and varied. The popular communication tools for knowledge sharing on the Internet refer to applications such as e-mail, instant messaging, video-conferencing, voice over internet protocol (VoiP), Internet relay chat and chat rooms (Kreijns et al., 2003; Boneva et al.,2006; Steinfield and Scupola, 2006). These tools (e-mail, instant messaging, telephone, and video-conferencing) are complementary to each other in supporting both synchronous (e.g. instant messaging) and asynchronous (e.g. e-mail), as well as intrusive (e.g. telephone calls) and less intrusive (e.g. using instant messaging to respond to an urgent requests).

Social Media Tools: On the other hand, together with the advance of ICT with the introduction of Web2.0[4], the recent trends in social networking sites, blogs, wikis and forums become valuable platforms for knowledge sharing. Vossen (2009) defines Web 2.0 in four dimensions. These are the social dimension, infrastructure dimension, functionality dimension and the data dimension. These dimensions technically are related with the Nonaka's (1994) process of knowledge sharing as socialization, externalization, combination and internalization. With regard to Nonaka's (1994) statement about **socialization** - process of creating tacit knowledge through shared experience- social dimension, is described as the software for sharing user-generated content or collaborative use of it (Vossen, 2009). These description of social media tools **-Social Networking Sites (SNS)-** refers to the applications for the interactions among users in which they create, share, and exchange information and ideas in online communities and networks. Another process of knowledge sharing is **externalization -**the conversion of tacit knowledge to explicit knowledge- (Nonaka, 1994), make **Wikis** a conversational technology within the frame of meaningful dialogues (Andreano, 2008) externalizing practitioners experiences for submitting it to the Web 2.0 platforms (McAfee, 2006). According to Andreano (2008), wiki technology allows users to directly interact with the content they encounter. The process of **Combination -**the reconfiguration of existing information for having new knowledge by sorting, adding, re-categorizing, and re-contextualizing- (Nonaka, 1994), appears as **forums** in Web 2.0 technology (McAfee, 2006). The final process defined by Nonaka (1994) is **internalization** -conversion of explicit knowledge into tacit knowledge-. For this process, Web 2.0

[3] **Long-standing tools** such as databases and digital archives that allow searching or communicating with document contributors; hence, their value for developing awareness of expertise distribution is limited (Yuan et al., 2013).
[4] The term Web 2.0 was coined in 1999 to describe web sites that use technology beyond the static pages of earlier web sites.

serves as **blogs** allowing users to express themselves through storytelling and narrative (Du and Wagner, 2006). Table 2 presents popular communication tools and their purposes while Table 3 shows social media tools by giving differences among them and relations between knowledge sharing processes.

Table 1: Popular online communication tools

E-mail	Write, store, send, and receive asynchronous messages electronically; can include attachments of word documents, pictures, audio, and other multimedia files.
Instant messaging	Allows the synchronous exchange of private messages with another user; messages primarily are in text but can include attachments of word documents, pictures, audio, and other multimedia files.
Chat rooms	Synchronous conversations with more than one user that primarily involve text; can be either public or private. Internet Relay Chat (IRC) is a protocol for live interactive Internet text messaging (chat) or synchronous conferencing.
Videoconferencing	A set of telecommunication technologies which allow two or more locations to communicate by simultaneous two-way video and audio transmissions.
Voice over Internet	A methodology and group of technologies for the delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet.

Source: Subrahmanyam (2008)

Table 2: Differences between wiki, forum and blog

SNS	**Wiki**	**Forum**	**Blog**
Socialization	**Externalization**	**Combination**	**Internalization**
Personal and community supply	Community supply	Community supply	Personal supply
Mostly developed by authenticated users and the owner	Mostly developed by authenticated users	Mostly developed by anonymous users	Mostly developed by the owner
Content publishing consisting of text, video or audio	Displays text and graphic content contributions	Content publishing consisting of comments and descriptions of entries	Content publishing consisting of text, video or audio
Pushes content to subscribers	List of edits to entries	Shows others with similar Entries	Pushes content to subscribers
Notification to owner or commenter's when the new comment have been made	Notification when changes have been made	Displays number of people who bookmarked same content	

Source: Treem and Leonardi (2012)

Conclusion

The rapid development in ICT and its extensive use in organizations shaped the structures of organizations in order to adapt new conditions and acquiring, creating and diffusing knowledge within the organization and among organizations. More generally, ICT based working, especially computerization effects organizational change by adding value in two ways; it increases productivity of workers and it increases knowledge acquisition within the organization and between organizations, as well as coordination and monitoring (Brynjolfsson and Hitt, 2003). ICT applications improves central management's ability to monitor agents and results and increase the relative profitability of decentralization. On the other hand, ICT applications decrease communication and information processing costs and increase organizational performance by enabling central decision making. Decentralization associated with some sort of informal communication and more initiatives which make transfer of implicit knowledge easier and effective. On the other hand, centralization associated with some sort of formalization and specialization which make transfer of explicit and procedural knowledge easier and cost effective.

Within the scope of the study, the relationships between information and communication technologies and the workplace organization, it has been assumed that an analysis of the functionalities of tools associated with knowledge sharing activities provides new insights into the conditions of organizational constructs in online communities of practices in sense of managing knowledge. This study expects to find that structures of workplace organization positively and significantly has been influenced by the use of ICT in sense of communication technologies. The constructs of authority might be shaped by the messages transmitted through the communication tools. The results may suggest that the constructs of organizational structure needs to be determined by handling other applications used by individuals in the organizations. The harmony in the use of these technologies make the division difficulty and it reflects this difficulty to reach significant relationships between the constructs of ICT and the constructs of organizational structure.

References

[1] Acemoglu, D., Aghion, P., Lelarge, C., Van Reenen, J., and Zilibotti, F. (2006).Technology, Information and the Decentralization of the Firm (No. w12206). National Bureau of Economic Research.
[2] Andreano, K. (2008). Knowledge Management 2.0? The Relationship between Web 2.0 Technologies and KM Theory. Knowledge Management in Organizations, 15.
[3] Arvanitis, S. (2005). Computerization, workplace organization, skilled labour and firm productivity: Evidence for the Swiss business sector. Economics of Innovation and New Technology, 14(4), 225-249.
[4] Autry, C. W., & Griffis, S. E. (2008). Supply chain capital: the impact of structural and relational linkages on firm execution and innovation. Journal of Business Logistics, 29(1), 157-173.
[5] Barney, J. (1991). Firm resources and sustained competitive advantage. Journal of management, 17(1), 99-120.
[6] Baum , Joel A . , and Paul Ingram . 1998 . Survival Enhancing Learning in the Manhattan Hotel Industry 1898 – 1980 . Management Science 44 (7): 996 – 1016
[7] Baum, J. A., & Ingram, P. (1998). Survival-enhancing learning in the Manhattan hotel industry, 1898–1980. Management Science, 44(7), 996-1016.
[8] Blanchard, A., and Horan, T. (2000). Chapter 1: Virtual communities and social capital. Knowledge and Social Capital: Foundations and Applications, Eric L. Lesser (eds.) Butterworth-Heinemann, Woburn, MA, 159-178.
[9] Boase, J., Horrigan, J. B., Wellman, B., and Rainie, L. (2006). The strength of Internet ties: The Internet and e-mail aid users in maintaining their social networks and provide pathways to help when people face big decisions. Washington, DC: The Pew Internet and American Life Project. Retrieved on June, 22, 2007.
[10] Bolton, P., & Dewatripont, M. (1994). The firm as a communication network. The Quarterly Journal of Economics, 809-839.

[11] Boneva, B., Quinn, A., Kraut, R., Kiesler, S., and Shklovski, I. (2006). Teenage communication in the instant messaging era. Computers, phones, and the Internet: Domesticating information technology, 201-218.
[12] Bresnahan, T. F., Brynjolfsson, E., & Hitt, L. M. (1999). Information technology, workplace organization and the demand for skilled labor: firm-level evidence (No. w7136). National bureau of economic research.
[13] Brown, J. S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. Organization science, 12(2), 198-213.
[14] Brynjolfsson, E., & Hitt, L. M. (2003). Computing productivity: Firm-level evidence. Review of economics and statistics, 85(4), 793-808.
[15] Brynjolfsson, Erik and Haim Mendelson (1993) "Information Systems and the Organization of Modern Enterprise", Journal of Organizational Computing, 3, p.245-255.
[16] Brynjolfsson, E., and Hitt, L. M. (2000). Beyond computation: Information technology, organizational transformation and business performance. The Journal of Economic Perspectives, 23-48.
[17] Caroli, E., and Van Reenen, J. (2001). Skill-biased organizational change? Evidence from a panel of British and French establishments. Quarterly journal of economics, 1449-1492.
[18] Chapman, R.L., Soosay, C. and Kandampully, J. (2003), "Innovation in logistic services and the new business model", International Journal of Physical Distribution & Logistics Management, Vol. 33 No. 7, pp. 630-50.
[19] Damanpour, F. (1996). Organizational complexity and innovation: developing and testing multiple contingency models. Management science, 42(5), 693-716.
[20] Daugherty, P. J., Chen, H., & Ferrin, B. G. (2011). Organizational structure and logistics service innovation. International Journal of Logistics Management, The, 22(1), 26-51.
[21] Disney, S. M., Naim, M. M., & Potter, A. (2004). Assessing the impact of e-business on supply chain dynamics. International Journal of production economics, 89(2), 109-118.
[22] Eliiyi, Deniz Türsel and Dicle Yurdakul Şahin (2011) "Improving Performance and Customer Satisfaction via the Use of Information Technologies in Public Transportation and Logistics Systems", in Public Sector Reform Using Information Technologies: Transforming Policy into Practice (ed. T. Papadapoulos and P. Kanellis), p.212-222, Pennsylvania: IGI Global.
[23] Ellison, N. B., Steinfield, C., & Lampe, C. (2007). The benefits of Facebook "friends:" Social capital and college students' use of online social network sites. Journal of Computer-Mediated Communication, 12(4), 1143-1168.
[24] Europe, P. I. (2008). European innovation scoreboard 2007. Comparative analysis of innovation performance.
[25] Feng, Cheng-Min and Chien-Yun Yuan (2006) "The Impact of Information and Communication Technologies on Logistics Management", International Journal of Management, 23(4), p.909-924.
[26] Flint, D.J., Larsson, E. and Gammelgaard, B. (2008), "Exploring processes for customer value insights, supply chain learning, and innovation: an international study", Journal of Business Logistics, Vol. 29 No. 1, pp. 257-81
[27] Freeman, C., & Soete, L. (Eds.). (1997). The economics of industrial innovation. Psychology Press.
[28] Grant, R. M. (1991). The resource-based theory of competitive advantage: implications for strategy formulation. Knowledge and Strategy.(Ed. M. Zack) pp, 3-23.
[29] Grant, R. M. (1996). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. Organization science, 7(4), 375-387.
[30] Hampton, K., & Wellman, B. (2003). Neighboring in Netville: How the Internet supports community and social capital in a wired suburb. City & Community, 2(4), 277-311.
[31] Huysman, M., & Wulf, V. (2005). The role of information technology in building and sustaining the relational base of communities. The Information Society, 21(2), 81-89.
[32] Huysman, M., & Wulf, V. (2006). IT to support knowledge sharing in communities, towards a social capital analysis. Journal of information technology, 21(1), 40-51.
[33] Jacobs, L. C., & Chase, C. I. (1992). Developing and Using Tests Effectively. A Guide for Faculty. Jossey-Bass Inc., Publishers, 350 Sansome Street, San Francisco, CA 94104.
[34] Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. Computers in human behavior, 19(3), 335-353.
[35] Lam, A. (2004). Organizational innovation.
[36] Leeuwen, George van, and Shikeb Farooqui. 2008. "ICT, innovation and productivity." In Eurostat "Information society: ICT impact assessment by linking data from different sources." 222-239.

[37] Millen, D. R., & Patterson, J. F. (2003, April). Identity disclosure and the creation of social capital. In CHI'03 extended abstracts on Human factors in computing systems (pp. 720-721). ACM.
[38] Miller, D. (1992). The Icarus paradox: How exceptional companies bring about their own downfall. Business Horizons, 35(1), 24-35.
[39] Mintzberg, H.(1983) Structure in Fives: Designing Effective Organizations, Englewood Cliffs, Prentice Hall
[40] Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. Organization science, 5(1), 14-37.
[41] Olson, E.M., Slater, S.F. and Hult, T.M. (2005), "The performance implications of fit among business strategy, marketing organization structure, and strategic behavior", Journal of Marketing, Vol. 69 No. 3, pp. 49-65.
[42] Organisation for Economic Co-operation and Development. (1997). The Measurement of Scientific and Technological Activities: Proposed Guidelines for Collecting and Interpreting Technological Innovation Data: Oslo Manual. OECD.
[43] Özdemir, Dilek and James Darby (2009) "One Less Barrier to Foreign Direct Investment in Turkey? Linkages Between Manufacturing and Logistics Operations in Istanbul and the Marmara Region", European Urban and Regional Studies, 16(1), p.87-99.
[44] Pigg, K. E., & Crank, L. D. (2004). Building community social capital: The potential and promise of information and communications technologies. The Journal of Community Informatics, 1(1).
[45] Quan-Haase, Anabel and Barry Wellman (2004) "How Does the Internet Affect Social Capital", Social Capital and Information Technology, 113, p.135-113.
[46] Rogers, M. (1998). The definition and measurement of innovation (pp. 1-27). Parkville, VIC: Melbourne Institute of Applied Economic and Social Research.
[47] Subrahmanyam, K., Reich, S. M., Waechter, N., & Espinoza, G. (2008). Online and offline social networks: Use of social networking sites by emerging adults. Journal of Applied Developmental Psychology, 29(6), 420-433.
[48] Teece, D. J. (1998). Capturing value from knowledge assets. California management review, 40(3), 55-79.
[49] Treem, J. W., & Leonardi, P. M. (2012). 7 Social Media Use in Organizations. Communication Yearbook 36, 36, 143.
[50] Tushman, M. L., & Nelson, R. R. (1990). Introduction: Technology, organizations, and innovation. Administrative Science Quarterly, 1-8.
[51] Utterback, J. M., & Abernathy, W. J. (1975). A dynamic model of process and product innovation. Omega, 3(6), 639-656.
[52] Wagner, S.M. (2008), "Innovation management in the German transportation industry", Journal of Business Logistics, Vol. 29 No. 2, pp. 215-32
[53] Wang, Q., Woo, H. L., Quek, C. L., Yang, Y., & Liu, M. (2012). Using the Facebook group as a learning management system: An exploratory study. British Journal of Educational Technology, 43(3), 428-438.
[54] Wenger, E. (1998). Communities of practice: Learning, meaning, and identity. Cambridge university press.
[55] Wenger, E. C., & Snyder, W. M. (2000). Communities of practice: The organizational frontier. Harvard business review, 78(1), 139-146.
[56] Yuan, Y. C., Zhao, X., Liao, Q., and Chi, C. (2013). The use of different information and communication technologies to support knowledge sharing in organizations: From e-mail to micro-blogging. Journal of the American Society for Information Science and Technology. 64(8),1659-1670

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Operational Criteria Evaluation for Collaboration of Innovative SMEs

İrem Düzdar [1], Gülgün Kayakutlu [2], Bahar Sennaroğlu [3]

Abstract

SMEs have to organize alliances with universities or other research organizations, global business companies as well as other SMEs. Each type of alliance has specific risk and success criteria to be studied. SMEs need to construct successful alliances in order to have sustainable business in a competitive environment. Pre-analysis of the path for successful alliances will lead improvements in innovative power. This study attempts to perform qualitative analysis of the SME alliances in order to express the criteria supporting the success in innovation. In this empirical study, the survey results will be extracted by literature taxonomy to categorize criteria of innovation success. These results will be analyzed by Analytic Hierarchy Process to prioritize the innovation criteria to help any SME or large business to reduce risks in future alliances. This study will allow structuring strategic decisions based on operational criteria.

Keywords: Analytic Hierarchy Process, Innovation, Taxonomy

Introduction

OECD has defined the innovation notion as "the implementation of a new or significantly improved product or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" [1]. The competitive market conditions are forcing Small and Medium Sized Enterprises (SMEs) to cooperate for innovation, but the presence of the risks in the case of defining the route for success is an undeniable fact for collaborating SMEs. The stated strategic decisions of alliances must be powered by the association rules directed to the innovative synergy. The innovative collaboration can be defined as "cooperative arrangements engaging companies, universities, and government agencies and laboratories in various combinations to pool resources in pursuit of a share research and development (R&D) objective" [2].

Various items which have common features can be categorized or codified into groups or clusters by taxonomies [3]. In other words the reviews can be categorized by taxonomies in the base of their principal specifications [4]. The literature taxonomy is used for innovation collaboration factors in SMEs. In this context it is observed that the operational, managerial, financial, and technological elements of innovation need to be kept going for a long time. It is observed that there are many operational factors, which are focused in value chain as primary process for innovation as the result of the literature analysis [5]-[6]-[7].

In this study, effective factors described by a taxonomy have been determined by group decision technique. The priorities of these operational factors are evaluated using Analytic Hierarchy Process (AHP) technique. Based on these priorities, SMEs can define new strategies to have competitive advantage for collaborative innovation.

[1] İrem Düzdar, İstanbul Arel University, Engineering and Architecture Faculty, Department of Industrial Engineering, Istanbul, Turkey, iremduzdar@arel.edu.tr
[2] Gülgün Kayakutlu, İstanbul Technical University, Management Faculty, Department of Industrial Engineering, Istanbul, Turkey, kayakutlu@itu.edu.tr
[3] Bahar Sennaroğlu, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, bsennar@marmara.edu.tr

Methodology

The most common methods of Multi Attribute Decision Making (MADM) problems are the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Analytic Hierarchy Process (AHP) and outranking. The PROMETHEE (Preference Ranking Organization METHod for Enrichment Evaluations) is one of the widely used outranking techniques [8]-[9].
Feng et al. (2011) used an integrated method that includes AHP, scoring method and weighted geometric averaging method for selection of collaborative innovation research teams [10]. To evaluate the inclinations and choices of the stakeholders a specific AHP model application is used by Álvarez et al. (2013) in a distinctive social infrastructure projects [11].
The theory of quantifiable and intangible criteria evaluation, AHP, serves as a very useful method for MCDM problems, which are dealing with the selections and prioritization. The AHP can be used to solve the problems dealing from investment to resource allocation and organization planning including politics, economics, social, marketing, and management areas [12].

Assuming that we are dealing with n criteria at a given hierarchy, the procedure create an $n \times n$ pairwise comparison matrix, **A**. The pairwise comparison is done as the criterion in row i (i=1,2,…,n) is leveled relative to each of the criteria denoted by the n columns. Letting a_{ij} define the element (i,j) of the matrix **A**, AHP uses a discrete scale from 1 to 9 for pairwise comparisons (Figure 1). For consistency, $a_{ij} = k$ automatically means that $a_{ji} = 1/k$. All the diagonal elements a_{ii} of the comparison matrix **A** equal 1**.** Therefore, when n criteria are being compared, n (n−1)/2 pairwise comparisons are required to fill in the matrix **A** [13].

Likert-type or frequency scales uses fixed answer formats and are prepared for rating attitudes or ideas. These ranked measures rate the levels of agreement/disagreement [14].

1	equal importance
3	moderate importance of one over another
5	strong or essential importance
7	very strong or demonstrated importance
9	extreme importance
2,4,6,8	intermediate values
Use reciprocals for inverse comparisons	

Figure 1. AHP pairwise comparison scale [13]

Consistency tells that the decision maker is showing coherent judgment in specifying the pairwise comparison of the criteria or alternatives.

Mathematically, a comparison matrix **A** is consistent if $a_{ij}\, a_{jk} = a_{ik}$, for all i,j, and k. This property implies that all the columns (and rows) of **A** to be linearly dependent. The columns of any 2×2 comparison matrix are dependent, and hence a 2×2 matrix is always consistent.

Given that human thinking is the basis for generating these matrices, some degree of inconsistency is expected and should be tolerated provided that it is not *unreasonable*. To measure the consistency to see whether or not it is reasonable, the consistency ratio (CR) is used. Given **w** is the column vector of the relative weights w_i, i=1,2,…,n, **A** is said to be consistent if, and only if,

$$\mathbf{A}\mathbf{w} = n\mathbf{w} \tag{1}$$

For the case where **A** is inconsistent, the relative weight, w_i, is approximated by the average of the n elements of row i in the normalized matrix **N**. Letting $\overline{\mathbf{w}}$ be the computed estimate, it can be shown that the closer n_{max} to n, the more consistent the comparison matrix **A**.

$$\mathbf{A}\overline{\mathbf{w}} = n_{max}\overline{\mathbf{w}} \quad , n_{max} \geq n \tag{2}$$

The value of n_{max} is computed from $\mathbf{A}\overline{\mathbf{w}} = n_{max}\overline{\mathbf{w}}$ by observing that the ith equation is [15]

$$\sum_{j=1}^{n} a_{ij}\overline{w}_j = n_{max}\overline{w}_i \qquad ,i = 1,2,...,n \tag{3}$$

$$\sum_{i=1}^{n}\left(\sum_{j=1}^{n} a_{ij}\overline{w}_j\right) = n_{max}\sum_{i=1}^{n}\overline{w}_i = n_{max} \qquad \text{given } \sum_{i=1}^{n}\overline{w}_i = 1 \tag{4}$$

This means that the value of n_{max} can be determined by first computing the column vector $\mathbf{A}\overline{\mathbf{w}}$ and then summing its elements [15].

CI : Consistency index of **A**
RI : Random consistency index of **A**
CR : Consistency ratio of **A**

$$CI = \frac{n_{max} - n}{n-1} \tag{5}$$

$$RI = \frac{1.98(n-2)}{n} \tag{6}$$

$$CR = \frac{CI}{RI} \tag{7}$$

If CR is less than or equal to 0.1, then the level of inconsistency is acceptable. Otherwise, the inconsistency in **A** is high and the decision maker is advised to revise the elements a_{ij} of **A** to realize a more consistent matrix [13].

Application and Results

The criteria derived from the literature review, that affect the innovation on the basis of the operation is classified by knowledge. The 'Operational' group covers Operational Management, Processes Style, Production & Manufacturing Style, Service Style, Outsourcing Experience, Demand & Supply Management, Inventory Management, Quality Management, Design Operations and, Sales Management. Design Operations, Demand & Supply Management, and Production & Manufacturing Style are frequent in operational criteria (Table 1).

Table 1: Operational criteria frequency

Operational criteria	**Number of frequency**
Operational Management	**3**
Processes Style	**3**
Production & Manufacturing Style	**7**
Service Style	**4**
Outsourcing Experience	**3**
Demand & Supply Management	**7**
Inventory Management	**1**
Quality Management	**3**
Design Operations	**8**
Sales Management	**1**
Total	**40**

The factors shown in Table 1 were evaluated by 5 experts with AHP pairwise comparison scale. The geometric mean technique was applied to these evaluations for the group decision. The geometric mean is "the nth root product of n numbers" and can be calculated by using the following formula:

$$G = \sqrt[n]{x_1 x_2 \dots x_n} \tag{8}$$

AHP technique was used for determining the relative importance of operational criteria. It was observed that inconsistency was at an acceptable level. The priorities of operational criteria according to their weights are seen in Table 2.

Table 2: Weights for operational criteria

Criterion	Priority
Design Operations	0.161
Demand & Supply Management	0.155
Exportation	0.112
Inventory Management	0.095
Operational Management	0.075
Marketing Activities	0.073
Working Conditions	0.068
Employment Rate	0.062
Production & Manufacturing Style	0.048
Number of Executives	0.040
Quality Management	0.030
Outsourcing Experience	0.029
Service Style	0.024
Sales Management	0.021

Conclusion

Design Operations and Demand & Supply Management have maximum importance for the operational criteria. Therefore, achieving high performance in these two sub-criteria will bring competitive advantage to SMEs for innovation collaboration. These two influencers may be seen as the most important factors to distinguish the SMEs for innovation collaboration. The SMEs, which have less experience in exportation because of their economies of scale, will prefer to collaborate with the successful alliances in exportation for innovation. Among the other operational criteria, the marketing activities have intermediate importance and sales management has minimum importance.

It must be emphasized that the criteria related to human resources have intermediate importance. This may be recognized as one of the priorities of collaborators for innovation.

As a further study, the operational criteria derived from the literature taxonomy can be compared with the other grouped criteria generated in the same manner.

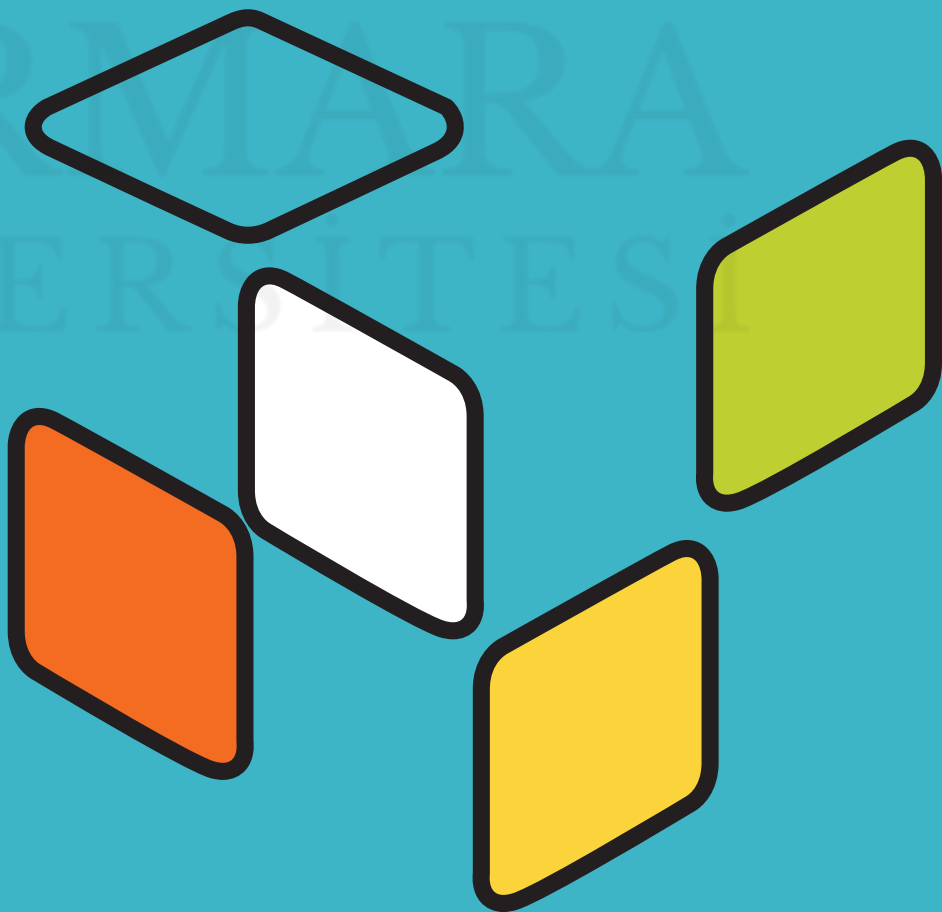
References

[1] OECD, (2009), (http://www.oecd-ilibrary.org/), Retrieved October 20, 2015.
[2] Block, F., Keller, M.R., 2009, Where do innovations come from? Transformations in the US economy, 1970–2006. *Socio-Economic Review*, *7* (3), 459-483.
[3] De Jong, J.P., Marsili, O., 2006, The fruit flies of innovations: A taxonomy of innovative small firms, *Research policy*, *35*(2), 213-229.
[4] Cooper, H.M., 1982, Scientific Guidelines for Conducting Integrative Research Reviews", *Review of Educational Research*, 52 (2, Summer), 291–302.
[5] Poggel, C., Schönwetter, G., 2010, Analyzing differences in the logistics competence between SMEs and Large Companies – an empirical study. *Proceedings of the 2nd ICLT*.
[6] Singh, R.K., Garg, S.K., Deshmukh, S.G., 2008, Strategy development by SMEs for competitiveness: a review, *Benchmarking: An International Journal*, 15 (5), 525 – 547.
[7] Hughes, A., Wood, E., 2000, Rethinking innovation comparisons between manufacturing and services: the experience of the CBR SME surveys in the UK,105-124, Springer US.
[8] Bozbura, F.T., Beskese, A., Kahraman, C., 2007, Prioritization of human capital measurement indicators using fuzzy AHP. *Expert Systems with Applications*, 32(4), 1100-1112.
[9] Yoon, K.P., Hwang, C.L. ,1995, Multiple attribute decision making: an introduction, (104), *Sage Publications*.
[10] Feng, B., Ma, J., Fan, Z.P., 2011, An integrated method for collaborative R&D project selection: Supporting innovative research teams, *Expert Systems with Applications*, 38(5), 5532-5543.
[11] Álvarez, M., Moreno, A., Mataix, C., 2013, The analytic hierarchy process to support decision-making processes in infrastructure projects with social impact, *Total Quality Management & Business Excellence*, 24(5-6), 596-606.
[12] Saaty, T.L., Vargas, L.G., 1994, Decision Making in Economic, Political, Social, and Technological Environments with theAnalytic Hierarchy Process, *RWS Publications*, Pittsburgh, PA.
[13] Saaty T., 1980, The Analytic Hierarchy Process, *McGraw-Hill*, NY.
[14] McLeod, S., 2008, Likert scale. Simply Psychology.
[15] Taha, H. A., 2003, Operations Research: An introduction, 7e, Prentice Hall, NJ.

MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ

PROCESS MANAGEMENT



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Performance Evaluation of Projects in Software Development

Filiz Çetin[1], *Çiğdem Alabaş-Uslu*[2]

Abstract

IT firms are able to develop various types of software development projects from small sized projects to very large ones. A software development process is carried out by different stages of the project management such as analysis, design, development and testing. At the end of the process, performance of the project is evaluated by project sponsor who represents the customer of the project. There are different factors that effect the performance of the projects like risk, project size, project type and priority, team size, budget, duration, change requests and delays. In this study, we aim to statistically analyze effects of these factors on performance evaluation of the project sponsor. Additionally, we try to develop a statistical model to aid the project sponsor in performance evaluation. We use real data from software development department of telecommunication firm.

Keywords: Software Development, Project Performance, Statistical Models

Introduction

Project is a temporary collection of efforts to create a unique product, service or result. Project has definite beginning and end, definite scope and aim within a limited budget [1]. Each project has a sponsor which is defined in [1] as "the person who is the entity giving resources and support to the project". According to the methodology proposed in [1], the project is closed with the approval of the sponsor.

Software development projects are different and more difficult from other engineering projects [2], as their complexity and high rate of failure [3]-[4]. CHAOS manifesto by Standish group [5] represent that in 2012, 18% of software projects failed and 43% faced with challenges. A small portion of software projects has been found successful [5]. Therefore understanding and measuring software project success is a critical process in characterizing software development projects.

Literature about project success is divided into four periods [6]-[7]: First is "Early 1970s"; success literature focuses on time, cost and quality. This dimension is defined as "iron triangle" [8]. Second is "1980s to 1990s" that looks at the technical aspects of a project to how it related to the client organization [9], and success was typically described with a single measure for the project instead of multiple measures over the life [7]. Third is "1990s to 2000s" that gives importance to critical success factors frameworks and internal and external stakeholders [10]. The "21st Century" is the last one and continuing today that researches focus on stakeholder with project success [11]-[13]. Davis [6] also emphases about this period that there is a high attention of owner and sponsor involvement in projects.

Prabhakar [14] expresses that different stakeholders such as customers, employees and managers assess project success in any organization. Project success is best judged by the stakeholders, especially the

[1] Turkcell Teknoloji, Turkcell Teknoloji plaza, Yeni Mahalle, Pamukkale Sokak, Soganlık, 34880, Kartal, Istanbul, TURKEY, filiz.cetin@turkcell.com.tr

[2] Department of Industrial Engineering Marmara University, Goztepe Campus, 34722, İstanbul, TURKEY, cigdem.uslu@marmara.edu.tr

primary sponsor [13]. Prabhakar [14] notes schedule and budget performance are considered inadequate as measures of project success. Agarwal and Rathod [5] state that cost, time and quality are still important criteria for evaluating the performance of software project, however cost is considered to be the least important criterion for figuring a project's success. Procaccinoa & Verner [15] find that completing a project on time and completing it within budget, do not appear to have much relevance for the importance to the project success. According to the Muller & Judgev [7], there are differences in the rating of success criteria by project type. Muller & Judgev [7] explore the statistical behavior and associated relationships between project success factors, PM tools, and PM methods. In their research, Reyes et al. [3] aim toward developing software project success/risk analysis models which can aid project managers in identifying, analyzing and controlling potential risks during software development. Because of the complexity of the project success concept discussed above, there is lack of consensus among authors in the field [16].

In this study, we look for the statistical effects of factors on performance evaluation of the project sponsor. Moreover, we develop a neural network model to be used to estimate project performance. In the first section we give factors which have influence on performance evaluation. Second section is about analysis of the factors statistically. Third section explains the tabu search training algorithm for neural networks. Fourth section is the implementation of the algorithm for the performance evaluation of the projects. Finally we give conclusions in the last section.

Factors in Performance Evaluation of the Projects

In this study, factors which may effect performance evaluation of projects are determined by examining the historical data and relying expert opinions in a software development company in Turkey. Throughout the study, "project" term is used to mean "software development projects". These factors and their short descriptions are listed in Table 1.

Table 1. Description of factors in evaluation of project performance

Factor No.	Factor Name	Factor Description
F1	Type of project	There are many types of project such as infrastructure, service, product, feasibility. Every project must fall into one of these types.
F2	Methodology	Software development methodologies are described in here.
F3	Number of baselines	Baseline is a point of reference.
F4	Severity	Indicates the severity level of the project
F5	Duration of project	Indicates total elapsed time of the project
F6	Difference btw actual and planned baseline dates	Difference between the actual and planned dates
F7	Duration of analysis	Time span for analysis
F8	Duration of development	Time span for development
F9	Duration of test	Time span for test
F10	Total number of launches	Total number of launces
F11	Total number of issues	Total number of bugs and issues seen throughout the project
F12	Total number of risks	Total number of an events that may end up with a negative impact
F13	Total number of Change Request	A change request is a formal proposal for an alteration to some product or system
F14	Project team size	Size of the project team
F15	Occurance of stand by	Number of occurences of stand-bys (on-hold)
F16	Duration of stand by	Elapsed time until the project starts again
F17	Reason of stand by	The reason of the standy by
F18	Complexity of project	The level of complexity of the project (can ben complex, moderately complex or not complex)

The historical data also contains a project sponsor grade for each project. Each project has a sponsor mostly a manager or executive having overall accountability for the project. The sponsor acts like a

champion of the project, selling and marketing the project throughout the company. In this paper, it's assumed that performance of a project is evaluated by the project sponsor and the assessed grade by him/her is treated as a measure of the performance for the project.

Statistical Analysis of the Factors in Performance Evaluation of the Projects

In this section, a statistical analysis is carried out to show the factors which are statistically significant in the evaluation of project performances by the project sponsor. For this purpose, the main factors notated by F1 through F18 are analyzed by the linear regression at significance level of 5%. Result of the study indicates that the type of project (F1) and the duration of project (F5) are statistically significant in the the regression model of explanation of the grades assessed by the sponsor.

Once the main factors which statistically significant on the grades of projects are obtained, a further analysis is implemented to analyze the factors which effect these main factors. Regression analysis shows that the relationships between F1 and F4, F11, and F14 are statistically significant at level of 5%, whereas F2, F3, F6, F7, F8, F9, F11, F12, and F18 are statistically significant in a regression model of F5.

This statistical study points out that five of the factors that are "total number of launches, total number of change request, occurance of stand by, duration of stand by and reason of stand by" neither directly nor indirectly effect the evaluation of project sponsors. Therefore, they are dropped from the further analysis explained in the next sections.

Tabu Search Training Algorithm for Neural Networks

Tabu search training (TST) algorithm is proposed by Dengiz et al. [17] as a new supervised-learning approach to train multi-layer perceptrons (MLPs) for estimation purposes. MLPs are a kind of neural networks which consists of layers. Each layer of an MLP contains different number of neurons and the neurons in successive layers are connected by weights (synapses). Dengiz et al. [18] also show the application of TST algorithm to obtain neural network metamodels for the optimization of two different manufacturing systems.

TST algorithm utilizes a short-term memory to prevent of cycling of moves and a longer-term memory for diversification purpose. The algorithm proceeds iteratively by repeating the neighborhood generation mechanism managed by the short and the long-term memories until a termination criterion is met. The neighborhood generation mechanism, utilization of the short-term and long-term memories, parameter optimization and other aspects of the algorithm can be found in Dengiz et al. [17] in detail. The distinguishing characteristics of TST algorithm are given below briefly. Pseduo-code of the algorithm is also presented in Figure 1.

1. Vector of current weights, $W_{cur} = [w_1, w_2, ..., w_n]$, is initialized randomly from a uniform distribution in the range of [-0.5, 0.5].
2. At each iteration only one weight, w_j, is increased or decreased by v_j drawn from a uniform distribution in the range of $[B_L, B_U]$ to provide a sensitive local search. Change in a weight is called a move and resulting weight vector is a neighbor. Neighborhood of W_{cur} contains nK neighbors obtained by changing each weight n K times.
3. The algorithm iterates by moving from current solution to the best available neighbor with the minimum RMSE (root mean squared error) given in equation 1, if the move which creates this neighbor is allowed through the tabu mechanisms.
4. Short-term memory consists of tabu lists (mechanisms). Both the indices of modified weights and the amounts of change in weights are kept in related tabu lists to avoid from cycling around local optima. Tabu list, *tvs*, records v_j values for each weight, w_i, through the last V iterations. The list

tvs forces the generation of random v_j values to be sufficiently different from the recorded V values. If v_j is near to one of V values then B_L and B_U bounds are increased by Δ at a time. Tabu lists, *tis* and *tds*, keep track of weight indices to prohibite increasing of a weight which decreased during last S iterations and vice verca.

5. Frequency information about the highly repeated moves is recorded in a long-term memory, *freq*, to extend the search to the unexplored regions of the solution space. According to the long-term memory a weight w_j changed F times during L successive iterations is prohibited to give a chance the moves which made infrequently.

$$RMSE = \sqrt{\frac{\sum_{e=1}^{E}\sum_{j=1}^{J}\left(d_{ej} - o_{ej}\right)^2}{EJ}} \qquad (1)$$

Where d_{ej} and o_{ej} are the actual output and estimated output of the jth node in the output layer, respectively. E is the number of exemplars in the training set and J is the number of nodes in the output layer.

Initialize TST parameters
Repeat
For $i = 1$ *to* n
  For $j = 1$ *to* K
    $B_U \leftarrow B_U$
    $B_L \leftarrow B_L$
    Repeat
      Generate $v_{i,j} \leftarrow$ Uniform $[B_L, B_U]$ or $v_{i,j} \leftarrow$ - Uniform $[B_L, B_U]$
      Generate the neighbor $W^{((i-1)K+j)}$ and calculate the RMSE value
      If $\left|v_{i,j} - tvs_i\right| \le \left(\frac{B_U - B_L}{2}\right)$ for any element in tvs_i *then*
        $B_U \leftarrow B_U + \Delta$, $B_L \leftarrow B_L + \Delta$, tabu_status $\leftarrow$ true
        If $(v_{i,j} > 0)$ and $(iter \le tis_i + S)$ *then* tabu_status $\leftarrow$ true;
        If $(v_{i,j} < 0)$ and $(iter \le tds_i + S)$ *then* tabu_status $\leftarrow$ true;
        If $(freq_j > F)$ *then* tabu_status $\leftarrow$ true;
      End If
    Until (tabu_status $\leftarrow$ false) or (RMSE$\{W^{((i-1)K+j)}\}$ < RMSE$\{W^*\}$)
  Next j
Next i
If $W^{((i-1)K+j)}$ is the best neighbor with minimum RMSE *then*
  update W_{cur}, tabu lists tds_i or tds_i and tvs_i
  r $\leftarrow$ r +1 if r < L then update $freq_j$ else r $\leftarrow$ 0 and void $freq_j$
End If
Until a termination condition is met

Figure 1. Pseduo-code of TST algorithm

Implementation of Tabu Search Training Algorithm for Performance Evaluation of the Projects

In this section, TST algorithm is used to develop an NN model to estimate performance evaluations of the projects. Structure of the NN model is MLP in which one input, one hidden and one output layers exist. Totally 13 factors which have been found as important on performance of evaluations of the project sponsors are the inputs of the MLP. Therefore 13 input neurons occur in the input layer to each of the inputs. Output layer consists of only one neuron and output calculated from this neuron is the estimation of performance evaluation with respect to the introduced inputs to the model. Addiditionally, one bias factor also must be included to both input and hidden layers. Structure of the MLP is given in Figure 2. Only one remaining question about the structure is the number of neurons in the hidden layer. To find the number of neurons in hidden layer experimentally, MLP model is trained separately for varying number of hidden neurons. Available data to develop the MLP contains 855 exemplars. Each exemplar is associated with the 13 factors and one grade which represents performance evaluation of the project sponsor. To select the best size of hidden layer, 570 exemplars out of 855 is used for training purpose and the remaining 285 for testing purpose. The algorithm aims to minimize RMSE over the training set. The error, which is used to calculate RMSE, is the difference between the grades by project sponsor from the historical data and the estimation of the grade by the MLP. Results from this fine-tuning study is summarized in Table 2. Table 2 shows that training and testing RMSE values according to varying number of the hidden neurons are close to each other. This results indicates robustness of TST algoritm against the hidden layer size. Nevertheless, the hidden size is set to 12 neurons since the lowest testing RMSE is obtained by using 12 hidden neurons.

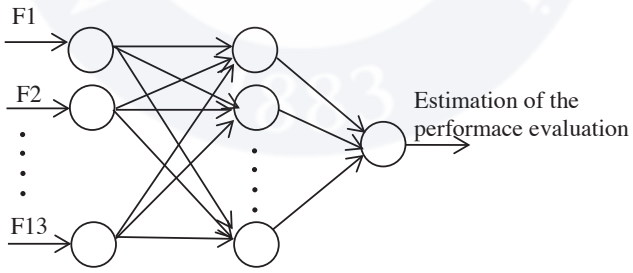


Figure 2. Structure of MLP to estimate the performance evaluation

Table 2. Training and testing RMSE values according to varying number of the hidden neurons

# of hidden neurons	Training RMSE	Testing RMSE	Average of training and testing RMSE
6	0.00351	0.00429	0.00390
7	0.00354	0.00427	0.00390
8	0.00351	0.00425	0.00388
9	0.00353	0.00425	0.00389
10	0.00352	0.00431	0.00392
11	0.00350	0.00429	0.00390
12	0.00352	0.00424	0.00388
13	0.00350	0.00428	0.00389
14	0.00351	0.00426	0.00388

Once the structure of the MLP is constructed, TST algorithm is employed for training purpose using 570 patterns that are randomly picked from the historical data of the software development company and then the MLP is tested on an additional 270 patterns. A four-fold cross validation technique is used to validate the MLP. Cross validation is a standard tool in statistics to validate statistical predictions [19]. Table 3 represents the results of the four-fold cross validation in terms of the training and testing RMSE values achieved by TST algorithm. TST algorithm is run for 5 replications and 5000 iterations per replication. As standard deviation of the RMSE values of the five replications is quite small, the number of replications is found enough. Average RMSE values given in Table 3 shows the validity of the MLP to estimate performance evaluations of the projects.

Table 3. Cross-validation results

Folds	Training RMSE	Testing RMSE
Fold 1	0.00340	0.00445
Fold 2	0.00353	0.00422
Fold 3	0.00335	0.00434
Fold 4	0.00351	0.00411

To represent extrapolation capability of the MLP model, the model is also tested on an additional data (including 350 patterns) which are not used in both training and testing sets. TST algorithm is utilized to train the MLP over 855 patterns. The best MLP structure from the five replications of TST algorithm is then tested on the additional data. Result of this experiments shows that the training RMSE is 0.00356 while the extrapolation RMSE is 0.00445.

Conclusions

In this study, an NN model, MLP, for performance evaluations of the projects in a software company is developed. Although there exist numerous statistical approaches proposed to evaluate performances of projects in the related literature, NNs are used rarely. A tabu search based supervised learning approach by Dengiz et al. [18] is used to train the MLP for estimation of project performances. Data used to train and test the MLP is derived from the historical data of the company. Results obtained from the cross-validation show that proposed MLP model is valid for the company. The MLP trained using the complete data also is tested on an additional data which are not used in both train and test set to show the generalization capability of the proposed approach. The experimental study indicates that proposed MLP model can be utilized to estimate the project performances and therefore can aid the decision maker to self-evaluate his/her decisions on the projects.

References

[1] Pmbok, 2013, A Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fifth Edition.
[2] Repiso, LR, Setchi, R., Salmeron, JL, 2007, Modelling IT projects success: Emerging methodologies reviewed. *Technovation*. 27, 10, 582-594.
[3] Reyes F, Cerpa N, Candia-Vejar A, Bardeen M, 2011, The optimization of success probability for software projects using genetic algorithms, *Journal of System and Software*, 84(5): 775-785.
[4] Standish Group, 2013 Choas manifesto 2013: Think Big, act Small.
[5] Agarwal, N., Rathod, U., 2006. Defining "success" for software projects: an exploratory revelation. *International Journal of Project Management*, 24, 358–370.
[6] Davis, K., 2014, Different stakeholder groups and their perceptions of project success, *International Journal of Project Management*, 32,189-201.
[7] Müller, R., Jugdev,K. ,2012, Critical success factors in projects, *International Journal of Managing Projects in Business*, Vol. 5 Iss 4 pp. 757 – 77.

[8] Atkinson, R., 1999, Project management: cost, time and quality, two best guesses and a phenomenon, its time to accept other success criteria, *International Journal of Project Management*, 17, 337--342.
[9] Pinto, J.K., Slevin, D.P., 1988, Project success: definitions and measurement techniques. *Project Management Journal*, 19 (1), 67–73.
[10] Lester, D.H., 1998, Critical success factors for new product development, *Research Technology Management* 41 (1), 36–43.
[11] Turner, J.R., 2004, Five conditions for project success, *International Journal of Project Management* 22 (5), 349–350.
[12] Turner, J.R., Zolin, R., Remington, K., 2009, "Modelling success on complex projects: multiple perspectives over multiple time frames", in: Gemuenden, H.-G. (Ed.), *The Proceedings of IRNOP9, the 9th Conference of The International Research Network of Organizing by Projects*, Berlin, June. Technical University of Berlin, Berlin.
[13] Turner, J.R., Zolin, R., 2012, Forecasting success on large projects: developing reliable scales to predict multiple perspectives by multiple stakeholders over multiple time frames, *Project Management Journal* 43 (5), 87–99.
[14] Prabhakar, G.P., 2008, What is project success: a literature review, *International Journal of Business and Management*, Vol. 3 No. 9, pp. 3-10.
[15] Procaccinoa J.D., Verner J. M., 2006, Software project managers and project success: An exploratory study, *The Journal of Systems and Software*, 79,1541–1551
[16] Berssaneti F. T. & Carvalho M. M., 2014, Identification of variables that impact project success in Brazilian companies , *International Journal of Project Management*.
[17] Dengiz, B., C. Alabas-Uslu and O. Dengiz, 2009, Optimization of manufacturing systems using a neural network metamodel with a new training approach, *Journal of the Operational Research Society*, 60(9), 1191-1197, 2009.
[18] Dengiz, B., C. Alabas-Uslu. and O. Dengiz, 2009, A tabu search algorithm for the training of neural networks, *Journal of the Operational Research Society*, 60(2), 282-291, 2009.
[19] Stone, M., 1974, Cross-validatory choice and assessment of statistical predictions, *Journal of the Royal Statistical Society Ser. B*, 36, 111–147.

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

A Model to Develop a New Smartphone by Using Concurrent Engineering and Quality Function Deployment Methods

Barış Egemen Özkan [1], *Gökhan Kalem* [2]

Abstract

The aim of the study is to propose a model that will set a baseline for a further comprehensive research to find the effects of "Concurrent Engineering (CE) coupled with Quality Function Deployment (QFD) techniques for the development of a new smartphone" on the product life cycle and the level of customer satisfaction. The design of a new smartphone has been selected as the research case. Companies need to develop new products as fast as possible in order to be successful. Thus, it is required to grab competitive advantage by means of continuous review of new product development techniques since mobile communication technologies are so dynamic in many aspects. CE is considered to be one of the methods used to shorten product design and deployment time. Besides concurrent engineering, deploying the correct product with better quality regarding the customer needs is also targeted. This study is the initial part of an ultimate overarching project that focuses on making the smartphone development process faster and efficient using CE. QFD method is utilized to transfer and to fulfill customer requirements into the product development phases. We propose a model to develop a new smartphone using both QFD and CE techniques.

Keywords: CE, Smartphone, QFD

Introduction

New product development has never been as complex as now. Head spinning technological advances is leading to various and constantly changing dynamic customer demands at lower cost with increased performance [30]. Quick change of technology and obsolescence, which comes with the increased usage of COTS sources, shortens the lifespan of the most products and therefore capturing the market share before others enables an organization to hold onto market. Morgan showed that delivering a product to market before rivals bring great market share along with a lot of competitive advantages [28]. At that point Concurrent Engineering (CE) is shown as one of the solutions to shorten new product development and to deploy to market the product [24]. Deploying the correct product that will meet the consumer needs is another important issue to be taken care of. The dynamic and quickly changing nature of consumer needs are to be taken into account in order to hold more market share than competitors [26]. At this point Quality Function Deployment is one of the tools to be used.

CE and QFD are both tools and methods that will shorten the design cycle of the correct product required by the consumers. Therefore these two methods are complementing each other. In this research we focused on blending those two methods and investigated the outcome. We used smartphone technology as our use case. While there are two dominant smartphone models that are taking the world's most market share we still believe that there is enough room to improve considering the open ended technological advances in consumer electronics and user needs.

[1] Baris Egemen OZKAN, Marmara University, Institute of Pure and Applied Sciences, Industrial Engineering PhD Program, Istanbul, Turkey, barisegemenozkan@marun.edu.tr
[2] Gokhan KALEM, Marmara University, Institute of Pure and Applied Sciences, Engineering Management PhD Program, Istanbul, Turkey, gokhankalem@marun.edu.tr

Scope, Aim and Assumptions of the Research

Scope

The scope of this research is to set a case study to develop a new affordable smartphone for especially young and middle age generation in Turkey with medium level income. We have used Concurrent Engineering and QFD techniques within the research explaining their advantages and strong sides.

Aim

The aim of the study is to propose a model that will set a baseline for a further comprehensive research to find the effects of "CE coupled with QFD techniques for the development of a new smartphone" on the product life cycle and the level of customer satisfaction.

Assumptions

There are some assumptions in the study. Firstly, QFD results are based on the internal customers of the firm (employees of the operator) because the new smartphone development process must be executed secretly and so it seems impossible to do that with real customers. In the study, we assumed that the target market is young and middle-aged customers (16-55 years old) with medium level income.

Concurrent Engineering and Quality Function Deployment

Concurrent Engineering

CE is defined as simultaneous design and implementation of all processes used in product development, marketing and deployment. It includes all or a subset of the processes from concept development to after-sell services and eventually out of service processes, as US Department of Defense mentions it as "cradle-to-grave consideration" [28]. We can consider CE as an alternative to traditional waterfall method. At waterfall method all major processes follow each other and each process use the output of the previous process as input. Simultaneous integration in cross-functional departments that are responsible for different aspects of product development is key factor for successfully implementing CE. In CE, cross-function teams do not wait for each other but instead work together and contribute to each other's work from the beginning till end.

According to Smith, the CE is inevitable outcome of primarily several factors: specialized engineering trainings, development in the communication technology and ease of access to information and last but not least increased competitive environment to reduce the product lead time as well as to increase quality [28]. As the heat of the competition increases the emphasis is focused from lower costs to shorter production times.

There are different levels of implementing CE, from low level of complexity to high level. While low level of complexity involves less different functional groups, the latter requires more different functional groups to involve in design process. Higher concurrency brings faster lead times for new product design however such approach also introduces higher complexity, and more management risks along [28].

In order to successfully implement CE, there are two fundamental actions to be done. First, cross-functional integration must be fully ensured. Collaboration of people from different functional groups and quick resolution of conflicts, if arises, is the core of essential integration. Such

achievement is not an easy one in an organization where teamwork culture is not mature yet. All functional groups must be lead and directed towards a common goal and integration must be fully controlled by the manager in order to achieve a full integration between different functional groups in CE. Secondly, managers have to find ways to improve design practices in the organization. New technological advances in communication, design, business processes are often adapted to CE design processes. That would also bring the necessity to train people to use such practices effectively. For example, Computer-Aided-Design (CAD) is one of the most often used recent methods. Physical layout and work conditions are also another important factors in implementing CE. Managers have to adjust the level of CE implementation taking the level of design expertise of people in the organization as well as the complexity and the type of the product and customer type [28].

With CE, lead-time to deploy a new product to market is remarkably reduced as the quality of the product is increased [16]. Market research and other methods to understand the real customer needs are introduced into product development in the early design phase and hence the quality of the product is increased in terms of meeting the customer needs [11]. The number of defects in both product and processes are decreased at design by taking manufacturing capabilities into account [28].

While CE is promising shorter lead-time to market new products with higher quality, it does not come for free. It is expensive to implement CE. It requires more resources at the beginning of the product development. There is also a potential risk of frequent rework of the product design since earlier concurrent work with less complete information [25]. In some cases, especially in R&D projects, inclusion of the contribution of latter stage processes into product design in earlier phases may slow down the product design. Loch pointed out 4 managerial challenges in CE implementation as task definition, scheduling and timing, coordination and integration of tasks with proper exchange of information and finally support process establishment inside the organization [18].

QFD

Quality Function Deployment (QFD) is a “method to transform qualitative user demands into quantitative parameters, to deploy the functions forming quality, and to deploy methods for achieving the design quality into subsystems and component parts, and ultimately to specific elements of the manufacturing process.”[1] QFD is used to transform the customer needs into system requirements. Customer needs are captured by using methods such as Voice of customers in terms of expectations, preferences and aversions of customers from the product.

After the Second World War, the concept and methods of QFD was developed as a follow-on outcome of the transformation of the Statistical Quality Control (SQC) into Total Quality Control (TQC)[1]. In 1960s, when the quality assurance was a well known subject used but implemented after the product was actually manufactured, Akao raised the question to set certain quality checks at design phase even before the production starts. The concept of Quality Deployment (hinshitsu tenkai) was first published in 1972 [2] in the form of quality tables, which was inspired from the idea of Oshiumi (Oshiumi Kiyotaka, 1966). With his own words, Akao described the Quality Deployment as a methodology of “converting user demands into substitute quality characteristics, determining the design quality of the finished good, and systematically deploying this quality into component quality, individual part quality and process elements and their relationships’[1]. However it was only 1980s when the concept of QFD was introduced in Europe and USA.

With QFD, the quality assurance focus has shifted from process-oriented approach to design-oriented approach. The quality aim is moved from after production defect exploitation to before production, design and planning phases. QFD also provided a common language in terms of practices and outcomes to be used by all stakeholders, especially designer engineers [1].

QFD is implemented with a set of phases starting from understanding customer needs to system requirements, designing, planning production processes and setting performance measures for production and maintenance. House of Quality is one of the tools used to translate user needs into system requirements [14].

House of Quality (HOQ) is a tool to convert customer needs into technical system requirements as well as to compare different design and product candidates, so the design engineers focus on the most important aspects of the new product. HOQ, embody 6 different sections.

First part represents the structured customer needs, which are the outcome of the Voice of Customer process. Raw customer needs are structured in similar sets of requirements based on affinity of the needs and most likely those needs are to be labeled with a new requirement segment name. Second part of HOQ is the planning matrix. This part quantifies the customer needs and priorities those needs based on the customer's performance perception of the existing products in terms of meetings needs. This part also allows adjustment of different figures of quantification process. Third part of HOQ is technical requirements matrix. This is the top floor of the HOQ. This part represents the engineering characteristics of the customer needs in terms of the production companies' understanding. In another words it is the translation of customer needs into measurable technical system requirements. Fourth part of the HOQ is the relationship matrix. This part is the main body of HOQ and it is 2 dimensional matrixes. On one side the user needs (WHAT) reside while other dimension is the technical requirements (HOW). Each cell in the matrix represents the relationship level value of each user need to each technical requirement.

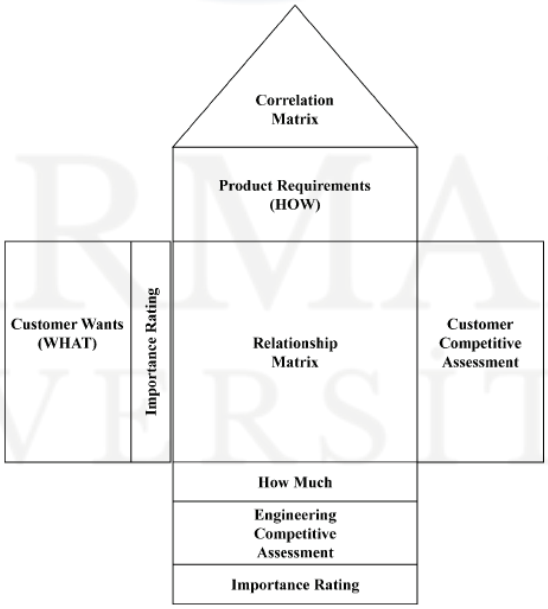


Figure 1. House of Quality

The roof of the HOQ is the fifth section and it represents the information regarding the relationship between each technical requirements creating correlation matrix. How one requirement does affects the other one is the point, which the roof matrix is addressing. The affect may be improving or deteriorating, in other words positive or negative direction.

The last section of the HOQ is the bottom floor, target matrix. This part includes technical priorities, benchmarks and targets. This part is the augmentation of all the matrices in the HOQ. The technical priorities are calculated from the requirements, benchmarks values are calculated from the competitive products and finally target metric values are calculated for each requirement by using all metrics found so far.

Smartphone Market Overview

Market Review

With the advent of 3G (Third Generation Mobile Communication Technology) at the beginning of 2000s, people started enjoying the mobility and being connected everywhere. It has enabled people to obtain information on mobile environment and to handle many processes much easier via mobile internet. Today mobile phones are used to satisfy a lot of needs of people. Security, social interaction, information search, management of daily life, video communication, e-learning, e-commerce, location based services and even many health services makes only a small set of the mobile communication facilities [8]. Especially with the launch of iPhone in 2007, smartphones started to present much more mobile experience thanks to their rich visual interfaces and contentful applications. Thus, it has completely changed traditional mobile phone concept and performed various functions by means of development in the third party applications [32].

QFD and CE Applications in Smartphone Market

QFD is considered to be a form of concurrent engineering tool that has been successfully applied in the manufacturing sector in the United States and Japan [15]. The implementation of QFD along with concurrent engineering has been highlighted by many researches. Ho and Lin have focused on developing methods on using CE and QFD for Original Development Manufacturing (ODM) [9]. Tsuda showed another application of CE with QFD techniques while focusing on the integration of features [29]. Qian showed and extensive review of CE models with dependent and interdependent stages of processes [25]. Fine et.al. showed a goal approaching approach to optimize multiple goals while implementing CE, in which case goals are to optimize designs of product, process and supply chain [5]. Piedras et.al. showed another product development model using CE and QFD together and proposed a model with an holistic quantitative approach for product-process optimization [22]. Sun showed that the methods being used to assure quality used with concurrent engineering speeds up the product design process as well [27]. Kusar et.al. showed that different level team structures are necessary based on the scale of the project. While big projects to require 3 level team structures, 2 level team structures is enough for medium and small size product development projects [17]. Prasad proposed a different model, in which CE and QFD is implemented, named as concurrent function deployment (CFD). He proposed to implement 6 value set, namely “functionality (quality), performance (X-ability), tools and technology (innovation), cost, responsiveness, and infrastructure (delivery)”, to implement in parallel rather than serial [23]. At the same time Brad showed similar approach to implement CE and QFD at the same time, and named this approach as Concurrent Multifunction Deployment (CMFD) [4]. Ho et.al. proposed another model using CE and QFD model together for Original Design Manufacturing (ODM) business [9]. Pal et.al. proposed another application of QFD with Analytic Network Process (ANP) specifically for rapid prototyping [20]. Pheng et.al. proposed a model of QFD and CE in design and build project which is rarely studied in the literature [21].

In smartphones market, it is significant to apply quality techniques in a fast and correct way in order to meet the necessities of product/service market since the demands are dynamic and unsteady. This will also assure the firms to consume their resources in the right way. Although CE and QFD practices have been applied to the products and services of smartphones, any specific study regarding the design of the phones have not been found during the literature survey. This shows the lack of combination of the CE and QFD applications in this industry. More information regarding application of these techniques in mobile communication industry is going to be given in detail in this section.

The QFD application in the mobile phone technology dates back to 2000s, when Nokia and Ericsson was the two leading mobile device manufacturer [33]. The results of those academic and industrial researches not only enabled these two companies to understand the customer needs and eventually to develop as best as they can to hold onto market but also to develop effective development processes [31].

Since 2000, along with Nokia and Ericsson, there have been numerous mobile device manufacturers in the market. However within last decade two manufacturers leads the market, namely Apple and Samsung. Currently there are more than 1 billion smartphone users in the world. On average, those two companies share the %40 of the market. LG, Lenovo, Huawei and Xiaomi are following them on average 15% market share in aggregate. Each one of those companies is in a fierce competition to capture as much market share as possible. More than one billion consumer increases the appetite. Hence, such competition forces each company to touch the consumer and serve the best product [4][6][7][12][19].

Proposed Model

In the recent years, smartphones have been promoted seriously depending on quick development of mobile communication and mobile internet. The smartphone popularity in the world has also affected Turkish market. High ratio of young population in Turkey is the most important factor that gives the market remarkable acceleration with respect to global market. For instance, the leader mobile network operator of Turkey had only 2 million smartphones used by its subscribers at the end of 2010. This number reached 9.6 million with the increase of 380% by the end of 2013. Therefore, the firm's smartphone penetration ratio ascended to 30% [1]. This ratio is so similar in whole market of Turkey as well.

Three mobile network operator companies in Turkey have launched individual initiatives to design and produce smartphones for the potential customers. Each has unique business models to design and produce the smartphones. Within the scope of this research we focused on only one of the operator's way of production. Following chapter defines the current model to develop operator branded smartphone.

Current Model to Develop a New Smartphone

In 2010 the firm started to launch its own smartphones to the market as the leading operator in the market while it had been going on selling world renowned smartphones such as iPhone and Samsung Galaxy series in Turkey. T-series (such as T30, T40 and T50) are the smartphone models launched with the operator's own brand between 2011 and 2014. The firm targeted on mid and low level income customers who are between the ages of 16-55 and having a smartphone first time.

Requirement Analysis

Customer requirements and demands are playing main role in this point. In the current situation, market trends and market research applied by third parties are making the operator oriented in the smartphone requirements. These requirements shape the product features. In addition, some leading smartphone manufacturers in the global market mentioned above are important role models for the operator to develop a smartphone with respect to their requirement. Therefore, sometimes it can cause some failure cases in the market because the firm needs to have its own methodology to be performed amongst target segment in order to obtain accurate voice of customer.

Design

The operator determines the smartphone designs in terms of software and hardware before the mass production. Software selection is limited by the ODM's choice because the operator is not involved in the whole process of software development after the request is sent. Thus, ODM's suggestions are leading this process. The hardware design is more important at first sight according to the customer and smartphone's design should meet customer expectations as well. The operator utilizes the dominant smartphone design, which is already launched by global smartphone manufacturers so as to attract the most of customers in the target segment.

Production

The firm uses two equipment manufacturers in production of these smartphones. One of these companies is the ODM vendor which is producing devices for the operator. The other company is the manufacturer of chipset, the most important component of smartphone.

The firm has used Original Design Manufacturing (ODM) outsourcing business model in production and development process of its own smartphones, operator branded. Although the firm has an ODM department to handle this business model, it uses outsource ODM vendor from new product development to the distribution of products. The advantage of the ODM outsourcing business model is that the firm can save organic resources by way of commissioning product design and manufacturing to selected ODM vendor. In many industries, ODM customer does not get involved in its ODM vendor's product development activities and simply relies on the design and manufacturing capabilities of the ODM vendor to acquire the product. However, it is slightly different in the telecommunication sector due to strict competition and necessity of perfect product to meet customers' requirements.

The firm is more involved in its ODM vendor's product development activities to obtain a higher-quality product on time at a competitive price. This requires close cooperation between the operator and its ODM vendor. This study focuses on this scenario to make the process faster and efficient using Concurrent Engineering. The firm's new T-series smartphone (TX) project is selected in the case study.

In-House Tests

Prototype devices are subjected to some tests by technical units of the firm and analyzed in detail before their launch.

Keeping the device details secret has high importance in the mobile communication sector because of fierce competition. Therefore, prototype devices are tested formally by the firm's technical and non-technical employees internally as well as they use these smartphones in their daily lives. Consequently, defects and development areas are informed to the ODM vendor and

the firm keeps providing feedbacks until the mass production phase. Technical teams (engineers) perform functionality and network performance tests for the devices. On the other hand, non-technical employees (sales and marketing teams) use these phones with the end user perspective.

Methodology to Develop Model

In order to get high-quality products from ODM vendors, it is necessary for the operator to implement an effective and efficient product development process which allows them to work with their ODM vendors concurrently in designing and manufacturing their smartphones with operator brand [9]. By integrating QFD and CE into the proposed methodology, we believe that the operator will be able to carry out its product development with ODM vendor more effectively and launch good-quality smartphones into the market on time.

Product designs are the most efficient when the R&D team, engineering team, purchasing team, process engineering team, product management team, logistics team and after-sales service team are all involved. Thus, team working and the relationships between departments in the firm are taken into consideration with an important approach [13].

Before the product development phase, customer requirements are the most important input. These requirements are converted into system's engineering characteristics. In the parts of deployment phase, engineering requirements are translated into part characteristics [9]. In the firm a detailed survey and study had been executed to understand customer requirements regarding smartphones. It enabled the firm to hear *Voice Of Customer* (VoC) much more closely in the way of a new smartphone development and launch in the market.

Customer questionnaire was arranged in order to collect the VoC. Target customers being included in the project were the employees from sales, marketing, vendor management, device test and network quality assurance departments. As explained above, these persons had the experience of using T21 and T30 respectively.

Initially, focus group meetings were performed with the attendance of network quality assurance and device testing teams and then important features of a smartphone were discussed among these groups. Customer satisfaction criteria were derived from the meetings including Ease of use, Switch speed between interfaces, Visuality (interface), Internet connection rate etc.

In the foreground of these satisfaction criteria for smartphones, non-technical teams from sales, marketing and vendor management department attended in the customer questionnaire. The biggest factor affecting this choice of this questionnaire group was that these persons were more interacting with the real customers of the firm. In the A section of questionnaire, the level of importance was calculated from average of replies to the customer requirements. In the B section of questionnaire customers were asked to evaluate the satisfaction levels of T21 and T30 smartphones for their expectations. Eventually, arithmetic average was calculated from all replies.

The brainstorming meetings executed amongst device testing and network quality assurance departments enabled the determination of technical requirements that will satisfy the customer demands. Basic technical features were determined as an outcome of those meetings some of which includes Network technology supported by device, operating system, hardware design, software design, processor power etc.

Another questionnaire was utilized in order to measure the correlation level between customer and technical requirements as well. This study made clear in which level each technical specification meets customer requirements. How technical features affect each other was handled

in correlation matrix under the roof of HOQ. A number of weak or strong positive correlations were found between many technical specifications of smartphones.

At the final step Kano questionnaire was arranged among the group who initially attended to the QFD questionnaire at the beginning of the study. Then, customer requirements for smartphone were categorized properly based on the replies to the Kano questionnaire. This process was performed by allocating them to the three sets of requirements: basic, linear and attractive requirements.

After execution of Kano Model with the QFD Quality Management Technique, new smartphones should be designed according to the results. The smartphones are suggested to have the below mentioned properties as a result of this QFD study:

- The usage of the newest version of Google Android operating system
- The design of a user friendly interface
- The addition of shortcuts to the main screen (like Google search)
- Higher capacity battery, preserving the hardware design
- Higher touch-screen sensitivity via IPS technology
- The use of a larger screen in hardware design (minimum 4 inch)

CE Model for the Mobile Network Operator

As mentioned before ODM outsourcing is an appropriate and cost effective method for the operator to develop its own smartphone because of limited resources and capabilities in this area. Know-how is the main lack of the firm because its primary business is not smartphone development and production. In addition, it has no specific product development process for ODM outsourced product development. So, the current process is only based on ODM vendor's development process.

A dedicated project team assigned from the operator is needed to concurrently participate in its ODM vendor's product development process. Component suppliers also need to get involved in development concurrently to assist the firm and vendor in solving quality issues, so that the product development schedule can be kept on time. In the smartphone development the main component suppliers are the chipset (processor) manufacturers such as Qualcomm, Intel, Mediatek and Nvidia companies.

The involvement of CE team members is essential at every stage of the proposed methodology. CE team members include a product manager, network quality engineer, device feature engineer, device test engineer, procurement engineer, ODM vendor team and ODM component supplier team. With these factors in mind, an outsourced product development methodology based on QFD and CE is proposed in this study. It is shown in Figure 2.

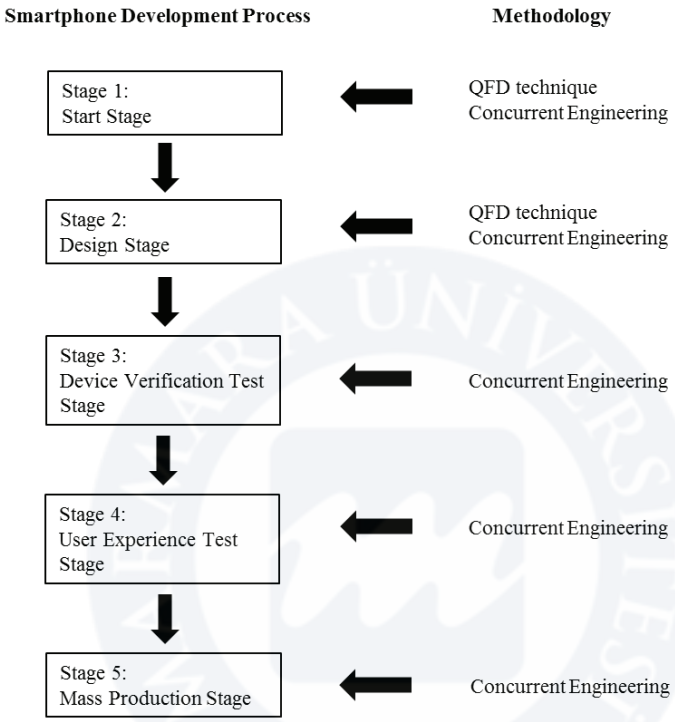


Figure 2. QFD and CE based smartphone development methodology for the operator

Stage 1: Start Stage

The purpose of start stage is to complete product marketing requirement specifications and arrange a kick-off meeting to announce new smartphone development to the ODM vendor and component supplier.

At the start stage, CE team needs to acquire marketing requirement specifications from customers in order to hear voice of customers. QFD study is utilized here to collect the voice of customer by means of customer questionnaire. It is also very important to inform CE team members in detail. Then technical requirement specifications determined in QFD study is the most significant item that will be announced to the ODM vendor and chipset supplier. Technical features required for the smartphone development are listed in the previous section. These are also called engineering specifications.

It is necessary for the operator's CE team to discuss the request with ODM vendor and component supplier so that they can wholly understand the requirements of the firm. The flow can be seen in Figure 3.

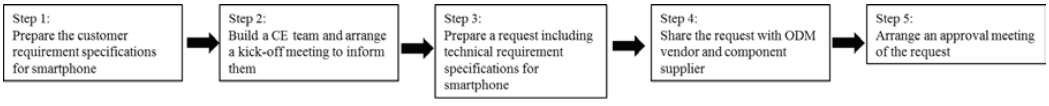


Figure 3. The process of the start stage

Stage 2: Design Stage

The purpose of the design stage is for the operator to integrate into the ODM vendor's smartphone design process. The identified vendor can start the development. In order to produce a higher-quality product, the operator, ODM vendor and chipset supplier need to hold a smartphone design-planning meeting to discuss design related issues concurrently. CE implementation among these groups enables them to create a strong product design plan. The flow can be seen in Figure 3. QFD is really useful tool for translating engineering specifications into necessary parts. The new smartphone should be designed according to the results of QFD Quality Management Technique executed by the firm.

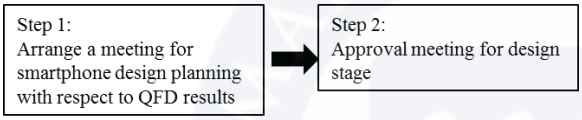


Figure 4. The process of the design stage

Stage 3: Device Verification Test Stage

The purpose of the device verification test stage is to have the operator's CE team test the prototype sample provided by the ODM vendor. After the design stage, ODM vendor sends a working sample to the operator, so that concerned team can verify whether the smartphone's network operational functions are in line with the technical requirement specifications defined in the start stage. To ensure the correct software and hardware design, CE team needs to execute network conformance and performance tests (NCPT) to check the prototype smartphone working with ODM vendor. The operator, ODM vendor and chipset supplier need to solve problems concurrently and keep the smartphone development schedule on time if there are any quality issues during the NCPT stage. NCPT process is managed by network quality engineer and device feature engineer amongst CE team members. The process can be seen in Figure 5.

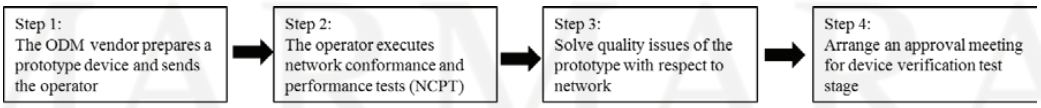


Figure 5. The process of the device verification test stage

Stage 4: User Experience Test Stage

The purpose of the user experience test (UXT) stage is to have the operator's CE team conduct the UXT on working smartphone samples provided by the ODM vendor. At this stage, ODM vendor prepares UXT samples and send them to the operator for testing with respect to the smartphone's user experience. These tests including some basic smartphone capabilities such as calling, SMS, MMS, internet, social media applications, camera, WiFi, Bluetooth etc. are performed by device test engineer. If there are any quality issues with the UXT samples, the operator needs to invite the ODM vendor and chipset supplier to concurrently handle these issues. The flow can be seen in Figure 6. The interaction and cooperation between the operator and ODM vendor is crucial to deal with quality issues of new smartphone before the production.

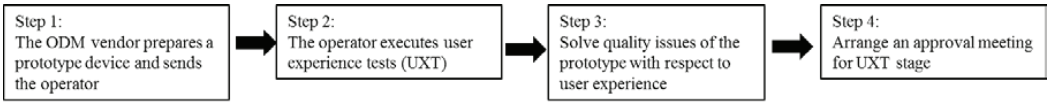


Figure 6. The process of the user experience test stage

Stage 5: Mass Production Stage

After fulfillment of the UXT stage, the ODM vendor can begin mass production. The operator needs to be present for the mass production to check smartphone product quality and ensure the delivery on time.

As explained above, the proposed methodology is composed of five stages. It offers a step-by-step procedure in order to assist the operator successfully execute ODM outsourced smartphone development with its ODM vendor.

Conclusions

Conclusions

First of all, smartphones have been analyzed from the customers' point of view using QFD method and the most important marketing requirement specifications and technical specifications have been determined. Later on the CE Model has been included in order to enable the operator to work concurrently with its ODM vendor and the chipset supplier. Finally, the concurrent engineering model for the mobile network operator has been built.

With the operator, ODM vendor and chipset supplier working closely on implementing the proposed methodology, it can be expected that the development and marketing of new smartphone on time in the market. The correct time to market is truly very important for the operator due to competitive environment in the smartphone sector.

Thanks to the emphasis on the CE cooperation amongst the operator, ODM vendor and chipset supplier, the competitive cost of smartphone with high quality can be successfully obtained. Especially to win the confidence of existing customers and attract new customers, the operator must ensure the high quality of its own branded smartphones.

As mentioned in the study, QFD and CE seem so complementary methodologies for each other in order to perform concurrent engineering application on a smartphone development because both methods provide fulfillment of customer wishes and requirements as well as reduction of new smartphone development time in all development phases.

Future Work to Do

This study consists of a proposal of the new smartphone development on the leading mobile network operator in Turkey based on CE and QFD methodologies. There are of course some assumptions in the study such that there are no selection process of ODM vendor and chipset supplier for the smartphone development and QFD results also come from the internal questionnaire applied in the employees of the operator because the new smartphone development process must be carried out with the high confidentiality inside the firm.

In the next study, this proposal can be realized within the firm and more concrete results can be observed and interpreted in terms of the success of concurrent engineering methodology on a smartphone development by the operator.

Another extension of this research would be to further implement QFD by using fuzzy logic theorem.

References

[1] Akao, Y. (1997). QFD: Past, Present, and Future. International Symposium on QFD'97. Linkoping.
[2] Akao, Y. (1972). "New Product Development and Quality Assurance – Quality Deployment System" *Standardization and Quality Control*, 25(4), 7-14.
[3] A.S., T. I. (2014). *Annual 2013 Report*. Retrieved December 03, 2014, from Turkcell: http://yatirimci.turkcell.com.tr/2013/Turkcell_TR_2013.pdf
[4] Brad, S. (2009). Concurrent multifunction deployment (CMFD). *International Journal of Production Research , 47* (19), 5343–5376.
[5] Fine, C., Golany, B., & Naseraldin, H. (2005). Modeling Tradeoffs in Three-Dimensional Concurrent Engineering: a Goal Programming Approach. *Journal of Operations Management , 23*, 389-403.
[6] Fung, R. Y., Chen, Y., & Tang, J. (2007). A quality-engineering-based approach for conceptual product design . *Journal of Advanced Manufacturing Technology* , 1064-1073.
[7] Ghiya, K. K., Bahill, A. T., & Chapman, W. L. (1999). QFD : Validating Robustness. *Quality Engineering , 11* (4), 593-611.
[8] Havrila, M. (2013). Cell phone Usage and Broad Feature Preferences: A study Among Finnish Undergraduate Students. *Telematics and Informatics , 30*, 177-188.
[9] Ho, Y., & Lin, C. (2009). A QFD, concurrent engineering and target costing based methodology for ODM companies to formulate RFQs. *Journal of Manufacturing Technology Management, 20* (8), 1119-1146.
[10] Hoa, Y.-C., & Lin, C.-H. (2012). A QFD- and concurrent engineering-based outsourced product development methodology for ODM customers . *Total Quality Management , 23* (10), 1153–1169.
[11] Hsiao, S.-W. (2002). Concurrent design method for developing a new product. *International Journal of Industrial Engineering* (29), 41-55.
[12] ipgo. (2014). Retrieved November 20, 2014, from Ingeniería de producción y gestión de operaciones: http://ipgo.webs.upv.es/good_choice/project/pt4.pdf
[13] Kalem, G. (2013). *Quality Function Deployment and Its Application On a Smartphone Design*. Graduate School Of Science, Engineering, Istanbul Technical University. Istanbul: Istanbul Technical University.
[14] Kamara, J. M., Anumba, C. J., & Evbuomwan, N. F. (1999). Client Requirements Processing In Construction: A New Approach Using QFD. *Journal of Architectural Engineering , 5* (1), 8-15.
[15] Kogure, M., & Akao, Y. (1983). Quality Function Deployment and CWQC in Japan. *Quality Progress*, (pp. 25-29).
[16] Koufteros, X., Vonderembse, M., & Doll, W. (2001). Concurrent engineering and its consequences. *Journal of Operations Management* , 97-115.
[17] Kusar, J., Duhovnik, J., Grum, J., & Starbek, M. (2004). How to reduce new product development time. *Robotics and Computer-Integrated Manufacturing* (20), 1-15.
[18] Loch, C. *Product Development and Concurrent Engineering*. University of California.
[19] Mazur, G. (2013, August 22). *An Apple a day, keeps competitors away!* Retrieved November 20, 2014, from QFD Institute: http://www.qfdi.org/newsletters/apple_a_day_keeps_competitors_away.html
[20] Pal, D. K., Ravi, B., & Bhargava, L. S. (2007). Rapid tooling route selection for metal casting using QFD–ANP methodology . *International Journal of Computer Integrated Manufacturing , 20* (4), 338 – 354.

[21] Pheng, L. S., & Yeap, L. (2001, June). Quality Function Deployment In Design/Build Projects . *Journal of Architectural Engineering* , 30-39.
[22] Piedras, H., Yacout, S., & savard, G. (2006). Concurrent optimization of customer requirements and the design of a new product. *International Journal of Production Research , 44* (20), 4401–4416.
[23] Prasad, B. (2000). A concurrent function deployment technique for a workgroup-based engineering design process . *Journal of Engineering Design* , 102-119.
[24] Pullan, T. T., Bhasib, M., & Madhuc, G. (2010). Application of concurrent engineering in manufacturing industry. *International Journal of Computer Integrated Manufacturing , 23* (5), 425–440.
[25] Qian, Y.-j., Goh, T. N., & Lin, J. (2014). Recent Advances in Concurrent Engineering Modeling. *5th International Asia Conference on Industrial Engineering and Management Innovation*, 6-9, Atlantis Press.
[26] Simpson, T. W., Jiao, J., Siddique, Z., & Holtta, K. (2014). *Advances in Product Family and Product Platform Design*. Springer.
[27] Sun, H., & Zhao, Y. (2010). The empirical relationship between quality management and the speed of new product development . *Total Quality Management , 21* (4), 351–361.
[28] Swink, M. (2001). Concurrent Engineering. In P. M. Swamidass, *Inoovations in Competitive Manufacturing*, 245-261.
[29] Tsuda, Y. (2007). Models After Concurrent Engineering Product Development Processes . *Quality Engineering , 9* (4), 641-651.
[30] Ucler, C. (2009). *Concurrent Engineering Methodology for SMEs and an Application*. Institute For Graduate Studies In Pure And Applied Sciences . Istanbul: Marmara University.
[31] West, B. M., & J., O. (2002). The house of flexibility: using the QFD approach to deploy manufacturing flexibility. *International Journal of Operations & Production Management , 22*, 50-79.
[32] Zhang, L., Liu, Y., & Guo, W. (2010). Research on Diversified Designing Methods and User Evaluation of Smartphone Interface,. *International Symposium on Computational Intelligence and Design*.
[33] Zheng, X., & Pulli, P. (2007). Improving mobile services design: a QFD approach. *Computing and Informatics , 26*, 369–381.

MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Program Allocation Process Improvement by an Assignment Model

Okay Işık [1], Muhammet Bilge [2], Yıldırım Kılıçarslan [3]

Abstract

As the only source of jet pilot candidates for Turkish Air Force, Air Force Academy (TuAFA) applies several screening processes in order to acquire an average group of 150 cadets from civilian high school graduates each year. Besides the nationwide examinations (YGS-LYS), there are several others such as medical, flight, athletics evaluations and etc. Because the number of criteria for screening is large, the spread of the distribution of YGS-LYS scores of the candidates, which is assumed to be the aptitude towards college education, is a lot wider than those of other universities. Although admission to faculty for civilian high school students is regulated by the YGS-LYS score; in order to provide a balance distribution among different programs in terms of YGS-LYS score, placement to aerospace, electronics, computer and Industrial engineering programs of the Faculty is governed by a special directive. Although the directive considers candidates' preferences, the ultimate goal of the algorithm in the directive is to keep the balance of academic success among different programs in the allocation process. In this study, we propose an alternative assignment model which tries to minimize the deviations from students' preferences while maintaining the balance of the distribution among programs. We showed that, the performance of the proposed model is significantly better regardless of the distribution of the preferences.

Keywords: Balanced Assignment Problem, Process Improvement, Stable Marriage Problem

Introduction

Graduation from a reputable university is assumed to be the key to succeed in life. On the other hand, in most of the developing countries, competition is fierce because the number of seats is disproportionally scarce against the population of students. In Turkey, match between the students and the programs is basically determined via the national exams, LGS (Transition to Higher Education Examination) and LYS (Undergraduate Placement Examination). In 2013, 38.2% of the students who passed the pre-elimination exam LGS and had the right to choose a program, did not attempt to do so, because they were sure that their combined score (40%LGS+60%LYS) would not allow them to get a seat in their order of preference. Hence they kept their position instead of making a choice in vain.

To our knowledge, there has been little quantitative research on LYS type placement exams in terms of the match between student preference and the overall value to society. It is assumed that a student who is placed to the first program in his/her order of preference will be more successful or willing to do so during his/her entire career. As an example in Turkey, after the announcement of combined YGS-LYS scores, students are allowed to choose 30 alternative programs to form their order of preference. They usually sort the programs on the basis of previous years' ground scores. The allocation is simple; the one who has higher score is more likely to place to his/her first slot in the preference list. However due to the time limit and waste number of programs, student choices and the resulting placement are subject to discussion. Most of the students choose programs thinking of their self-economic interest or career, some for academic interest and some just follow the crowd. There is no concern about the demand in the economy or the overall welfare of the society. As a result, intellectual capital distribution is not balanced, leaving some economic segments underdeveloped and some skyrocketed.

College admission problem can be modeled as an assignment problem, where students and universities have preferences over each other. In the literature [1-4], assignment problem where two sets of elements given a set of preferences for each element, known as the *stable marriage problem (SMP)*. A matching is a mapping from the elements of one set to the elements of the other set. A matching is stable whenever it is not the case that both:

- Some given element A of the first matched set prefers some given element B of the second matched set over the element to which A is already matched, and

[1] Okay Işık, Turkish Air Force Headquarters, Cost Analysis and Statistics Division, Ankara, Turkey
[2] Muhammet Bilge, 2nd Jet Main Jet Base, Pilot Candidate, Izmir, Turkey
[3] Yıldırım Kılıçarslan, 2nd Jet Main Jet Base, Pilot Candidate, Izmir, Turkey

- B also prefers A over the element to which B is already matched.

In other words, a matching is stable when there does not exist any alternative pairing (A, B) in which both A and B are individually better off than they would be with the element to which they are currently matched. Hospital/residence problem is a special case of SMP, – also known as the college admissions problem – differs from the stable marriage problem in that the "women" can accept "proposals" from more than one "man" (e.g., a hospital can take multiple residents, or a college can take an incoming class of more than one student). Algorithms to solve the college admissions problem can be college-oriented (female-optimal) or student-oriented (male-optimal).

In [1], it has been proved that, for any equal number of men and women, it is always possible to solve the SMP and make all marriages stable. However, stability does not necessarily mean optimality. In [4], it has been shown that finding a maximum stable matching for the problem of allocating students to projects, where both students and lecturers have preferences over projects, and both projects and lecturers have capacities is NP-hard. Therefore, many of the literature focus on approximation algorithms [5].

Program placement problem discussed here is similar to college admissions problem where programs establish priorities according to students' combined academic score and students' preferences can follow arbitrary distributions. We applied the proposed method to TuAFA's Faculty which has four different programs.

This paper consists of five sections. Section 1 is the introduction, in section 2 TuAFA's current placement algorithm is presented, which is followed by the proposed assignment model in Section 3. Section 4 reserved for the empirical findings of our model and finally the concluding remarks provided in Section 5.

TuAFA Program Placement Algorithm

In order to overcome the problem of uneven distribution of intellectual capital among different programs, Turkish Air Force Academy (TuAFA) follows a different placement strategy for its programs. Applying to the Turkish Air Force Academy (TuAFA) is considerably more involved than applying to a typical university in Turkey. There are many steps and challenges an applicant must meet. TuAFA seeks individuals who possess good academic skills besides leadership potential. This is because TuAFA offers both university degree and officer diploma for its graduates, and more importantly, at the end of the 4 year education, those who are qualified as a jet pilot candidate can fly supersonic aircraft equipped with cutting edge technology. Moreover, a life time career is guaranteed in one of the World's distinguished NATO allied air force.

Because of its unique offerings and intense evaluation strategy, the number of applicants for TuAFA's freshman class pools an average of 6,000 high school graduates to enroll only 150 cadets each year. As a result, the spread of the distribution of YGS-LYS score of the applicants is wider than those of similar colleges in Turkey, but representative of the initial pool. TuAFA Faculty has four alternative engineering programs namely, Aerospace (AE), Electronics (EE), Computer (CE) and Industrial Engineering (IE). A poorly administered program allocation in a boarding school, may result undesirable preference information, in a sense all the students follow the same preference structure which makes it hard to find a compromise between programs' quota and student preferences. Because they would basically sort programs depending on the previous year's graduation rate, follow the leader, or word of mouth.

Current program placement algorithm presented below:

1. Record candidates' order of preference in order from most to least preferable,
2. Sort candidates descending order according to academic score and split them into groups according to class requirement,
3. Take the first group and place the first candidate to his/her first choice,
4. Place the next candidate according to his/her order of preference if it is not occupied by the previous,
5. Go to step 4 until all candidates placed.

Advantage of the above placement algorithm is, academic scores or intellectual capital will definitely be distributed evenly among programs but also within variance of the programs will almost be equal. However, a candidate who has higher score can be placed to the last spot in his/her preference list. For example, if there exist 8 classes and 2 classes for each program, according to academic score 8th candidate can be placed to his 4th preference, while 121st student will be placed to his/her first preference. This is not fair and penalizes successful candidates. The question is can there be any other approach satisfying distributional constraints and also reasonable for diligent students. In other words, the outcome is female-optimal and in the next section we propose an alternative assignment model, where the student preferences are considered and Pareto optimality can be achieved.

Proposed Assignment Model

In order to provide a compromising solution for all stakeholders, a preference score, x which is a measure of candidate's unhappiness is introduced to penalize deviations from candidate's first preference. Let

Sets:

R Set of programs, $\{CE, EE, IE, AE\}$

x_{ij} ith candidate's preference score for jth program, $\forall x \in \{0, 1, 2, 3\}$, $\forall i \in \{1, 2, 3, \dots, n\}$ $\forall j \in R$

where n is the number of candidates. If ith candidate has a preference score array {1, 3, 2, 0}, his order of preference is actually *AE p CE p IE p EE*. His/her first choice is *AE*, then *CE*, then *IE* and then *EE*. We checked that the solution is not sensitive to different choices of values for x:

Parameters:

s_i ith candidate's combined academic score,

b_j jth program's quota,

a average academic score of all candidates, $a = \frac{\sum_i^n s_i}{n}$

Variables:

A binary variable is used if ith candidate assigned to his/her jth preference,

$$y_{ij} = \begin{cases} 1, & \text{if } i\text{th candidate assigned to } j\text{th program} \\ 0, & \text{otherwise,} \end{cases}$$

$\varepsilon_j^-, \varepsilon_j^+$ deviations of average academic score of jth program from a

The objective function is:

$$Min\ Z = (f, \varepsilon_j^-, \varepsilon_j^+) \qquad (1)$$

Minimizing f, which is a measure of total unhappiness, will move the search process towards candidates' first preferences, while minimizing ε_j^- and ε_j^+, will provide a balanced academic success distribution among programs.

Subject to:

$$f = \sum_{i=1}^{n}\sum_{j=1}^{4} x_{ij}y_{ij} \quad (2)$$

Average academic score for *j*th program is:

$$\frac{\sum_{i=1}^{n} y_{ij}s_i}{b_j} + \varepsilon_j^- - \varepsilon_j^+ = a \quad (3)$$

The programs' quotas must be met:

$$\sum_{i=1}^{n} y_{ij} = b_j \quad (4)$$

Each candidate must be assigned to exactly one program:

$$\sum_{j=1}^{4} y_{ij} = 1, \quad (5)$$

$y_{ij} = 0$ or $1, \varepsilon_j^-, \varepsilon_j^+ \geq 0$

IBM ILOG CPLEX optimization software is used to run above model for different data sets. The results are summarized in the next section.

Empirical Findings

The proposed multi-objective model is applied to 137 candidates who applied in 2012 fall admission period. Next, in order to generalize the performance of the model, same number of candidates with same preference distribution is generated. Then to see the effect of number of students and preference distribution, 250 students from uniform and skewed preference distributions are generated. Academic scores are also generated and assigned to students from the normal distribution with mean 53.21 and standard deviation 18.98, as 2012 fall semester. Program placement results of the proposed model and the directive's algorithm are compared on the basis of unhappiness metric.

In Figure 1, comparison of proposed model and the directive's algorithm is presented for 2012 fall semester. The proposed model placed significantly more students to his/her first preference than the directive. Moreover unlike the directive, no students placed to his/her last preference. In unhappiness scale, the proposed model produced 62% less unhappiness than the directive. The mean academic score of the programs are almost equal. ANOVA in Table 1, showing the mean scores according to proposed model placement, revealed no significant differences among programs.

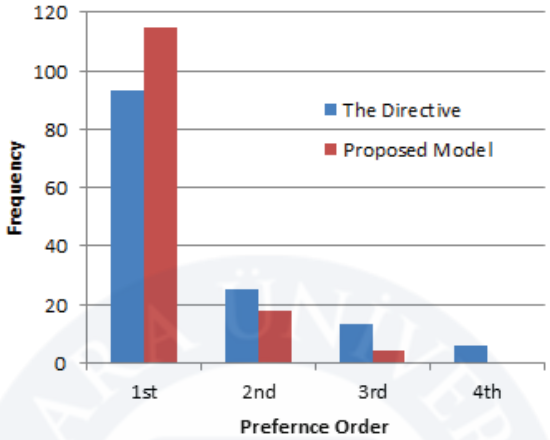


Figure 1. Placement Results for 2012 Fall Semester Data

Table 1. ANOVA of the Mean Academic Scores with the Proposed Model Placement

Programs:	**Count**	**Mean Score**	**Variance**
Computer Eng.	34	53.52	1819.60
Electronics Eng.	35	51.49	1802.04
Industrial Eng.	35	54.67	1913.35
Aerospace Eng.	33	53.19	1755.36

ANOVA

Source	SS	df	MS	F	p – value
Between groups	181.47	3	60.49	0.165	**0.920**
Within Groups	48819.73	133	367.07		
Total	49001.20	136			

In Figure 2, the distribution of preference listings is presented for 2012 fall semester. Here, horizontal axis represents students' order of preference in descending order and vertical axis represents frequency of the students who picked that preference. For example, first column in the graph represents 16 students who picked {3, 1, 0, 2} order (*IE, EE, AE, CE*).

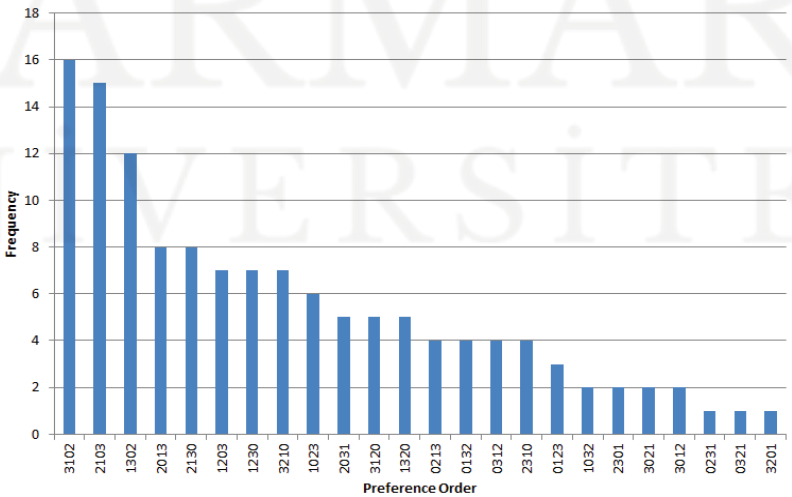


Figure 2. Preference Frequency in Descending Order for 2012 Fall Semester

Despite some preference listings highly cited than others, all possible permutations are recorded by the students. For 4 programs, 4! = 24 different preference listings are possible. In order to generalize the results for the proposed model, 10 different data sets are generated from the same distribution for 137 cadets and results are tabulated in Table 2. On the average, the proposed model produces 67% less unhappiness than the directive's algorithm.

Table 2. Results for the 2012 Fall Preference Distribution (137 cadets)

Data Set	The Directive Unhappiness Score	Proposed Method Unhappiness Score	Relative Unhappiness Efficiency of Proposed Method (%)
1	110	39	65
2	124	37	70
3	114	37	68
4	129	35	73
5	144	58	60
6	134	45	66
7	146	43	71
8	117	40	66
9	113	36	68
10	131	45	66
Mean	**126.2**	**41.5**	**67**

The performance of the proposed method can change depending on the distribution of cadets' preferences. We expect similar results with uniform or almost uniform preference distributions. 10 data sets each having 250 cadets with equally likely preference listings are generated. The results of both methods in unhappiness metric are tabulated in Table 3.

Table 3. Results for the Uniform Preference Distributions (250 cadets)

Data Set	The Directive Unhappiness Score	Proposed Method Unhappiness Score	Relative Unhappiness Efficiency of Proposed Method (%)
1	324	99	69
2	318	105	67
3	313	106	66
4	328	109	67
5	331	107	68
6	317	109	66
7	308	105	66
8	318	111	65
9	324	115	65
10	313	108	65
Mean	**319.4**	**107.4**	**66**

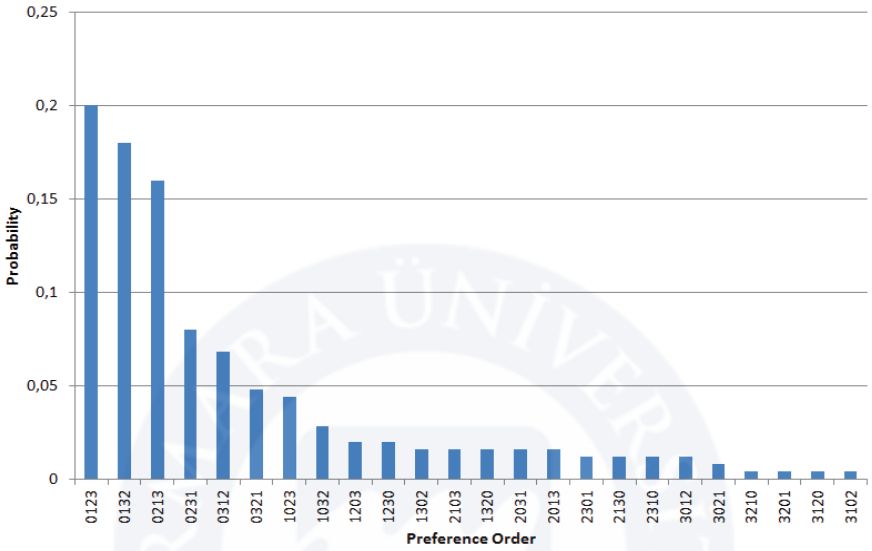


Figure 3. Preference Probabilities in Descending Order for Simulated Skewed Distribution (250 cadets)

Table 4. Results for the Skewed Preference Distribution (250 cadets)

Data Set	The Directive Unhappiness Score	Proposed Method Unhappiness Score	Relative Unhappiness Efficiency of Proposed Method (%)
1	323	155	52%
2	328	172	48%
3	340	182	46%
4	333	172	48%
5	335	166	50%
6	330	171	48%
7	319	166	48%
8	319	160	50%
9	315	153	51%
10	327	160	51%
Mean	**326.9**	**165.7**	**49%**

For uniform and skewed preference distributions, our assignment model produces 66% and 59% less unhappiness accordingly. Proposed model is relatively more efficient in unhappiness metric for both of the distributions. We showed that regardless of the preference distribution proposed assignment model is superior to the algorithm in the directive and also provide a balanced academic score distribution among programs.

Concluding Remarks

In this study we have considered an alternative model for the student-program allocation problem, in which students have preferences over programs and balanced academic score distribution among programs need to be maintained. A practical and easy to apply optimization model is shown significant improvement opportunities without violating system constraints. The proposed model can be extended to solve the assignment problem of graduates of TuAFA who will assign to branches other than pilotage.

Acknowledgement

This study was started as part of a quality improvement project in TuAFA and accomplished by senior cadets. The Authors express their gratitude to officials at Human Resources Evaluation and Admission Center in

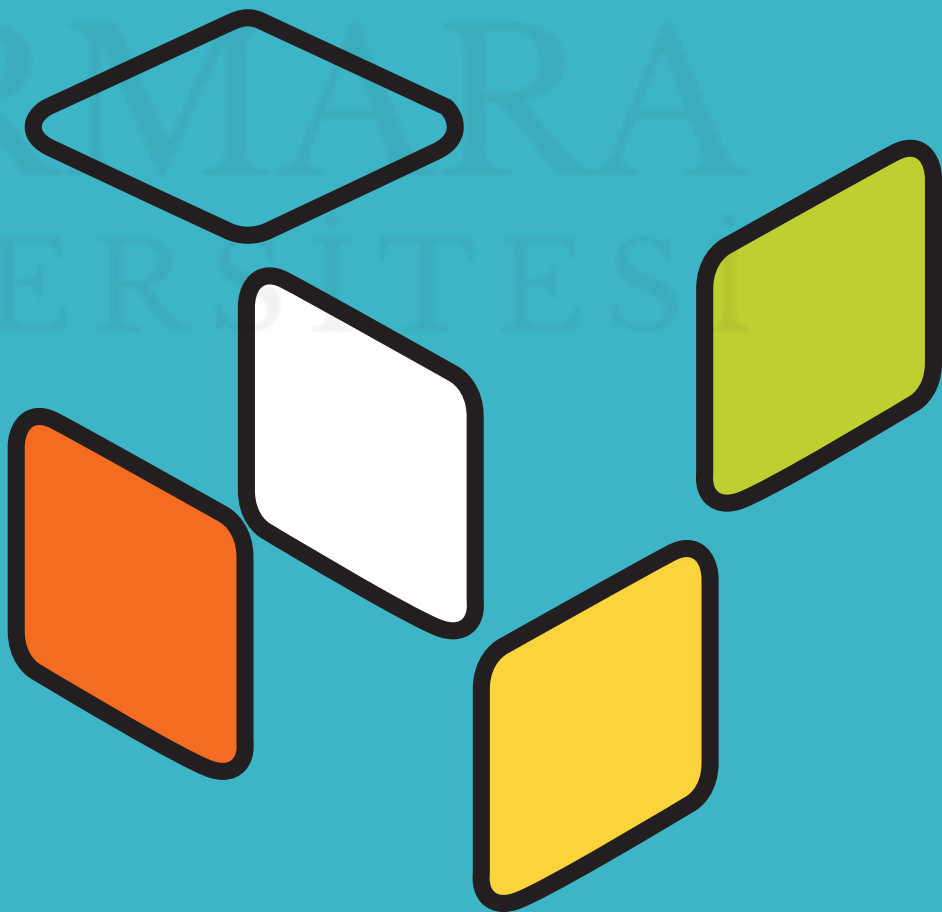
TuAFA, for their close support.

References

[1] Gale, D., Shapley, L.S., 1962, College admissions and the stability of marriage, *American Mathematical Monthly*, 69–1, 9–15 .
[2] Saito, Y., Fujimoto, T., Matsuo, T., 2008, Multi-sided Matching Lecture Allocation Mechanism, *New Challenges in Applied Intelligence Technologies*, volume 134 of Studies in Computational Intelligence, Springer.
[3] Gusfield, D., Irving R.W., 1989, "The stable marriage problem: structure and algorithms", MIT Press, Cambridge, MA, USA.
[4] Manlove, D.F., O'Malley, G., 2005, Student project allocation with preferences over projects. *In Proceedings of ACID2005: the 1st Algorithms and Complexity in Durham*, 4, 69 – 80, KCL Publications.
[5] Marx, D., Schlotter, I., 2009, Parameterized Complexity and Local Search Approaches for the Stable Marriage Problem with Ties, *Algorithmica*, 58(1), 170–187.

MARMARA ÜNİVERSİTESİ YAYINEVİ

FINANCE AND ECONOMICS



Complexity of Predictive Market Fluctuations in Econophysics: FTSE, DJIA & BIST-100

Cem Çağrı Dönmez [1] , *Tolga Ulusoy* [2]

Abstract

What are the main characteristics of Econophysics? In what follows, we will try to summarise some basic principles. Each of them will be illustrated by one or several researches performed by econophysicists.
In this paper the key structures of entropy, temperature and energy of stock markets in the manner of statistical physics are obtained. On the basis of some hypothesis of quantum mechanics, this paper considers stock markets as quantum systems and investors as particles. A quantum model of stock price fluctuations is defined in a theoretical framework. Essentially, the models are based upon models of statistical physics and quantum mechanics in which energy is conserved in exchange processes. The relative entropy is used as a measure of stability and maturity of financial markets from financial information about some considered emerging markets (Turkey) and some considered mature markets (England, United States). The model analytically calculates and simulate the system in FTSE-100, DJIA and BIST-100 indexes basic predictive model in Econophysics is discussed.

Keywords: Finance, Physics, Econophysics, Entropy, Temperature and Energy of Stock Markets

[1] Cem Çağrı Dönmez, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, cem.domez@marmara.edu.tr

[2] Tolga Ulusoy, Kastamonu University, Faculty of Economics and Administrative Sciences, Kastamonu, Turkey, tulusoy@kastamonu.edu.tr

Introduction

The science explaining the reasons and the results of economy with physical reasons and results more to define these more concretely is called "*Econophysics*" [1]. A market mostly displays the motions of a fluid or gas. Bachelier's, conducting studies on price fluctuations in Paris stock Exchange during 1900s, laid the foundations of the financial analysis of nowadays with his study on the association of physics and mathematics [2] then, Einstein had developed formulations enlightening the behaviors of today's investors with his study on the behaviors of particles in gasses [3].

In the 60s and 70s, a team consisted of three Americans: physicist Fischer Black, economist Myron Scholes and engineer Robert Merton have developed the Black-Scholes equation that can anticipate the price changes including financial variables such as time, price, interest rate and volatility.

The research they have carried comprised the basis for a huge as well as very new financial industry for the composition of derivative instruments and even more they have succeeded to receive the Nobel Prize in economics field thanks to the equations derived from physics [4].

Although it is a proved fact that physics and money have many common points[1], the point of departure can be considered in this way: When management of money is considered as a physical test, both requires involving with equations and numbers. Physics is based on developing some physical events in the world utilizing mathematical equations. Scientists have worked on how to implement the models developed in physics to "*financial world*" during recent years and they are focused on how to adapt some mathematical models obtained in "*molecular world*" to financial literature. Models are created utilizing processes where random results are formed and some research is carried on the pricing of financial instruments, the future movements of money and capital markets, trend of market and starting from their research efforts are made to make it possible to utilize these results by investors to reach profitable investment strategies.

Thermo-Economy: Carnot Cycle and Finance Relationship

It is known that in the second law of thermodynamics it is said that all systems left by itself in the universe, to natural conditions will go through irregularity, disorder and degradation directly proportional with time. It is known that the transition of a system from a regular organized and planned structure to an irregular, dispersed and unplanned condition increases the entropy of the system and the high level of irregularity of a system leads the increase of entropy of the system at the same level. If we investigate Carnot Cycle in finance, it is possible to give following information [5].

With closed integration where W is the made investment (suffered obligation by investor) Q is the $return/profit$ in consequence of the investment:

$$-\oint \delta W = \oint \delta Q$$

is reached.

[1] Dominant method in neo-Classical economy is adapting thermodynamics to economics. At the same time, Neo-Classical economics is the start of engineering-economy tradition. Especially for L. Walras and I.Fisher interaction with thermodynamics is almost exact. Walras and Fisher have applied 1st Law of thermodynamics to economics

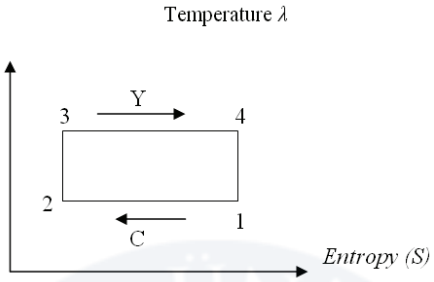


Figure 1: Carnot Cycle

$$ds = \frac{1}{\lambda}\delta Q$$

When the opposite value of the temperature is placed:

$$-\oint \delta W = \oint \lambda ds$$

equation is reached.

When the difference of the inputs to and outputs from the portfolio of investment Y is the return of the investment, C all expenses suffered for investment then delta Q (ΔQ) indicates net profit:

$$-\oint \delta W = \oint \delta Q = \oint \lambda ds$$

$$= \int_1^2 \lambda_1 ds + \int_3^4 \lambda_2 ds = Y - C = \Delta Q$$

the equation gives the net remaining investment amount at the end of the investment. Let's try to see how adiabatic processes and isothermal processes available in thermal physics at the closed area integration shown in Figure 1 are explained in the financial investment field (Mimkes, 2006). During *1-2 process*, the investor is buying securities for his portfolio. Since the work carried in the financial vessel yet collecting the securities together the change with entropy is $\Delta S < 0$. For instance, the cost (carried work) for n_1 units of shares at λ_1 the price level should be:

$$C = \lambda_1 \Delta S$$

This section corresponds to "***reversible isothermal compression of financial instruments***" in financial thermodynamics. At this stage heat profit of investor) is given out. The entropy change here:

$$\Delta S = \frac{q_1}{\lambda_1} \approx q_1 < 0$$

At 2-3 process, the investor has formed his portfolio with those allocated from revenue. In order to arrive selling stage the occurrence of temperature at $\exists \lambda_2 > \lambda_1$ Is waiting for. The thing indicated with λ_1 here is the price/temperature of securities after ***t*** time. The investor is not going forward to un-negligible changes. Since there is an entropy fixation in the process, entropy change is zero. This step corresponds to "***reversible adiabatic compression of financial instruments***" in financial thermodynamics.

Heat is not input to the system at this step. Here it's assumed that the temperature of security, increased from λ_1 to λ_2 due to external factors. During 3-4 process the investor wants to sell security to financial market with $\lambda 2$ price, assuming that the market has reached expected temperature where investor expectations are met. The revenue after sales will be:

$$Y = \lambda_2 \Delta S$$

This step corresponds to "***reversible isothermal financial expansion***". The change with entropy is now positive. It is equal to:

$$\Delta S = \frac{q_2}{\lambda_2} \approx q_2 > 0$$

Here there is now financial heat flowing from hot portfolio to the system.

At 4-1 step, since the sale is realized there is portfolio stability. This section shows reversible adiabatic expansion. There is no heat output from the system. Therefore entropy change is zero. After this expansion fever is cooled down, in other words, formation of required base price is waited to the repurchase of the security. No input will occur to the portfolio of an investor until $\exists \lambda_1 > \lambda_2$ price is seen.

As the concepts of heat, entropy is at the forefront in *Carnot cycle*, it is seen possible to make these determinations:

1- The efficiency of investment can be possible with $\Delta\lambda$ temperature change.

2- If ΔS entropy change is linked with the probabilities of the system at different price steps, it may be possible to obtain sound assumptions for stock exchange market.

3- If sales-purchases in the portfolio of the investor are carried under the assumption of obtaining low temperatures under high entropy changes, this indicates a result that investment is made varied price ranges with relatively low risk. Purchase-sell processes are leading high probability continuity result. In such a case, it is possible to say that an investor can be readily entering exchange transactions in financial markets.

4- Let us consider the opposite condition. If the purchases- sells in the portfolio of investor are carried under the assumption of achieving high temperatures under low entropy changes, this gives a result indicating that investment is made with not fully diversified price ranges with higher risk. Purchase-Sell processes indicate that investor is tending to investment under low probability continuity assumption. In such a case it is not possible to say that investor can easily make exchange transactions in the financial market. Because the risk was taken over a certain level.

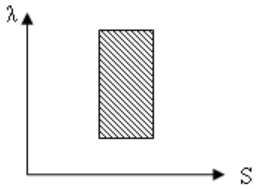


Figure 2: Risky investment cycle

Gray area states ΔλΔS multiplication lower entropy change under high temperature change. It is possible for investors to take high risk, high return expectation. Therefore, it should be deemed normal to have a trend through such investment. But the portfolio of the investor is not secure under this situation. When there are risky investments, high losses or high returns are very probable. In this section investor did not invest in financial instruments with complex returns and may be hedged, but instead invested in more speculative assets.

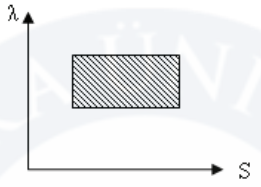


Figure 3: Non-risky investment cycle

Gray area states ΔλΔS multiplication for higher entropy change under low temperature change. The investor did not take risk here, preferring more volatile (easily sellable) securities with an acceptable level of return. Therefore, such an investment cannot be expected to give high returns. The portfolio of investor is safe in this condition. Since the subject matter is risk free investment, the probability of high losses and high returns are low (the probability is close to zero but not zero). In this part, investor was preferred financial instruments, giving complex returns and can be hedged.

Microscopic Modelling of Volatility and Effects of Temperature [7]

Any of calendar time stock's returns of volatility denoted by σ_i is multiplied by square-root of stock's trading frequency. This brings us the notion temperature of stock denoted by X_i

$$\chi_i = \sigma_i \sqrt{V_i}$$

The right side of this equality denotes multiplication of calendar time volatility with trading frequency.This multiplication shows a stocks temperature. Furthermore, in this research, an assumption is thrown out for consideration under this formula. If we can take a calendar time hypothesis with calculation of formula as a temperature of the stock market using volatilities, will the results significant? Providing that trading times of stock market are taken out to be 1 within a basis of daytime and stock market trading frequency is discussed as a normalized volume of the stock market, will it be possible for the research to give out significant results?

First evaluation was carried out between January 2003 and May 2012 in 2337 trading days and 4674 open-to-trade sessions regarding these days. The graphics about these have been discussed in the next section of the study. Certain data subject to the evaluation has been kept. With this data, temperature and entropy values have been calculated over the volume obtained during the day and FTSE-100, DJIA and BIST-100 index closing session values.

Volume and index closing values have been taken into account at the end of each session and they were accompanied with graphics. By doing so, there has been an attempt to determine the current direction of index trend. Intermediate values have been flattened for the date mentioned with the aim of avoiding any possible confusion.

Under separation of temperature formula, we have 2 parts. The one is calculated of volatility of calendar time returns of the index, the other one is production of trading frequency of the stock market.

Assumption under number of investors are constant, during the specific time $\boldsymbol{t}$, every investor of financial system denoted by $\boldsymbol{i}$ has a $\boldsymbol{w(t)}$ variable, which is accredited or alleviated the investor wealth. Then cumulative wealth or in other words direction factor in market players` investments is built up denoted by variable

$$W(t) = \sum_{i=1}^{n} w_i(t)$$

During changeovers from t_0 to t_1, each investors wealth change of $W_i(t) \rightarrow W_i(t+1)$. From this point every investor has $W(t)$ variable. In fact, even if an economic coefficient such as the growth rate, taxes, social yields and interest rates, which is the same for each $W_i(t)$, is at work during these transitions, they have been excluded from the study. If the value $W(t)$ which represents the increases and decreases statistically is considered as index value in the study, the market yield over $\boldsymbol{t}$ time will be

$$r(t) = \ln\left(\frac{W(t+1)}{W(t)}\right).$$

Variation of W within each trading time range is very small. Then, the volatility will be

$$Volatility = \left[\ln\frac{W_{(t+1)}}{W_{(t)}}\right]^2 / N$$

when one takes the average of the squares of yields over a certain time range. If it is considered as N step and transition step is taken as $N = 1$, new calculation formula of volatility will be

$$Volatility = \left[\ln\frac{W_{(t+1)}}{W_{(t)}}\right]^2$$

Constitute the basics of calculating, temperature formula has been formed as 2 parts. If one rewrites the volatility of calendar time returns, first one of the two parts of temperature formula which is subject to the calculation, the outcome is

$$Volatility = \left[\ln\frac{index_value_{(t+1)}}{index_value_{(t)}}\right]^2$$

We need for a variable called trading frequency of market in the section which constitutes for the secondary part in calculation of temperature.

According to the intrinsic time hypothesis, trading frequency means the number of trades through which related stocks pass over a certain time period. According to the calendar time hypothesis, on the other hand, it means trades experienced within a certain session. Since calendar time hypothesis constitutes for the basis of the assessment here, the number of contracts or the number of orders has

been taken into account for trading frequency and they have been normalized by using a coefficient, 10^{12}, in order to make the calculation easier.

$$Trading\ Frequency\ of\ Market_{t+1} = \sqrt{market_volume_{t+1} \times 10^{12}}$$

To sum up, the temperature of the market during $t+1$ time, λ_{t+1}, will be

$$\lambda_{t+1} = \left[\ln \frac{index_value_{(t+1)}}{index_value_{(t)}}\right]^2 . \sqrt{market_volume_{t+1} \times 10^{12}}$$

The notion "***entropy***" has been discussed in previous chapters. So, as an element of temperature, entropy has been considered as the variation of trend direction of the market. According to Bose-Einstein statistic, entropy of a Bose system, (Φ), is calculated as **Entropy of the market**

$$\Phi = \frac{\varepsilon}{\lambda} . \frac{1}{e^{\frac{\varepsilon}{\lambda}} - 1} + \log\left(1 + \frac{1}{e^{\frac{\varepsilon}{\lambda}} - 1}\right)$$

If one takes the index closing value in $\varepsilon = t+1$ time as a temperature value in $\lambda = t$ time, the entropy value in $\Phi = t+1$ time is calculated.

Entropy minimum and entropy maximum points provide further information for the trade in cyclic analyses. Entropy in this study appears as an application of the Second Law of Thermodynamics. This law, as mentioned previously, suggests that each event will ultimately present itself on a stationary level.

Like human beings and other substances, assets traded in financial markets have also a life-span. Forward movement of assets, i.e. towards a positive direction, or their backward movement, that is in a negative direction, can account for these life-spans. When entropy is applied to the equity market, it proves an indicator of the fact that movement of a financial instrument in one direction has ended and goes towards another direction.

In the simulation designer, entropy ceiling and entropy base points have been applied to equity markets. Laws have been displayed together with temperature and Bose Einstein condensation. Also, temperature and entropy values have been composed in different sessions, not as weekly, monthly or yearly.

In daily overview, entropy calculations have been carried out by using trading frequency in calculation, but in order to make the presentation robust, session times, which can be accepted as not trading times but calendar times have been taken as the basis. Furthermore, graphics regarding volatility-index and risk-temperature have been calculated daily on a monthly basis and represented graphically. And this allowed the study to make comparisons with other graphics. Also, by means of a polynomial on related graphics, interpolation which gives flatting of intermediate value has been undertaken for all values appearing so as to make monitoring easier and to enable rather scattered values to be studied all together. It has been of great importance to calculate intermediate values for enabling a comparison of two values on the same graphic.

Conclusion

This paper investigates the relation between Entropy of the market, temperature and energy of stock markets, structural change and the size of the stock market investigations. Entropy is not restricted to natural science, but is a function of mathematical and physical statistics. Econophysicists often use the concept of entropy to characterise the idea of uncertainty in Physical, Mathematical approach, economics and finance. As Dionisio [8] explain, "*entropy is a measure of dispersion, uncertainty, disorder and diversification used in a dynamic process, in statistics and information theory, and has been increasingly adopted in financial theory*". Our investigations that the diversity approach is more useful in the cases of new, unrecognised physical phenomena.

It is a fact that the investors, in contrast to gas particles, have enough recall ability to modify their behaviors constantly. In this context, it is already unlikely to totally apply gas particle behavior to financial markets. However, it is more sensible to carry out trading possibilities and risk estimation through a prediction of the direction of the existing trend via modern physical theories called the statistical structure of quantum. Therefore, this paper aims to achieve a different perspective, not found in other traditional studies on equity pricing and trend analyses about markets. In fact, as argued in most of the studies on the topic, it is obvious that the prices cannot be predicted thoroughly. Yet, as can be inferred from this study, one should not forget that rise and falls on pricing follow a certain succession. From that perspective, for a proper handling of the happenings in the past and easy understanding of potential conditions in the future, it is significant to consider the market as a scientific system. Considering that the markets have a personality around themselves, it is possible to conclude the following: Despite seeming to be formed through effects outside the market, the prices are actually determined by the internal dynamics of the market. Intra-market happenings determine the prices and external dynamics are held as reasons after the happenings have taken shape. The fact that the prices seem to be reacting to the external dynamics affects all the investors at the same time. However, what is important in a neutral situation is how the investors affect each other and their demands for being/not being in the same energy condition. This is, on the other hand, a condition to be evaluated within the statistical background of Econophysics.

References

[1] Mantegna, R.N., Stanley, H.E. (2000) Introduction to Econophysics: Correlations and Complexity in Finance, Cambridge University Press
[2] Bachelier, L. (1900) The theory of Speculation, Gauthier-Villars
[3] Einstein, A. (1956) "Investigations on the Brownian Movement", New York, Dover
[4] Merton, R., Scholes, B. (1972) The Valuation of Options Contracts and a Test of Market Efficiency, Journal of Finance, Vol. 27, No:2
[5] Carnot, Sadi; Thurston, Robert Henry (editor and translator) (1890) Reflections on the Motive Power of Heat and on Machines Fitted to Develop That Power, New York, John Wiley & Sons
[6] Mimkes,J. (2006) Econophysics and Sociophysics: Trends and Perspectives
[7] Derman, E. (2002) The Perception of Time, Risk and Return During Periods of Speculation
[8] Dionisio, A., Menezes, R., Mendes D. (2005) An Econophysics approach to analyze uncertainty in financial markets: An application to the Portuguese stock market, The European Physical Journal B 50 (1) 161-164
[9] Georgescu-Roegen, N. (1974) The entropy law and the economic process. Cambridge, Mass. Harvard Univ. Press
[10] Schinckus, C. (2009) Economic uncertainty and econophysics, Physica A: Statistical Mechanics and its Applications, 388 (20) 4415-4423

Figure 1

Ten Year Index Comparison for DJIA-FTSE100

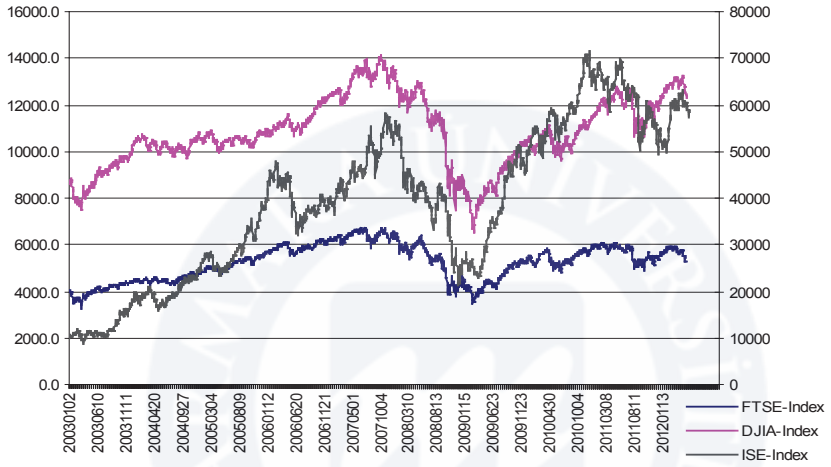


Figure 2

Ten Year Comparisons of FTSE 100 Index and FTSE Index Temperatures

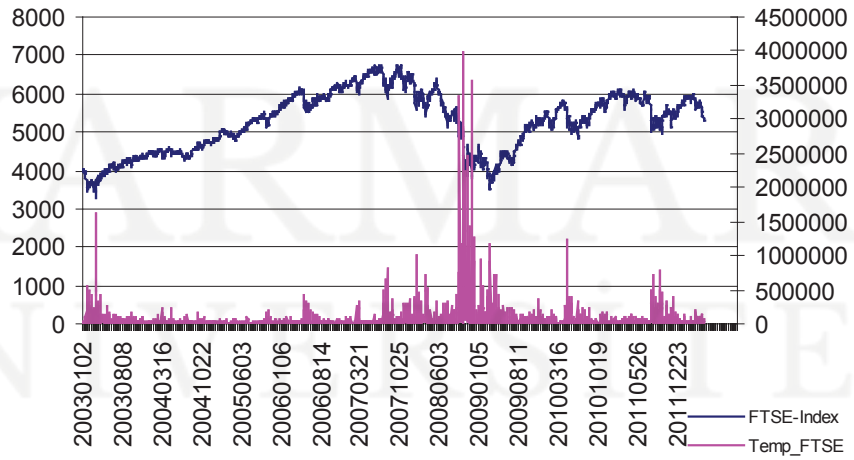


Figure 3

Ten Year Comparisons of DJIA Index and DJIA Index Temperatures

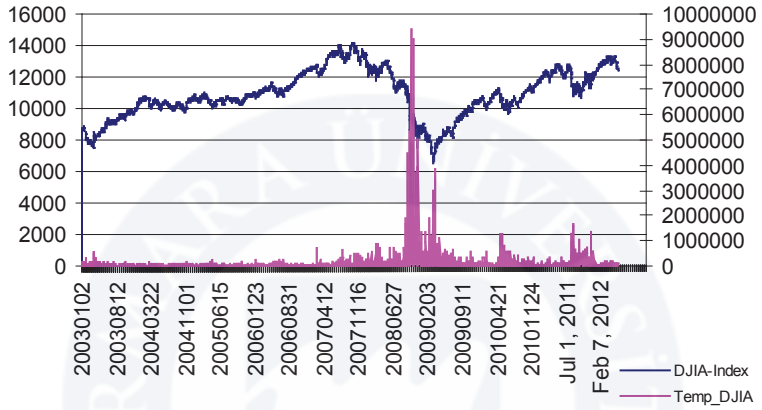


Figure 4

Ten Year Comparisons of ISE100 Index and ISE 100 Index Temperatures

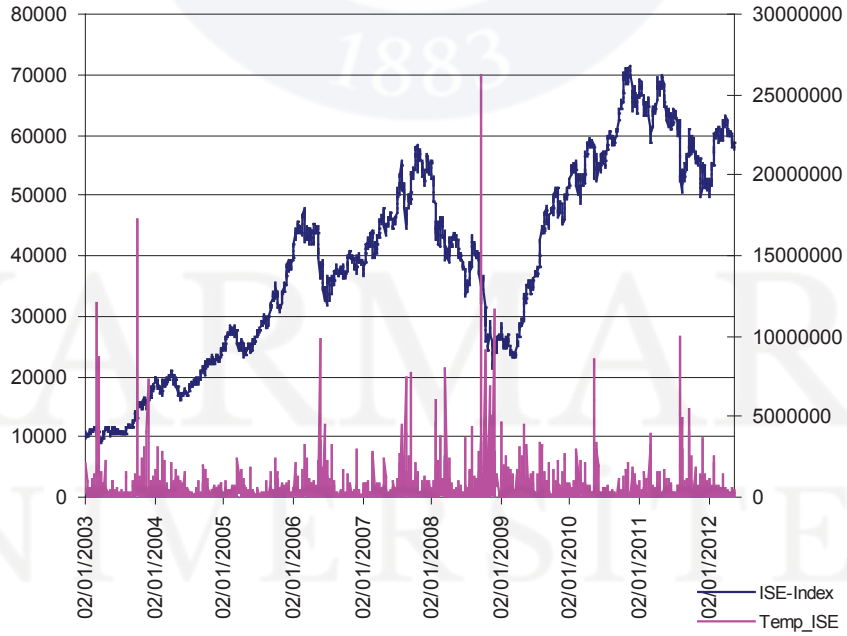


Figure 5

Annual Analogy Between FTSE Temperature and FTSE Risk for 2003

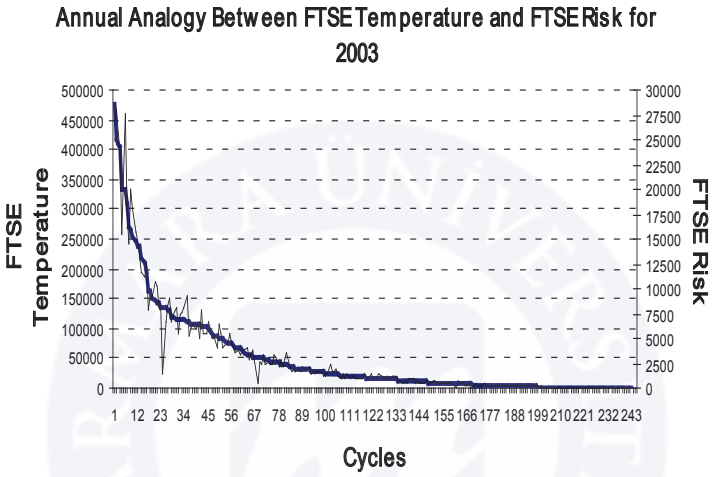
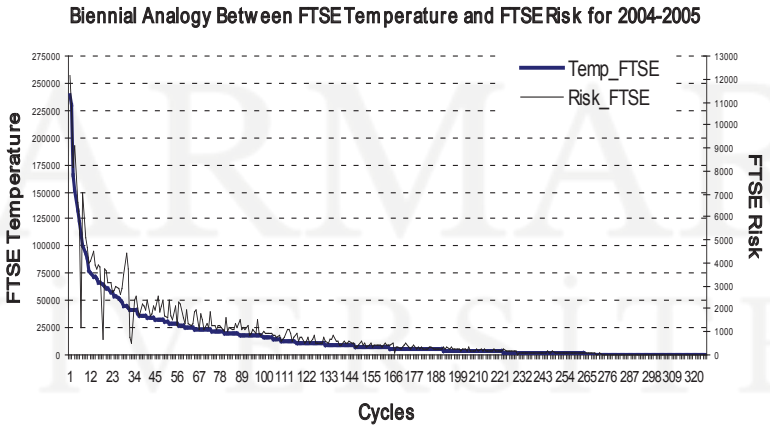


Figure 6

Biennial Analogy Between FTSE Temperature and FTSE Risk for 2004-2005



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

ICT and Economic Growth in Eight Islamic Developing Countries (D8)

Mahnaz Rabiei [1], *Ali Nezhadmohammad Alarlough* [2]

Abstract

Economic growth theories predict that economic growth is driven by investments in Information and Communication Technology (ICT). Empirical studies of this prediction have produced mixed results, depending on the research methodology employed and the geographical configuration considered. To provide yet a further test, this paper used panel data approach and applies it to the economy of D8 Group member countries (Iran, Turkey, Egypt, Nigeria, Bangladesh, Pakistan, Malaysia, Indonesia) over the time span of 1990-2009. The estimates reveal a significant impact on economic growth of investments in ICT in the D8 member countries. This implies that if these countries seek to enhance their economic growth, they need to implement specific policies that facilitate investment in ICT.

Keywords: ICT, D8 Group, Economic Growth, Panel Data

Introduction

The objective of this study is to explore the impacts of ICT investment on economic growth in a cross section of 8 Islamic countries using the data over the period 2000-2009. Panel data analysis is carried out to examine the factors affecting economic growth. To understand the current state of ICT and macroeconomic situation of 8 Islamic countries, a comprehensive review of pertinent statistics related to ICT and economic growth is examined to find common stylized facts in the economies.

ICT in D8 have for several decades been called on to support the transfer of business practice that has been considered to be effective in the successfully competitive economies. Some recent theoretical and empirical literature studies the positive effect of ICT on productivity.[1][2][3]and On the other hand some other recent empirical literature shows the potential negative impact of ICT on economic growth especially for the developing countries [4][5][6] The majority of these studies are based on the debate that technical changes are creative destruction. ICT has some positive impacts to enhance economic development; however in the other hand it has some negative impacts on some dimensions of economic development. Hence some studies, discuss the negative impacts of ICT on employment and labor market in particular the unemployment effect.[7][8][9][10]. In addition, that ICT could create some negative impacts for growth and convergence of developing countries. In fact the developed countries will have some more competitive advantages raising their domination on global world. Developing countries will be not only less competitive in the international market, but also will be threatened in their original local markets. ICT might also create some negative impacts in the income distribution within the developing countries.

ICT and Economic Growth: Empirical Studies

Recently, some studies have analyzed the relationship between ICT and economic performance. Many of them examined the impact of ICT on productivity growth. However, the main conclusion of most studies supported the positive impact of ICT on economic performances of

[1] Mahnaz Rabiei, Islamic Azad University ,South Tehran Branch, Economic Faculty, Tehran,Iran , dr_mahnaz_rabiei@azad.ac.ir

[2] Ali Nezhadmohammad Alarlough, Islamic Azad University ,South Tehran Branch, Economic Faculty, Tehran,Iran , economistmaster@yahoo.com

developed as compared to developing countries. For example, Jorgenson and Vu found that the contribution of ICT capital to world GDP had more than doubled and now accounts for 0.53 per cent of the world average GDP growth of3.45 per cent. The percentage was higher for the group of G7 countries, where ICT investments contributed with 0.69 per cent to a GDP growth of 2.56 per cent during 1995–2003.[11] Oulton and Srinivasan used a new industry-level dataset to quantify the role of ICT in explaining productivity growth in the UK, 1970-2000. The dataset is for 34 industries covering the whole economy (in the market sector). Using growth accounting they found that ICT capital played an increasingly important, and in the 1990s the dominant, role in accounting for labor productivity growth in the market sector. Econometric evidence also supports an important role for ICT. They also found econometric evidence that a boom in complementary investment in the1990s could have led to a decline in the conventional measure of TFP growth. Ketteni has shown that total ICT capital has a nonlinear effect on total factor productivity growth. Youngsang Cho, Jongsu Lee and Tai-Yoo Kim investigated the effects of information and communications technology (ICT) investment, electricity price, and oil price on the consumption of electricity in South Korea's industries using a logistic growth model.[12][13] They found that ICT investment reduces electricity consumption in only one manufacturing sector and that it increases electricity consumption in other five sectors including service sector in South Korea. Rimm Ben Ayed Mouelhi aimed at measuring the impact of information and communication technology use on the efficiency of the Tunisian manufacturing sector at the firm level within a simple theoretical framework. They used a firm-level panel data for the manufacturing sector in Tunisia to investigate whether adoption of ICT influences efficiency in factor use. The analysis is conducted through the use of a parametric method to measure technical efficiency. They estimated a stochastic production frontier and the relationship aims to explained technical efficiency differentials in a single stage as suggested by Battese and Coelli Battesse, G.E, Coelli, T.J. . A model for technical inefficiency in a stochastic frontier production functions for panel data.[14]

Khuong M. Vu examines the hypothesis that ICT penetration has positive effects on economic growth. This paper conducts three empirical exercises to provide a comprehensive documentation of the role of ICT as a source of growth in the 1996–2005 period. The first exercise shows that growth in 1996–2005 improved relative to the previous two decades and experienced a very significant structural change[15]. Sophia P. Dimelis and Sotiris K. Papaioannou have studied on the growth impact of Information and Communication Technologies using industry-level data for the US and the EU industries over the period 1980–2000. A panel data approach was employed to estimate the ICT effect using the system GMM and the pooled mean group panel data estimators. The GMM estimates suggested a significant ICT effect on growth during the 90s both in the US and in the EU. This effect for the EU was strong in the early 90s and weakened afterwards, as opposed to the US where it strengthened in the late 90s.[16] Diego Martínez, Jesús Rodríguez and José L. Torres studied the impact of information and communication technologies (ICT) on US economic growth using a dynamic general equilibrium approach. A production function with six different capital inputs was used, three of them corresponding to ICT assets and the other three to non-ICT assets. The technological change embedded in hardware equipment was found to be the main leading non-neutral force in US productivity growth, accounting for about one quarter of total growth during the period 1980–2004.[17] Hwan-Joo Seo, Young Soo Lee and Jeong Hun Oh built a model of cumulative growth to examine the dynamic interdependent relationship between ICT investment and economic growth for a sample of 29 countries in the 1990s. They confirmed the following facts: First, there is a positive correlation between ICT investment and economic growth. Second, non-ICT investment has as much influence on the growth gap as ICT investment. Third, those countries with a solid economic infrastructure and open trade regime experience more active ICT investments. Fourth, those countries with a comparatively lower productivity level

can reduce the gap using knowledge spillovers from more advanced countries. Fifth, reinforcement of patent rights has a positive influence on economic growth by stimulating the accumulation of ICT capital. Finally, ICT investment does not have a strong interdependent relationship with economic growth, while non-ICT investment has a cumulative causal relationship with economic growth and plays a key role in the process of widening the growth gap [18].

Theory and calculation

The Model

The following captures the general framework of growth models with ICT as an explanatory variable:

$$Y_t = Y(Y_t^{ICT}, Y_t^0) = A_t F(C_t, K_t, N_t) \quad (1)$$

Where t is time in all cases, Y is the total added value, Y_t^{ICT} YICT is added value of goods and services related to ICT, and Y_0 represents the value added related to other products. Production is possible through ICT inputs (C) and non-ICT inputs: physical capital (K) and labor force (N).

ICT influences economic growth, production and productivity in three basic ways. First ICT's goods and services (Y_t^{ICT}) are a part of the value added of the economy. Second, utilizing ICT capital, or C used as an input in the production of all goods and services will lead to economic growth. Finally ICT can cause economic growth through its contributions to technological change. If the growth of ICT's production is based on the benefits of efficiency and productivity in the activities, it will lead to an increase in productivity growth at the macro-economic level (Pahjola, 2002).

There are two different approaches to estimating the effect of ICT investments on economic growth: "the production function approach" and "the growth accounting approach".

The following generalized form of the Cobb Douglas production represents the production function approach:

$$Y = Af[L, K, ICT] = AL^{\alpha} K^{\beta} ICT^{(1-\alpha-\beta)} \quad (2)$$

Where the subscript t standing for time has been eliminated to simplify the presentation. Conversion to logarithm yields the following in log-linear form:

$$LNY=\beta_0+\beta_1 LNL+\beta_2 LNK+\beta_3 LNICT + \varepsilon \quad (3)$$

This relationship can be estimated using time-series within a country or cross section data across countries. Assuming constant returns to scale, and each factor receiving its marginal product

The Empirical Model

In his paper, we choose to work with the production function approach; because it was more widely used in economics and it had less restrictive assumptions. Specifically the following simple double log. Cobb-Douglass production was the equation used in our regression:

$$LnGDP_{it} = c + \alpha_1 LnK_{it} + \alpha_2 LnICT_{it} + \alpha_3 LnL_{it} + \alpha_4 LnFDI_{it} + \alpha_5 LnOPN_{IT} + U_{it} \quad (4)$$

where: α_0 is a constant coefficient, $LnGDP_{it}$ is natural logarithm of real GDP per capita in constant 2000 prices in US dollar, $LnICT_{it}$ is natural logarithm of investment in ICT, LnK_{it} is natural logarithm of gross domestic investment, LnL_{it} is log of total labor force , $LnOPEN_{IT}$ is an index that indicator degree of openness of the economy's growth rate dividing the total value of exports and imports over GDP. $LnFDI_{it}$ Is foreign direct investment as an indicator of technical and technological improvement. U_{it} is the model's random error component.

The Data

The data mainly were based on the World Bank (2010), world development indicator (WDI). The time period under The Data on foreign direct investment were compiled from the statistical resources published by the World Bank.

The data on ICT includes:
(a) Computer hardware (computers, accessories and enhancements)
(b) Software (agent systems, programming means, etc)
(c) Computer services (IT devices, etc) and communication services
(d) Wire and wireless communication equipment.

We took the ICT/GDP ratio from the World Bank's statistical Information. We applied the ratio to the data on real (2000 constant prices) GDP series available in various D8 member countries and arrived at the ICT series for these countries. Gross Capital Formation (or Gross Domestic Investment) includes expenditures on fixed assets (land and land improvement, plant, machinery and equipment, road and rail transportation, school, administrative, hospitals, and industrial and business buildings) plus net changes in inventories. The change in inventories also comprises investments in the form of goods held in stocks to deal with temporary unexpected fluctuations (World Bank, 2010).

The Table1 shows variable that used in model:

Table1. Variable and source of variable

Variable name	Variable description	Source	Time coverage
LNGDP	Log of gross domestic product	WDI	2000-2009
LNFDI	Log of foreign direct investment in flow	WDI	2000-2009
LNL	Log total employment	WDI	2000-2009
LNK	Log domestic investment	WDI	2000-2009
LNICT	Log ICT/GDP	WDI	2000-2009
LNOPEN	Value of exports and imports over GDP	WDI	2000-2009

Results and Discussions

Our findings based on the fixed-effects and random-effects models are summarized in Tables

Broadly, the results of both models confirm the expected relationship between the Gross Domestic Product on the one hand and ICT and other variables on the other. In both models, the variables representing the sources of growth have the expected signs. Since the models estimated were in logarithmic forms, all estimated coefficients represent elasticities.
In general a regression model of panel data is as follow:

$$H_0 : \beta_0 = \beta_1 = ... = \beta_n$$
$$H_1 : \beta_i \neq \beta_j$$

Where $E(U_i) = 0$ and have constant variance. μ_i Include fixed effects that show difference between individual, households or countries especial characteristic. v_{it} is residual term that: $v_{it} \approx IND(0, \delta_7^4)$ First we test heterogeneous between units by F-statistic. If null hypothesis isn't accepted, we use panel data. Null hypothesis is:

$$F(n-1, nt-n-k) = \frac{(RSS_{UR} - RSS_R)/(n-1)}{(1-RSS_{UR})/(nt-n-k)}$$

RRSS: Restrict Residual sum Squares
URSS: Unrestricted Residual sum Squares
N=numbers of units
K=numbers of parameters
Table 2 shows the coefficient of F-test statistics with 7.47 degree of freedom is equal to the number 17.830563 positive and statistically meaningful at the probability level of more than 99 percent.

Table2. Choosing Between Panel Data & OLS (Using F-Test)

Possibility	Degree of freedom	Statistic
0.0000	7.47	17.830563

Table 3 shows Hausman test for choice between Fixed Effect (F.E) and Random Effect (R.E) models. Generally accepted way of choosing between fixed and random effects is running a Hausman test. In Hausman test null hypothesis show Fixed Effect. In according above tests we run the regression whit random effect model (EGLS method).The coefficient of Hausman test statistics is equal to the number 101.131045 positive and statistically meaningful at the probability level of more than 95 percent. This means that Null hypothesis is rejected and we conclude that the best way to estimate the fixed effects.

Table3. Choosing Between Fixed and Random Effects (Using Hausman test)

Possibility	Degree of freedom	Statistic $\chi 2$
0.0000	5	101.131045

Statistically, fixed effects are always a reasonable thing to do with panel data (they always give consistent results) but they may not be the most efficient model to run. Random effects will give us better P-values as they are a more efficient estimator, so we should run random effects if it is statistically justifiable to do so.

Table 4. The effect of ICT investment on economic growth in the D8 member countries

Dependent variable: Log of GDP						
		Model estimation methods fixed effects			Model estimation methods random effects	
Explanatory variables	coefficients	Statistic *t*	Possibility	coefficients	Statistic t	Possibility
Constant factor	-40.80027	-4.354801	0.0001	4.411344	2.207929	0.0315
Total labor force	2.397376	4.594864	0.0000	0.223463	3.246164	0.0020
Gross domestic capital formation	0.871937	4.349334	0.0001	0.027252	3.785323	0.0004
Investment in ICT	0.629542	10.025721	0.0485	0.183977	2.365276	0.0216
Technical and technological development(FDI)	0.047278	1.724493	0.0912	0.209413	10.97333	0.0000
Degree of economic openness	-0.274671	-1.643813	0.1069	-0.609772	-8.213485	0.0000
R-Squared		0.960316			0.974168	
Adjusted *R-Squared*		0.950185			0.971776	
F-statistic		94.78089		0.0000	407.2804	0.00000

Table 4 shows the effect of ICT investment on economic growth in D8 member countries. Investment in ICT, gross domestic investment, human capital and direct foreign investment show a positive effect while Degree of economic openness show a negative effect on economic growth of D8 member countries.

Since ICT plays such a vital role in economic growth, there is no doubt, that government takes great part in promoting the awareness of the benefits associated with the use of ICT, but it is imperative to set up some independent bodies that would be actively involved in monitoring ICT performance in the economy, and make suggestions on improvements. The coefficient of ICT investment is positive and statistically meaningful at the probability level of more than 95 percent. Since all variables are in logarithm, the value of 0.62 for the ICT coefficient means that the elasticity of economic growth within the D8 member countries is actually 0.62 implying that a one percent increases in ICT investment would lead to a 62 percent economic growth in these countries. The gross domestic investment (K) coefficient in the estimated model is 0.87 and statistically meaningful at the probability level of more than 99 percent which implies that non-ICT investments also had a positive and meaningful effect on economic growth of the D8 member countries. The foreign Direct Investment (FDI) coefficient that is an indicator of the technical and technological indices of the model is positive, equal to 0.047 and acceptable at about 95 percent confidence level.

The sign of Total employment is positive and statistically meaningful at the probability level of more than 99 percent. It appears that in spite of some improvements in labor force in the D8 member countries. it is still necessary for businesses to think of ways of consolidating the trend, the maximize the benefits brought by the use of this technology. This could be achieved through regular technical optimization with the prime quest for speed, security and multifunction.

Moreover, a dynamic management with strong development focuses. It is also worth noting that flexibility in international trade laws is predominant in ensuring that businesses are able to import ICT goods of their choice and specification, from different parts of the world. The sign of Degree of economic openness is negative but it is not meaningful fixed effects.

Does the speed of ICT development affect the speed of economic growth? It is possible to say that if recent ICT developments have contributed enormously to economic growth in a short amount of time, in economic terms, then, there seems to be a positive correlation between the two. Hence, R&D in ICT must be encouraged and measured against the needs and demands of the market.

Summary and Conclusions

This paper concentrated on exploring effect of ICT on economic growth in the D8 member countries. ICT in D8 have for several decades been called on to support the transfer of business practice that has been considered to be effective in the successfully competitive economies, such as business process re-engineering, integrated enterprise information infrastructures, or customer relationship management systems. More recently, they have been channeling their professional skills into e-government projects, which have involved them in intervening in the explicitly political setting of government administration. There is a widespread expectation that government can be transformed into a network of rationalized institutions, as seen desirable from a contextual view of economic development. There results of the growth model estimations with ICT as an explanatory variable using Panel Data method in the context of the D8 member countries show that ICT has a meaningful effect on the economic growth of these countries. The coefficient measuring the effect of the ICT gross domestic investment on economic growth was positive, indicating that ICT investments affect economic growth of the D8 member countries in a positive way. Direct foreign investment coefficient, which is the technical and technological index of the model, is positive and meaningful at the probability level of about 95 percent. This shows that direct foreign investment growth has a positive effect on the economic growth of D8 member countries. The D8 member countries were left with the alternative of using their internal resources for investment to keep production and job creation. The positive and meaningful coefficient of gross domestic investment in the estimated model points to the direction of this argument.

Another variable is the degree of economic openness that has a negative but it is not meaningful effect in D8 member countries.

Since ICT can play a vital role as a mean for economic growth, it becomes necessary for the D8 member countries to encourage the utilization of ICT in order to boost economic growth. From the results presented in this paper some tentative conclusions can be drawn. The D8 member countries cannot get the full benefits of ICT unless they have the social and cultural Infra-structures and skills required for utilizing ICT's capabilities. It is essential for governments to provide the society with information and on-time services and to educate people on how to use ICT. They should encourage institutions, which are active in the field of ICT. Since direct foreign investment is a technological variable of the model and has a positive effect on economic growth, it is crucial for D8 member countries and to be more active in attracting direct foreign investment. To fill the gap that exists between D8 member countries and the leading countries in the field of ICT development, it is essential to allocate and ensure necessary financial resources for investing in network infrastructures and technology with the aim of providing new potentials in D8 member countries.

REFERENCES

1. Mansell, R. and When, U. (1998). *Knowledge Societies: Information Technology for Sustainable Development*. Oxford: Oxford university press.
1. Pohjola, M. (2000). Information Technology and Economic Growth: A Cross- Country Analysis. *WIDER/ UNU Working Paper series*, WP173.
2. Haacker M. & Morsink J. (2002).You say you want a revolution: Information Technology and growth. *IMF Working Paper*,WP/02/70
3. Dewan, S. & Kraemer, K.L. (1998). International Dimensions of the Productivity Paradox. *Communications of the ACM*, Vol. 41(8), pp.56-62.
4. Ambert M. & Chapell K. (2003).Education, dualisme régional et développement économique : Le cas de 14 Etats Indiens (1970-1993). *Revue Région et Développement*, n° 17.
5. Satti, S., Nour. O. M. (2002). The Impact of ICT on Economic Development in the Arab world: A comparative study of Egypt and the Gulf countries. *The United Nations University (UNU)-Institute for New Technologies (INTECH)*.
6. Aghion P. and Howitt P. (1998). *Endogenous Growth Theory*. Cambridge. Mass. MIT Press.
7. Freeman, C. & Soete, L (1985). Information Technology and Employment: An Assessment. *SPRU Sussex* . UK.
8. Freeman, C. & Soete, L (1994). Work for all or Mass Unemployment ? Computerized Technical Change into the Twenty – first Century. London, Printer.
9. Freeman, C., & Soete, L. (1997). *The Economic of Industrial Innovation* (3rd ed.). London: London and Washington Printer.
10. Jorgenson, D., Vu, K. (2005). Information Technology and the World Economy. *Scandinavian Journal of Economics*, 107(4), pp. 631-650.
11. Youngsang C., Jongsu L., & Tai-Yoo K. (2007).The impact of ICT investment and energy price on industrial electricity demand: Dynamic growth model approach. *Energy Policy*, 35(9), pp. 4730-4738.
12. Cho, Y., Lee, J. & Yoo Kim, T. (2007). The impact of ICT investment and energy price on industrial electricity demand: Dynamic growth model approach. *Energy Policy*, 35, 4730-4738.
13. Rimm, B., Mouelhi, A. (2009). Impact of the adoption of information and communication technologies on firm efficiency in the Tunisian manufacturing sector. *Economic Modelling*, 26(5), 961-967.
14. Khuong M.V. (2011). ICT as a source of economic growth in the information age: Empirical evidence from the 1996–2005 period. *Telecommunications Policy*, *35(4)*, pp. 357-372.
15. Dimelis S. D., Papaioannou S. K. (2010).ICT growth effects at the industry level: A comparison between the US and the EU. *Information Economics and Policy*, 23(1), 37-50.
16. Martínez, D., Rodríguez, J., & Torres L.J. (2010).ICT specific technological change and productivity growth in the US: 1980–2004. *Information Economics and Policy*, 22(2), 121-129.
17. Seo, J.H., Young, S.L., & Hun, O. J. (2009). Does ICT investment widen the growth gap?. *Telecommunications Policy*, *33(8)*, *PP. 422-431*.

18. Jorgenson, D. W., & Stiroh K. (1995). Computers and growth. *Economics of Innovation and New Technology*, 3=4,295-316.
19. World Bank, (2010), World Development Indicator 2010, World Bank.
20. World Information technology services Alliance, http://www.witsa.org/v2/

MARMARA ÜNİVERSİTESİ 1883
MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Integrate Remanufacturing In The Design Process: Design For Remanufacture (Dfrem)

Cem Çağrı Dönmez[1] , *Rosalba Prisinzano* [2]

Abstact

Companies that deal with the theme of Recovery in the development phase of a new product, abandon the traditional logic-based assessments at the end of the life cycle in order to verify the feasibility of the recovery itself and to identify the most appropriate strategy. In this case the recovery strategy is defined in advance and evaluated over a longer time horizon, so combined with the competitive edge. Addressing the issue of remanufacturing of a product in the design phase allows you to grapple with this challenge, in the stadium where there are fewer constraints and at the same time the best opportunities to simplify treatment, which is particularly complex and characterized by peculiar problems.

The aim of this paper is to present the state of the art on Design for Remanufacturing and control this type of design as part of a broader business strategy, with a view to a sustainable business of remanufacturing.

***Keywords*:** Re-Manufacturing, Sustainable Business of Re-Manufacturing

Introduction

In this paper we analyze how the "Design for Remanufacture" is a useful tool, able to reduce the cost and increase the profit margins of a company that aims to protect the environment to make a sustainable economy.

As part of ecodesign - an instrument which aims the reduction of 'environmental impact of production and the entire life cycle of the product thanks to the improvement of manufacturing operations - remanufacture is becoming a common technique, which is to regenerate a new product from an obsolete or a one who reached his end of life.

The concept of "design for Remanufacture" (DfRem) stems from the awareness that the decisions made during the design process can have a dramatic effect over the efficiency and effectiveness of the remanufacturing process.

This paper is divided into six sections and place the order to highlight how valid as economic, social and environmental choice to integrate the remanufacture in the design process.

[1] Cem Çağrı Dönmez, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, cem.domez@marmara.edu.tr

[2] Rosalba Prisinzano, Scuola Politecnica Di Palermo, Department of Chemical, Management, Computer Science and Mechanics engineering, Palermo, Italy, rosalba.prisinzano@studenti.unipa.it

Recovery of the product at the end of its useful life

Recovery of the product, alternative to the traditional disposal, is a response to environmental protection. Recovery, in fact, minimizes the demand for energy and raw materials, and the environmental impact of the refusal, and also gives the opportunity to start a profitable business. The environmental issues and eco-sustainability on one hand, and, on the other hand, the cost of the process, are, then, combined.

A sustainable type of closed loop must be adapted to some basic principles:

- Reducing waste by extending the useful life of the product;
- Re-use of the product / waste through practices reconstitution;
- Recycling of waste for the recovery of raw materials still useful;
- Use of landfills for the disposal as a last alternative.

A closed loop system includes distribution, product recovery and the final rejection management. Products and / or components that come back through the system of reverse logistics can be directly sold, recovered or disposed.

The products which are located in the last stage of their life cycle can be recovered through the use of 5 alternative strategies that have different levels of efficiency. They are: reuse, repair, reconditioning, remanufacture or recycle.

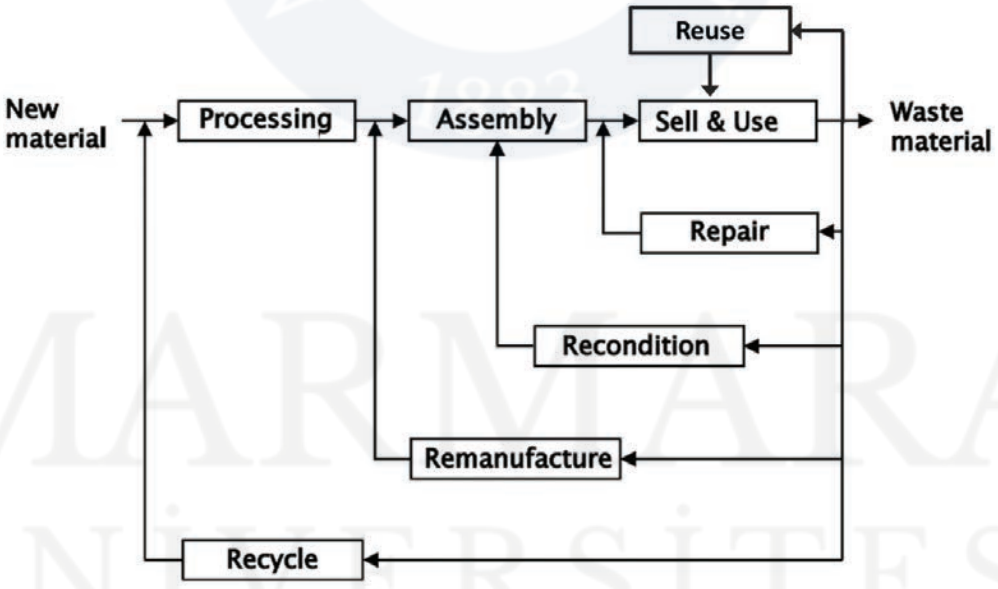


Figure 1. Closed loop design through reuse, repair, reconditioning, remanufacture or recycle

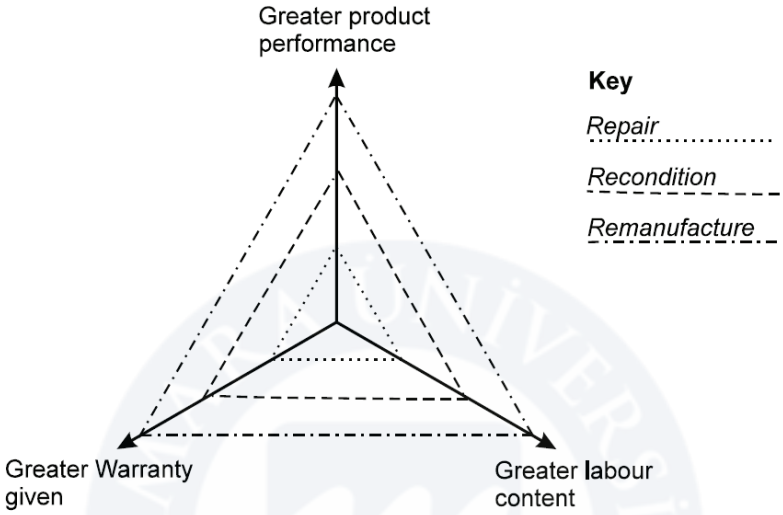


Figure 2. Hierarchy of recovery processes (Ijomah W., 2002)

In the figure above the fundamental differences between the strategies remanufacture, reconditioning and repair, based on three dimensions, are highlighted; the three dimensions are: level of offered warrant; promised performance; the content of work required in the treatment. It's clear that the best strategy is remanufacture.

The meaning of remanufacture

The definition that best expressed the meaning of remanufacture is to Ijomah:

" *Among the different recovery options at the end of life, this is the only one that shows the products used at least to the specific performance of the Original Equipment Manufacturer (OEM) and, at the same time, provides a guarantee equivalent to that provided for new*."

(Ijomah, 2002)

Moreover, we can also define remanufacture as an industrial process in which the product and its functional core is restored to life.

During this process the product passes through a series of steps: inspection, disassembly, replacement / reconstruction of parts, cleaning, assembly, testing and trials. All this allows this technique to be mainly applicable when recovered products maintain a relatively high added value compared with the valuation of the market or to their original cost.

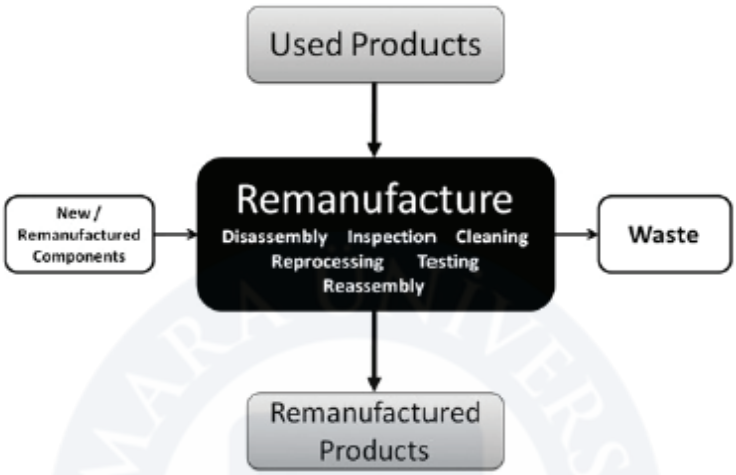


Figure 3. Illustration of a process of remanufacture

Among all the practices that invest used products intended to be reusable, this requires the highest use of resources and offers superior quality and durability. This is justified by the fact that the product needs to be removed in all its components that will be subjected to restoration or replacement, depending on the case.

Very often remanufacture is considered the final most advantageous option to make the product, even the most evolved form of recycling. Indeed, researchers Gaudette and Giuntini say that the energy consumed to start the product to a new cycle is, on average, approximately 20 - 25% of that required for brand new production, while the final cost is approximately 60% of that of first manufacture.

It's important to note that, recycling, in a profitable and environmentally sustainable model as the remanufacture, must represent the last step after the product is returned at the end of its life cycle.

Design for Remanufacture

The concept of "design for Remanufacture" (DfRem) stems from the awareness that decisions made during the design process can have a significant effect on the efficiency and effectiveness of the process of remanufacture.

Research has shown that the efficiency and effectiveness of the process of remanufacture are very decisions dependents during the design process (Ijomah et al., 2007). There are certain characteristics of the product that influence remanufacturability, and, therefore, have effect on the feasibility and profitability of this business strategy (Charter and Gray, 2008), as well as environmental saving (Kerr and Ryan, 2001).

Companies that deal with the theme of the recovery in the development phase of a new product forsake the traditional logic based on evaluations at the end of the life cycle, in order to verify the feasibility of the recovery itself and identifying the most appropriate strategy. In this case, the recovery strategy is defined *a priori* and evaluated over a longer timescale, so combined with the competitive edge.

Product remanufacturing adressing, during design phase, allows to simplify the treatment in the stadium where there are fewer constraints and, at the same time, the best opportunity to simplify and speed up a complex process characterized by peculiar problems. In this type of design is essential to pay attention to logistics, demand and technology of the recovery process of the generic product.

Remanufacturing starts from the core. Aspects such as the shape, the material, the connections between the components / modules may affect the way they approach the process. Design for remanufacture has a key role in the development of this business. The design itself can be considered a variable profit.

The remanufacturability of a product through a targeted design is affected by its physical characteristics determined during the design phase. The DfRem facilitates the treatment and can be understood as a two levels methodology:

- Configuration of the business model and product strategy (sales, marketing, after-sales and reverse logistics);
- Design and engineering of the product, strictly speaking.

Designing for the remanufacture means optimizing the process, configuring and establishing *a priori* the start of a business, defining the cost structure, the image, the company policy and evaluating the intensity of competition, the feasibility and potential gains (Willim et al., 2001).

Usually, using the definition of Design for Remanufacture, reference is made to the design in a strict sense, shifting the emphasis from the business model and strategy product.

The four areas of intervention, at the time in which it develops a product that will undergo a process of remanufacture, are:

- Its complexity;
- The coupling methods;
- The tools for assembly and disassembly;
- The increasing fragility of the components.

The company, in order for earn profit from the rework of the product, need to minimizing operating costs during consumption and maximizing the value of the product at the end of the life cycle.

DfRem is divided into a series of submethodologies that may also have divergent objectives according to the cases. These techniques, known as "Design for X", focus attention on different activities of the entire process of remanufacturing as is shown below.

Table 1. Design for X in the stages of a process of remanufacture (Gray, et al., 2007)

DESIGN STRATEGY	REMANUFACTURE PROCESS						
	Core Collection	Inspection	Disassembling	Cleaning	Restoring	Assembling	Testing
Design for Core Collection	✓	✓					
Design for Disassembly		✓	✓	✓	✓	✓	
Design for Multiple Lifecycles				✓	✓		
Design for Upgrade					✓		
Design for Evaluation		✓					✓

The following table lists the typical design problems that must be addressed in the various phases. An approach that follows the logic diagram of the table simplifies recovery and improves remanufacturability.

Table 2. Product design in order to simplify the steps of a process of remanufacture (Shu et al., 1999)

Process	Design Drivers	Motivations
Collection	Eliminate protrusions in the product's geometry	- Minimize possible damage during the transit - Simplify the storage
Disassembling	Reduce the quantity and variety of closures Use standard closures	- Reduce the tools to use - Reduce the time of the operation
Sorting	Using identical or similar parts	- Reduce the resources required to separate parts
Cleaning	Avoid forms that tend to attract dirt like grooves and recesses Use appropriate materials, shapes and colors	- Improve access to tools and cleaning fluids - Reduce exposure to dirt and possible damages during this phase
Inspection	Thoroughly and explicitly indicate the remaining life of the components	- Reduce efforts to verify the reusability of the component
Restoring	Design components that do not break; or concentrate defects and wearing course in removable or replaceable parts	- Reduce the need to resort to methods of labor-intensive or capital-intensive to restore

Implementation Strategies of DfRem

According to Hatcher, Ijomah and Windmill, the most effective way to promote the remanufacture is an integrated approach to the design process and product.

Production process level, it is possible to record economies of scale and development of skills in managing large variety of products, aiming to eliminate non-value added activities, based on feedback from an integrated production system. From this, Design for Remanufacture arises, that is, a sensitive design from a point of environmental view, and, in particular, oriented to the product remanufacturing.

Product development, in a strict sense, kicks off with the definition of the concept, an approximate illustration of the operating principles, shape and technology.

Among more concepts, which take form by the improvement of different aspects of the same idea, it's possible to select the one considered the most efficient and that better responds to the customer's needs. Later it's moved to the overall design process, in which we have the definitions product architecture, to achieve harmonization of the components and to translate the expectations of consumers in terms of technology, functional or market. The development cycle is closed with the phase of experimentation and testing, that validates the solution waiting for mass production. The decision to proceed with core or end-of-life product remanufacturing is take during the development and design stage, in order to eliminate or at least reduce the constraints that may arise as a result (Sundin, 2004).

Pursuins a remanufacture oriented strategy, according Hatcher, Ijomah and Windmill, should not lead to neglect other recovery options at the end of life. When it is not profitable to continue with the remanufacture, it is proceeded with residual options, such as recycling of materials.

From what was said, it is clear that a remanufacture strategy consists of three levels corresponding to the same number of treatments, which will be implemented according to the conditions of the core:

- Products remanufacture;
- Cannibalization of components;
- Materials recycling.

Only cores that meet prefixed standards are full recovered, while for others recovery is focused on individual parts or the simple recovery of the raw material.

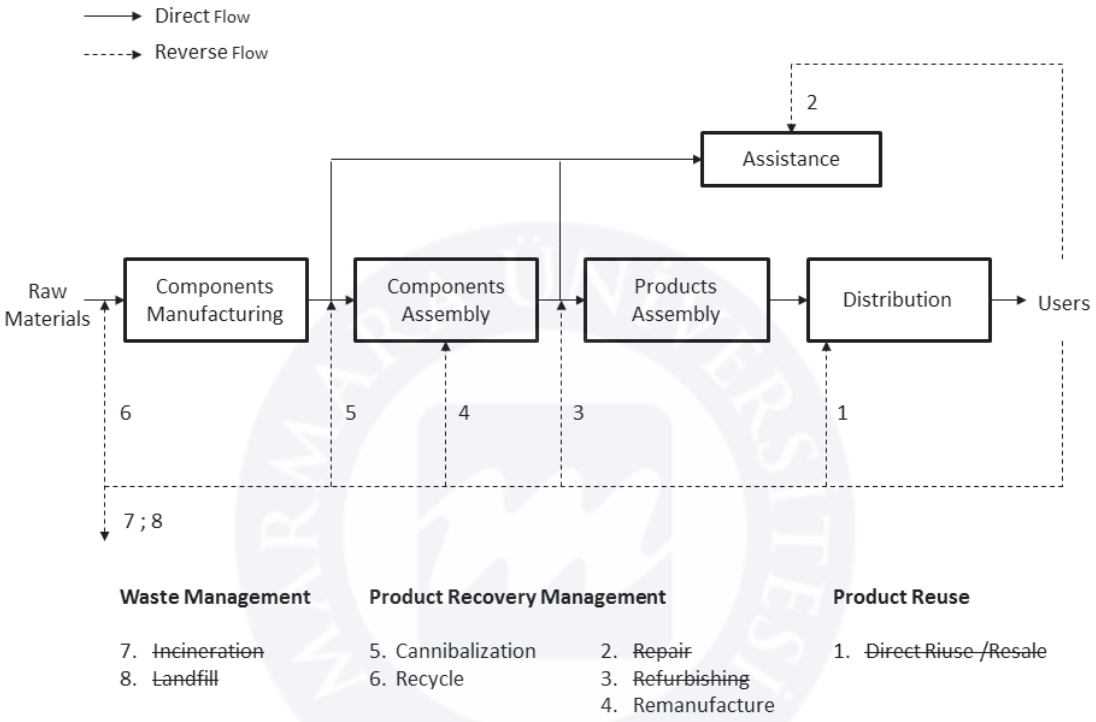


Figure 4. Mix of remanufacturing strategies (Thierry, et al., 1995)

As shown in the figure above, the goal, therefore, is to close product cycle, before it becomes waste. At the same time, however, to maximize the final result, it's not considered to direct reuse the good and repair as a compromise option, due to their unattractiveness, according to the business model outlined.

Benefits of the Design for Remanufacture

Environmental's Returns

Through a process of remanufacture and the integration of the same in the design process you can get a greater recovery of resources compared to other forms of recycling. According to the Energy Systems Division of Argonne National Laboratory, through this kind of activities it is allowed to save the equivalent of 422 * 10 ^ 21 J of energy per year. This energy, in terms of traditional production, would be used to build new components, and so it saves about 80%.

Products that have undergone a process of remanufacture, are kept out of the waste cycle for a long time, preserving landfill space.

Economic Issues

The recovery of the product can be a profitable business. The Design for Remanufacture, in particular, can allow a reduction in prices of 35 - 40% compared to new products and margins on average increased by 20% (Nasr et al., 1998).

Cost reduction can ensure appropriate returns on giving the company a competitive advantage and benefits to the consumer. Cost reductions not only affect the recovered product, but also first manufacturing goods. When selling recovered products, the consumer can take a threefold function: buyer of new products, buyer of products recovered but, first, a provider of end of life products. The company can exploit this situation to his advantage, especially when the markets are distinct and there is no danger of demand substitution.

Among the benefits of a design that integrates the remanufacture we can find the attainment of economies of scale due to the experience.

Hatcher and Ijomah, note that ethical and environmental reasons are not enough to justify investment by businesses. Each company makes investments with the aim to have profit, therefore it is necessary that they find affordability recovery.

In most cases, it's legislative obligations, government incentives, subsidies by agencies and the possibility of being able to have tax breaks, to push companies into the remanufacture.

Company Policy Motivations

Aspects concerning policy and business strategy, although not related to the immediate-profit, are particularly important for OEMs. In this set are included the connotation of the brand, the company's image, the aftermarket, and feedback on products. The image is a very critical factor in a successful business because it is built only through shrewd marketing policy and huge investments diluted over time.

The company that gives value to its greater environmental awareness, also guaranteed by the remanufacture, may create a enviromental friendly image. A fundamental element, so this approach is awarded by eco-friendly market, is its fair presentation highlighting the commitment made by the company and providing data that emphasize the benefits obtainable by consumers and all stakeholders.

Basically, the information can be of two different types: it can be associated with the least environmental impact of good and / or linked to its performances. These two types are not mutually exclusive with each other but, rather, is on their synergy that the company can achieve the best results in terms of image return.

Start recovery activities, through the collection of end of life products is a way to preserve the aftermarket by competitors or potential parties.

The Design for Remanufacture allows to constantly monitor customer needs and constraints of the products. Specifically, the most critical data are those which relate to the deterioration during the use since many conditions are impossible to simulate in the testing phase.

Guidelines and Design Standards

According to Ijomah, an approach based on the design for remanufacture should rotate primarily on:

- Coupling Methods;
- Product complexity;
- Used materials.

The complexity of coupling methods has an impact on the resources necessary to proceed to disassembly, in some cases, making it impossible.

The complexity of the product depends on the number of components, their internal allocation and the use of a modular design.

Designing durable and wear-resistant components, favors the preservation of the value added and simplifies the operation to be carried for the restoration and cleaning of the same.

As for the components' durability we need to consider that a too pusher design on this aspect could run the risk of extending the useful life of the good over the cycle of the technology; therefore, a differential design could be considered: ie, designing a structure in which the parameters of strength and durability are less stringent for some components easily subject to change.

Factors affecting the DfRem

Generally these factors fall into three main classes: technical factors, market and operational. The research carried out by Ijomah (2007), have also led to the development of a set of guidelines that may be followed by a designer in order to improve the ability to apply the remanufacture to a product. The figure below shows an overview of these technical factors.

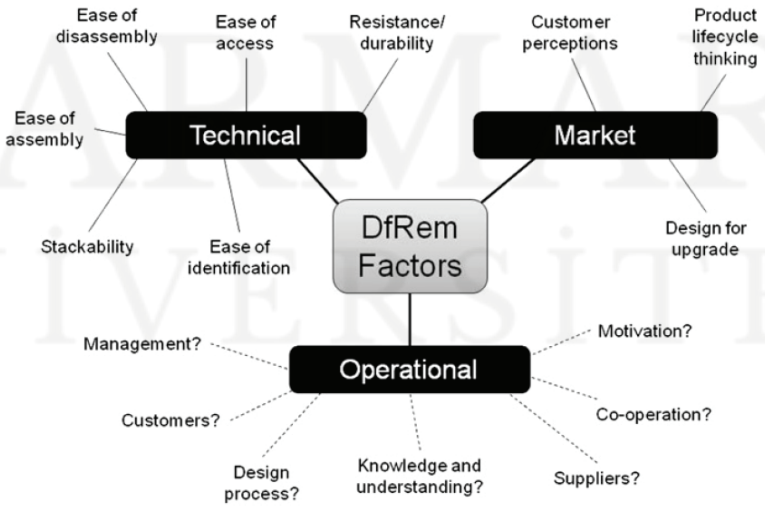


Figure 5. Map of the factors influencing DfRem (Hatcher, Ijomah - 2012)

Technical and market factors stem from research on remanufacture. The operational factors stem from research on eco - design and can be applied to the Design for Remanufacture, as will be explained later.

Technical Factors

Hatcher (2011), states that, in recent decades, DfRem was one of the topics more thorough researched on remanufacture. Most of the publications to date has focused more attention on technical factors that influence the remanufacturability of a product: product characteristics and features that can make a positive impact, or negative, on the process of remanufacture, depending on decisions taken during the development of new products.

Sundin (2004) presents a particular diagram, called "RemPro Matrix," which provides a detailed scheme of these technical factors, specifying which factors have a greater impact on each stage of the process of remanufacturing. Below is reported a generic diagram "RemPro Matrix".

Remanufacturing Step / Product Property	Inspection	Cleaning	Disassembly	Storage	Reprocess	Reassembly	Testing
Ease of Identification	x		x	x			x
Ease of Verification	x						
Ease of Access	x	x	x		x		x
Ease of Handling			x	x	x	x	
Ease of Separation			x		x		
Ease of Securing						x	
Ease of Alignment						x	
Ease of Stacking				x			
Wear Resistance		x	x		x	x	

Figure 6. Example of RemPro-matrix that illustrates the relationships characteristics sought in the product

The identification of technical factors contributed to the development of a number of methods and design tools in order to help designers to adapt their products to remanufacture. Some of these methods and tools have been developed specifically with the objective of integrating remanufacture in the process of product design and consider both purely quantitative characteristics, in particular metrics, qualitative, as the selection of the core. More complete methods have also been proposed, already used in the design, such as QFD (Quality Function Deployment) or FMEA (Failure Mode and Effect Analysis).

Although this type of approach has the advantage of being easily integrated, these methods and tools, however, do not address all the technical factors that influence the remanufacturability of a product.

It remains to find an appropriate approach to ensure that these factors are succesfully integrated throughout product development process.

Market Factors

Instead of technical factors, market factors have been widely neglected in studies and in articles published until now (Watson, 2008). However occasionally it is possible to find references to the challenges that the market factors faced by companies involved in the design and sale of remanufactured products.

When the remanufacturing is a successfull business venture, there is often a strong market demand for remanufactured products. However, there is a significant challenge in overcoming the perception of the consumer that a reconstructed product is not a product of "second-hand" and therefore of lesser quality than an equivalent newly manufactured. This difficulty is reflected in the fact that the remanufactured products are generally sold at a lower price (despite the same quality of a new Product) due to the lack of knowledge of the process of remanufacture by the customers. Therefore, customer acceptance is clearly an important factor in determining the success of the remanufacture.

Other market factors that pay attention are the life cycle of technology and fashion. To overcome this problem the authors suggest that the product should be rebuilt an easily upgradeable with the latest requirements or specifications most requested by customers.

Industry Implication

As claimed by Hatcher, Ijomah and Windmill, each management team, which tries to integrate issues related to remanufacture in its product development process, must be aware of operational factors, as well as the technical requirements.

Among the factors previously identified, some are easier to control than others. It is unrealistic to expect that you modify a business model to achieve the application of DfRem; on the contrary, any approach to DfRem must be adapt to the business model.

Attitudes and levels of commitment are difficult to change, even if it is not impossible with the right level of knowledge and understanding by managers and designers. Indeed, the designers often need to know practical examples of green design, that is, they need some kind of "inspiration".

The communication between the corporate body responsible for remanufacture and the designers plays a key role in a company. The company must always strive to actively improve the communication factor. Comunication must influence and inspire the designer.

The details of the design process are further checked by the project manager. As well as the simple introduction of new technical guidelines, an additional tool to control are the design reviews, which provide an opportunity for the adoption of proactive measures to integration of DfRem.

Next steps: mapping the DfRem integration

Hatcher, Ijomah and Windmill point out that product development can be described as a "human system - activities", this means that it is unlikely that the factors influencing the integration of Design for Remanufacture are effective even considered individually, because they are interdependent. It is, therefore, important to be able to develop a model of "integration network of DfRem". An understanding of the relationships and priorities between the various factors will allow the project team to see a company overview, enabling a more effective approach in making decisions that affect the integration of DfRem.

CONCLUSIONS

Today, all that might at first glance be considered a refusal, can be almost always looked in a different light, in some cases becoming a source not only of energy but of income, this is the case of remanufacture.

The possibility of applying the remanufacture of a product depends on a combination of variables, passing from the analysis of the application, the stability of the technology, the process and by their low environmental impact. Undoubtedly the remanufacture is a viable alternative for the recovery of the product come to the end of its useful life, but it is even more so if it is a conscious decision taken already during the design phase. The integrated design should be considered by companies as a very attractive business opportunity because it is able to generate competitive advantage.

The Design for remanufacture allows manufacturers to create environmentally friendly image for the company that can bring more opportunities to profit given that today more and more consumers decide to buy according to their own values. This, blended with a more customer information and greater public awareness of the social benefits of a remanufactured product, would alleviate the distrust of buyers so that they no longer have a wrong perception of the product.

The improvements due to the integrated design of the product are not only in terms of environmental impact and sustainability, but are translated into lower costs for companies which limit the supply of raw materials from suppliers and maximize the added value of its products, resulting in change of added benefits not only on the image, but also in terms of feedback on products, customer relationships and increased profits.

Although a good integration of DfRem requires substantial investment by companies, they should try to win their resistance to change, reconfigure their activities in order to obtain the best performance, but, above all, to create a cultural change, understood as a transformation of their mentality so as to achieve the possibility to capitalize on their product know - how generating economies of learning, based on the application of remanufacture, that lead to a clear reduction of time and costs of production.

REFERENCES

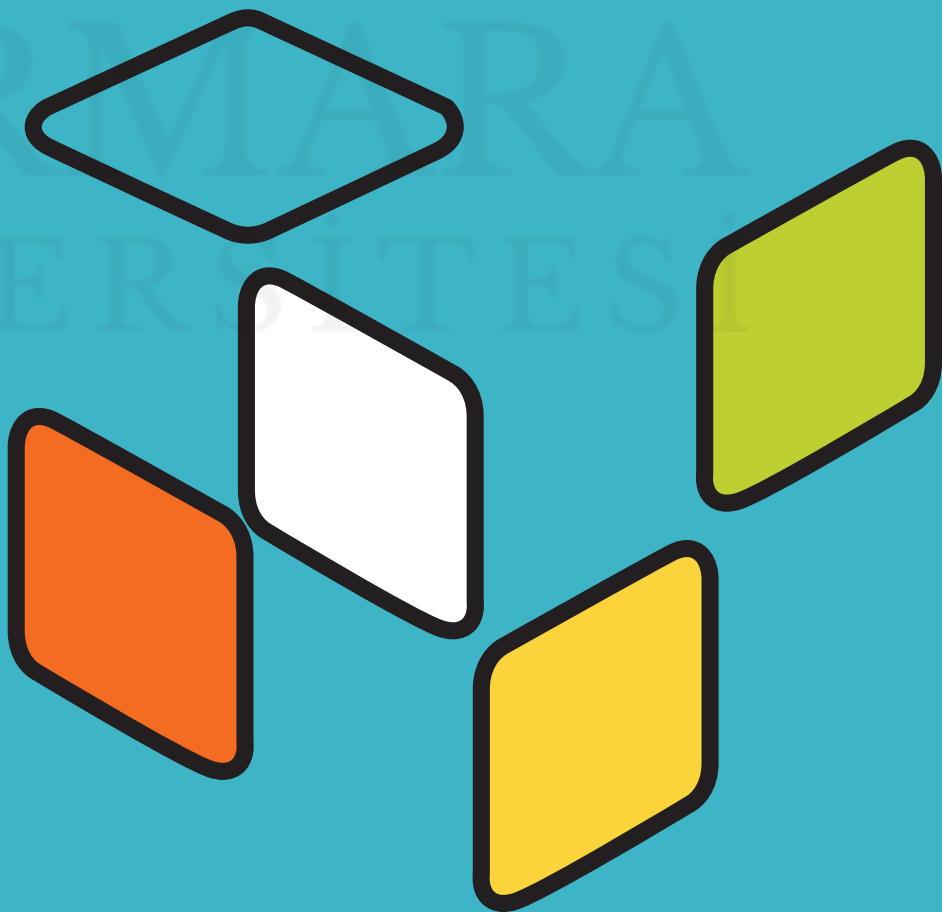
1. Hatcher G.D., Ijomah W.L. , Windmill J.F.C., 2013. Integrating design for remanufacture into the design process: the operational factors. Journal of Cleaner Production 39 (200 - 208).
2. Hatcher, G., Ijomah, W., et al., 2011. Design for remanufacture: a literature review and future research needs. Journal of Cleaner Production 19 (17e18), 2004 e 2214.
3. Watson, M., 2008. A Review of Literature and Research on Public Attitudes, Perceptions, and Behaviour Relating to Remanufactured, Repaired and Reused Products. Centre for Remanufacturing and Reuse. The University of Sheffield.
4. Sundin, E., 2004. Product and Process Design for Successful Remanufacturing. Linkopings Universitet.
5. Sundin, E., Bras, B., 2005. Making functional sales environmentally and economically beneficial through product remanufacturing. Journal of Cleaner Production 13, 913 e 925.
6. Subramoniam, R., Huisingh, D., et al., 2009. Remanufacturing for the automotive aftermarket-strategic factors: literature review and future needs. Journal of Cleaner Production 17, 1163 e 1174.
7. McIntosh, M., Bras, B., 1998. Determining the value of remanufacturing in an integrated manufacturing-remanufacturing Organization. Proceedings of the DETC98 ASME Engineering Technical Conferences, Atlanta, pp. 1 e 12.
8. Lam, A., Sherwood, M., et al., 2000. FMEA-Based Design for Remanufacture Using Automotive-Remanufacturer Data. Department of Mechanical and Industrial Engineering University of Toronto, Toronto.
9. King, A., Burgess, S., et al., 2006. Reducing waste: repair, recondition, remanufacture or recycle? Sustainable Development 14, 257 e 267.
10. Ijomah, W., McMahon, C., et al., 2007. Development of robust design-for remanufacturing guidelines to further the aims of sustainable development. International Journal of Production Research 45 (18), 4513 e 4536.
11. Hazen, B., Overstreet, R., et al., 2012. The role of ambiguity tolerance in consumer perception of remanufactured products. International Journal of Production Economics 135, 781 e 790.

12. Bras, B., Hammond, R., 1996. Towards Remanufacturing - Metrics for Assessing Remanufacturability. 1st International Workshop on Reuse. Eindhoven, The Netherlands, pp. 35 e 52.
13. British Standards Institution, 2011. ISO 14006:2011: Environmental Management Systems e Guidelines for Incorporating Ecodesign.
14. Charter, M., Gray, C., 2008. Remanufacturing and product design. International Journal of Product Development 6 (3 e 4), 375 e 392.
15. Lily H. Shu, Woodie C. Flowers, 1999. Applications of a design-for-remanufacture framework to the selection of product life-cycle fastening and joining methods. Robotics and Computer Integreted Manufacturing 15 (179 – 190).
16. Barquet A. P., Rozenfeld H., Forcellini F. A.,2013. An integreted approach to remanufacturing: model of remanufacturing system. Jurnal of remanufacturing, 3:1.
17. Ghoreishi N., Jakiela M. J., Nekouzadeh A., 2011. A cost model for optimizing the take back phase of used product recovery. Journal of Remanufacturing, 1:1.
18. Biswas W. K., Duong V., Frey P., Nazrul Islam M., 2013. A comparison of repaired, remanufactured and new compressors used in Western Australian small- and medium – sized enterprises in terms of global warming. Journal of Remanufacturing, 3:4.
19. Amaya J., Zwolinski P., Brissaud D.,2010. Environmental benefits of remanufacturing: the case study of the truck injector. G-SCOP Laboratory, Grenoble, France.

20. http://www.springer.com/engineering/journal/13243
21. http://www.epa.gov/ems/
22. http://www.oecd.org/
23. http://www.remanufacturing.org.uk/reuse-repair-recycle.lasso
24. http://www.srl.gatech.edu/education/ME4171/
25. http://ec.europa.eu/environment/ecolabel/
26. http://www.sepa.org.uk/waste/wasteregulation/producerresponsibility/weee.aspx
27. http://www.greenactions.it/viewdoc.asp?co_id=98
28. http://www.reman.org/AboutReman_main.htm
29. http://www.sustainability-indices.com/
30. http://definitions.uslegal.com/r/remanufacturing/

MARMARA ÜNİVERSİTESİ YAYINEVİ

QUALITY MANAGEMENT



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Performance Appraisals as a Quality Management Tool: Literature Review

Zeynep Tuğçe Şimşit[1], Özalp Vayvay[2]

Abstract

Nowadays, in our competitive business conditions controlling and improving quality levels of operational processes is not enough to gain advantages among rivals however as it is well known fact that performance of employee's create a great impulse on improvement, companies also need to examine and evaluate the performance of them as one of the part of their quality management strategies. In this point, performance appraisal which is a systematic and periodic process managed by a manager or consultant which (i) examines and evaluates an employee's work behavior by comparing it with preset standards, (ii) documents the results of the comparison, and (iii) uses the results to provide feedback to the employee to show where improvements are needed, become an important tool to achieve higher quality levels. For enterprises, performance appraisal helps them diagnose whether the adopted strategy and organizational structure will help to achieve their goals. In both ways, performance appraisals directly affect the quality levels in companies. For that reason, this study aims to create a vision for performance appraisals as a quality management tool so a literature review was constructed from the quality management view of point to understand the importance of performance appraisals.

Keywords: Performance, Quality, Strategy

Introduction

Historically, in the every period of time organizations and companies have been adapting themselves to changing conditions to survive and to be successful. Nowadays, global competition affects companies therefore in these business conditions the principal aim of organizations is to remain competitive by adapting changes to their structure. Thus, companies develop new and integrated strategies that let them be much more effective, efficient than ever in every new circumstance.

Quality movement and managing quality has always been one of the major interests of management theorists. Over years, quality movement extended its content and had rapidly internalized by countless organizations whether they are public or private ranging across manufacturing and service sectors [1]. The underlying reason is that the quality management is used in all areas of a company from beginning to end in other terms from the product form that are manufactured until the customer services provided after sales and helps to determine a firm's success in a number of ways. From a competitive business conditions point of view, since quality management can be defined as the "process of controlling, ensuring and improving quality; both in business operations and productivity", advantages that are provided by quality management cannot be ignored.

On the other hand, it is well known fact that performance of employee's creates a great impulse on improvement, so companies also need to examine and evaluate the performance of them as one of the part of their quality management strategies. In organizational life, evaluation of employees effectively and communicating feedback is always considered as a permanent challenge. Although it is a well-known fact that "performance" is itself a vague term, and capable of no simple definition, the measurement of the performance is compelling for managers and management theorists. What is more, the widespread shift from hierarchical organizational structures to more

[1] *Zeynep Tuğçe Şimşit, Marmara University, Engineering Faculty, Industrial Engineering Department, İstanbul, Turkey tugce.simsit@marmara.edu.tr*
[2] *Özalp Vayvay., Marmara University, Engineering Faculty, Industrial Engineering Department, İstanbul, Turkey, ozalp@marmara.edu.tr*

team based structures brings a shift in both the content and the structure of the employee evaluation process. In 2006, as Prajogo and Sohal [2] stated in their study that "The link between organizational strategy, structure and performance is a classical theme in strategic management literature, with the main thesis being that organization strategy determines organizational structure, which in turn influences organization performance [3]-[4]."

Human resource department managers try to lead performance appraisals to provide a variety of benefits such as improvement in performance, creating an opportunity for communication, data for individual decisions, etc. nevertheless Deming [5] identified performance appraisal as one of the seven deadly diseases that stand in the way of the TQM transformation. Besides, there are some studies to suggest continue conducting appraisals with quality movements because of the active, sophisticated nature of today's modern jobs , in this work environment. In this study performance management systems and importance of performance appraisals are examined from the organizations point of view. Then relationships between quality management systems and performance appraisals are considered with existing literature. The main aim of the study is inspecting performance appraisals as a quality management tools and reveal the relationship between them and provide a basis for future researches.

Performance Management and Performance Appraisals

Performance management provides an important integrated framework, both academically and practically [6]. Performance management systems start with aims and objectives. To evaluate performance mainly objectives are used and it is a well-known fact that objectives can be considered as the fundamental requirement for control [7]. Organizations generally meet multiple, competing and sometimes conflicting objectives [8]. Ferreria and Otley [9] tied to describe the structure and operation of performance management systems in their study because these systems are typically set out by managers to meet key partner expectations as Otley mentioned [10]. The conclusion of having to satisfy objectives at the same time is generally that performance becomes a multi-dimensional concept [10].

In 2011, Gruman and Saks [11] determine several stages for performance management process. In literature, generally consist of activities such as setting targets of performance, monitoring performance, facilitation, appraisals and feedback, and improvement [12]-[13]. As Holbrook Jr [14] stated "Performance appraisal has occupied the attention of researchers in human resource management, organizational behavior, and industrial/organizational psychology for many years." Performance appraisals are an important part of organizational life because they can serve a number of purposes. Several studies focused on solving performance problems, setting goals, administering rewards and discipline, and dismissal [15]-[16].The appraisal process is generally presented as the "acquisition of information to provide a rational decision-making and resource allocation" [17]. Performance appraisal establish a system that facilitate managerial control via developing data handling. The individual is given information on how they are doing and what they should be doing differently.

Performance appraisal is defined as "…a measurement of the achievement of organizational goals [18], and the goals of enterprise activities are to enhance business performance." However, Wilson [19] examined the assumptions that underlie the design of appraisal schemes thus identified the difficulties and dilemmas inherent in the process. Galbraith and Schedel [20] pointed out that performance appraisal indicators cannot be determined from a single perspective because of performance management nature. Furthermore, the scope and perspectives are very complicated and extensive. Venkatraman and Ramanujam [21] proposed performances of three areas, including financial performance, operational performance, and organizational effectiveness. To create competitive advantages, Kaplan and Norton [22] proposed using the balanced scorecard. They suggested integrating financial and non-financial indicators for the performance appraisal system.

In 1976, Maier [23] introduced the most common performance appraisal method which involves two stages: calculation of a rating and an interview in which the rating is communicated to the subordinate [23]. Ilgen [16] summarized a number of studies to reveal the effects of dissatisfaction with performance appraisals. Murphy and Cleveland [24] found that criticism and complaints generally based on performance appraisals in many firms.

From this point of view dissatisfaction is vital because employees are only satisfied when final appraisal ratings match their beliefs about their performance [16]. When performance feedback systems are viewed as unfair from employee point of view, employee resistance is increased against change and thus the likelihood of striking back at the system is increased [25].

Prior to 1980s, initial performance appraisal research efforts generally focused on improving the rating instrument. The underlying reason is that at initial studies main assumption is that the design of the evaluation form which is used during the performance appraisal process was the center of evaluation accuracy [26]. On the other hand, recent studies refused this assumption. According to recent studies organizational context, appraisal purpose, and rater motivation have much more importance when determining the evaluation outcomes rather than instrument format [24]-[27]-[28].

Performance management is a critical aspect of organizational effectiveness [29]. However, several studies provide that "…less than a third of employees believe that their company's performance management strategy process lead them in improving performance [13]". In 2002, Beswetherick [30] conducted a questionnaire about performance management systems effectiveness and results show that the majority of managers confirmed that performance appraisal was effective in determining their needs, supporting and monitoring their personal and professional development. Designing the ''right'' performance appraisal instrument is the first step and it is vital especially from employee perception of fairness. Employee acceptance is critical to the implementation [31] and sustaining the benefits of appraisals. If employee has justice concerns about the system, this causes several problems. One of the most critical of them is influence of employee responses to a variety of human resource decisions about pay differences, employee disputes, and layoffs. Moreover, justice concerns can be effective on reactions of both managers and employee about appraisal process. Landy et. al. [32] surveyed managerial and professional employees and found that experience of employees' about performance evaluation systems especially about performance appraisal interview is directly affect the perception of justice. Although there is not too many study about fair performance evaluation, Bretz et al. [33] reported that managers defined justice as the most important performance appraisal issue.

Although performance evaluation can be considered as the heart of performance management system [29], the full process can be extends to whole organizational policies, practices, and design features in other terms any procedure that interact to produce employee performance. This integrated approach represents a regulation to strategic human resources management [34]. Coens and Jenkins [35] stated in their study that human resources management requires performance appraisals in organizations to gain a variety of benefits [35]. As Şimşek et. al. [36] tried to provide objective and fair performance appraisal drivers in their study they also emphasize the importance of what is the importance of performance appraisals for human resource management, such as improving performance of operational level, creating an opportunity for communications, making decisions for employment, and creating individual development plans [36]. Although main aim of performance appraisals are motivating individuals and driving their behavior through the objectives of the organization [37]-[38], application of performance appraisal is not always smooth or productive.

As mentioned before, modern management theories often make it difficult for supervisors to "manage" subordinates' performance. In this continuously changing business environment, some researchers suggested that not managing subordinates' performance will be more effective in terms of focusing on managing the context. In 2007, Lilley and Hinduja [39] stated in their study that "The primary purpose of appraising and coaching employees is to instill in them the desire for continuous improvement." Management of performance should be non-threatening and action oriented [40]. Leeuw and Van den Bergb [41] investigated how performance management practices influence behavior of individuals. They conducted a survey among 102 companies thus identified three independent clusters of operator behavior that positively correlate with performance improvement; "Understanding", "Motivation" and "Focus on Improvement". To avoid resistance, performance management should not only be focused on tasks but also on the relation with operators. Another reason to focus on "facilitating", instead of "managing" performance has to do with developments in performance management

itself. Today, the focus of the performance management process is largely on results, as opposed to personality, behaviors, or competencies [13]-[42].

Environments change, organizations change, and so performance management systems also need to change in order to sustain their relevance and usefulness. Andres et. al. [43] stated that companies have been adapting themselves for changing business and environmental conditions and in this way performance management is one of the fundamental components. The change in the performance management systems applies not only the design infrastructure that supported the performance management systems but also to the way performance management information is used. However, the main issue is not the procedure of change, but rather the extent and type of change. Because it has to be including whole system that performance management taken place and it should be redesign again.

Quality Management and Performance Appraisals

Deming [5] stated that performance is a function of many forces such as the employee, coworkers of employee's, the job and equipment, customer, management and the working environment etc. This situation can be considered as the main reason of variance in other terms not only the individual but the whole system should be hold responsible for variance. Therefore, making fair evaluations for employee performances via performance appraisals cannot be possible. Some quality proponents advocated that "That is, most employees in the organization function at about the same level of performance, and thus it is systems-level features, such as materials and machinery, that are responsible for variations in performance." From employee point of view, they concerned solely with their own performance in these systems because dealing with quality issues in the system can prevent them from achieving higher levels of performance goals.

Waldman [44] suggested advanced group appraisals and a system orientation and Westerman [45] advocated the use for peer raters as an alternative perspective for the compatibility of performance appraisal and quality management. Masterson and Taylor [46] suggested an advanced performance management system in their study that include individual level program with evaluative and developmental components. Cary et. al. [1] used performance ratings as a function of person and system effects on rate performance. Deadrick and Gardner [47] offered the performance distribution assessment system to enhance communication and improve performance with identifying person and system influences in overall performance.

Organizational resistance to the elimination of performance appraisal may be well founded, if appraisal systems make important contributions to organizational effectiveness without impeding the success of quality management operations. In several studies, researches supported the idea that complete abandonment of performance appraisals, create some performance evaluation problems from both employers' and the employee' sides. Cardy and Carson [48] make some logical and statistical analysis to provide some arguments about this concept. Actually it is clearly seen from several studies that quality management systems and performance appraisals can work successfully since they can complete each other in some points.

Organizations adopting quality management systems and performance appraisals together can use this information more efficient rather than organizations in which just performance management systems are using for performance evaluation. What is more, in such organizations in which quality systems and performance appraisals adopted together employee performance expectations will contribute more to overall organizational performance more than will be in the case in organizations adopting only performance management systems. From employee point of view this integrated structure provides higher levels of participation in organizational activities and from supervisor point of view, they have a greater organizational support for their role as coach and stronger intentions to use performance management systems.

On the other side, using performance appraisals as a quality management tool can add values to total quality management system. Kurtzberg et. al. [49] stated that widespread shift from hierarchical organizational structures

to more team based structures comes a shift both the content and the structure of the employee evaluation process. Employees receive more accurate performance appraisals for individual employees and more coaching and development activities from their supervisors. This shift in the role of supervisor or manager creates a great impulse in organizations. The underlying reason is that employees have a better understanding of how their job performance contributes to organizations' goals. From the strategic planning dimension of quality managements system this understanding is critical. From many researches it is stated that employees in organizations adopting quality management and performance appraisals should report higher contributions to quality and organization and higher intensions to participate quality efforts. This analysis is directly related to human resource development and management and has a great importance since Deming [5] has encouraged the importance of rethinking human resource's role in supporting quality. Employees tend to have higher satisfaction with human resource management decisions such as promotions, training and compensation when quality management and performance appraisals use together.

In 1996, Cardy and Carson [48] examined performance ratings as a function of person and system. They stated that continue conducting appraisals in organizations should be studied from both employer and employee perspectives. From employer perspective, documentation of performance appraisals and feedback may be need for legal defense. What is more, appraisal dimensions and standards can operationalize strategic goals. Despite the fact that performance appraisals supported the belief of traditional individual focus, appraisal criteria include teamwork and the teams can be the focus of appraisal itself. From this point of view, employee perspective should be considered. Assessment and recognition of performance levels can motivate improved performance. Cardy and Carson (1996) stated that fairness requires that differences in performance levels across workers be measure and impact outcomes. Again in 1996, Masterson and Taylor stated in their study that rather than being contradictory quality management and performance appraisals may be quite complementary such that each adds value to the operations of other and to organization as a whole.

Conclusion and Further Studies

Performance appraisal is a human resource management tool that has received much attention from several researches [26]. Performance appraisal has occupied the attention of researchers not only in human resource management but also in organizational behavior and industrial/organizational psychology for many years.

In the literature, prior studies focused on improving rating factors for performance management. The underlying reason is that central point was the evaluation accuracy which is only depends on the design of the form. After new concept and trends emerged during recent years, the focused areas shifted from rating factors to purpose of the appraisals. As the business conditions changes organizations has to change their strategies and have wider visions and integrate their management concepts to survive.

Cardy and Carson [48] stated in their study that main challenge for managers and human resource professionals is to adopt traditional human resource management practices to a quality management environment. As Deming advocated in his study that rethinking human resource's role in the organizations have a great importance to support quality. As mentioned before, to integrate academic and real life cases performance distribution assessment method was offered by Deadrick and Gardner [47]. This method show that performance appraisals and quality management principles are compatible with each other the underlying reason is that method helps organizations develop and sustain quality management environments.

Nowadays, not only designing right fair performance appraisal system and facilitating these right systems are enough but also organizations engaged their quality principles their human resource strategies. Employee acceptance is always a critical concept for all organizations to sustain a system but in customer driven conditions this is not enough as long as it is not create value for customer. As a further study, the role of performance appraisals in quality systems has to be analyzed and results should be compared other quality tools. Since it creates an impulse on the performance of the employee, it should be proved that whether there will be a positive

impact on quality level or not. In literature several studies argued that performance appraisals and quality management can be used together however there are such a few study that tried to prove in a mathematical models.

References

[1] Cardy R.L., Sutton C.L., Carson K.P., Dobbins G.H., 1998, Person and System Effects Performance Appraisal: Ratings as a Function of the Degree of Performance Responsibility and Errorfulness, *Journal of Quality Management*, 3, 1, 79-99
[2] Prajogo D.I.,, Sohal A.S., 2006, The Relationship Between Organization Strategy, Total Quality Management (TQM), And Organization Performance—The Mediating Role Of TQM, *European Journal of Operational Research*, 168, 35–50
[3] Chandler A., 1962, Strategy and Structure, *MIT Press*, Cambridge
[4] Miles R.E, Snow C.C., 1978, Organizational Strategy, Structure, and Process, *McGraw-Hill Inc.*, New York
[5] Deming W.E., 1986, *Out Of the Crisis*, MA: Center for Advanced Engineering Study, Cambridge
[6] Otley D., 1999, Performance Management: A Framework For Management Control Systems Research, *Management Accounting Research*, 10, 363-382
[7] Otley D., Berry, A., 1980, Control, Organization and Accounting, *Accounting, Organizations and Society* 5, 231–244
[8] Chenhall, R.H., 2003,. Management Control Systems Design Within Its Organizational Context: Findings From Contingency-Based Research And Directions For The Future, Accounting, *Organizations and Society*, 28, 127–168
[9] Ferreira A., Otley D., 2009, The Design And Use Of Performance Management Systems: An Extended Framework For Analysis, *Management Accounting Research*, 20, 263–282
[10] Otley, D., 2008, Did Kaplan and Johnson get it right?, *Accounting, Auditing& Accountability Journal*, 21, 229–239
[11] Gruman J.A., Saks A.M., 2011, Performance Management And Employee Engagement, *Human Resource Management Review*, 21, 123-136
[12] Armstrong M., 2000, Performance Management: Key Strategies and Practical Guidelines, *Kogan Page Limited*, London, UK
[13] Pulakos E.D., 2009, Performance Management: A New Approach For Driving Business Results, *Wiley-Blackwell*, Malden, MA
[14] Holbrook Jr. R.L., 2002, Contact Points and Flash Points: Conceptualizing The Use Of Justice Mechanisms In The Performance Appraisal Interview, *Human Resource Management Review* 12, 101–123
[15] Dickinson, T. L., 1993, Attitudes About Performance Appraisal, In: H. Schuler, J. L. Farr, & M. Smith (Eds.), *Personnel Selection And Assessment: Industrial And Organizational Perspectives*, Hillsdale, NJ: Erlbaum, 141–161
[16] İlgen D. R., 1993, Performance-Appraisal Accuracy: An Elusive Or Sometimes Misguided Goal? In: H. Schuler, J.L. Farr, & M. Smith (Eds.), *Personnel Selection And Assessment: Industrial And Organizational Perspectives*, Hillsdale, NJ: Erlbaum, 235–252
[17] Townley B., 1992, In The Eye Of The Gaze: The Constitutive Role Of Performance Appraisal, In Managing Organizations, (Eds) P. Barrar and C.L. Cooper, Routledge, London
[18] Robbins S.P., 1990, Organization Theory: Structure, Design, And Application, *Prentice-Hall*, Englewood Cliffs
[19] Wilson F., 2002, Dilemmas of Appraisal, *European Management Journal*, 20, 6, 620–629
[20] Galbraith C., Schedel D.E., 1983, An Empirical Analysis Of Strategy Types, *Strategic Management Journal*, 4(2), 153–173
[21] Venkatraman, N., Ramanujam V., 1986, Measurement Of Business Performance In Strategy Research: A Comparison Of Approaches, *Academy of Management Review*, 11(4), 801–814
[22] Kaplan S.R., Norton D.P., 1992, The Balanced Scorecard Measures That Drive Performance, *Harvard Business Review*, 70(1), 71–79
[23] Maier N.R.F., 1976, The Appraisal Interview: Three Basic Approaches, *University Associates*, La Jolla, CA
[24] Murphy K., Cleveland J., 1995, Understanding Performance Appraisal, *Thousand Oaks*, CA: Sage
[25] Taylor M.S., Fisher C.D., Ilgen D.R., 1984, Individuals' Reactions To Performance Feedback In Organizations: A Control Theory Perspective, In: K.M. Rowland, G.R. Ferris (Eds.) *Research In Personnel And Human Resources Management*, Greenwich, CT: JAI Press, 2, 81–124
[26] Landy, F., Farr, J., 1980, Performance Rating, *Psychological Bulletin*, 87, 72−107
[27] Kozlowski S., Chao R., Morrison R., 1998, Games raters play: Politics, strategies and impression management in performance appraisal, In J. Smither (Ed.), *Performance appraisal: State of the art in practice*, San Francisco: Jossey-Bass
[28] Longenecker C., Gioia D., Sims H., 1987, Behind the mask: The politics of employee appraisal, *Academy of Management Executive*, 1, 183−193

[29] Cardy R.L., 2004, Performance management: Concepts, Skills, and Exercises, Armonk, NY: M. E. Sharpe
[30] Beswetherick N., 2002, To What Extent are Current Performance Appraisal Systems Considered to be Effective in Determining, Supporting, Monitoring and Evaluating an Individual Physiotherapist's Personal and Professional Development?, *Physiotherapy* 88, 11
[31] Latham G.P., Almost J., Mann S., Moore C., 2005, New Developments in Performance Management, *Organizational Dynamics*, 34, 1, 77–87
[32] Landy F.J., Barnes J.L., Murphy K.R., 1978, Correlates Of Perceived Fairness And Accuracy Of Performance Evaluation, *Journal of Applied Psychology*, 63, 751–754
[33] Bretz R.D., Milkovich G.T., Read W., 1992, The Current State Of Performance Appraisal Research And Practice: Concerns, Directions, And Implication, *Journal of Management*, 18, 321–352
[34] Delery J.E., Doty D.H., 1996, Modes Of Theorizing In Strategic Human Resources Management: Test Of Universalistic, Contingency, And Configurational Performance Predictions, *Academy of Management Journal*, 39, 802−835
[35] Coens T., Jenkins M., 2000, Abolishing Performance Appraisals: Why They Backfire and What to Do Instead, *Berrett-Koehler Publishers*, San Francisco
[36] Şimşek B. Pakdil F., Dengiz B., Testik M. C., 2013, Driver Performance Appraisal Using GPS Terminal Measurements: A Conceptual Framework, *Transportation Research Part C*, 26, 49-60
[37] Khoury G.C., Analoui F., 2004, Innovative Management Model For Performance Appraisal: The Case Of The Palestinian Public Universities, *Management Research News* 27, 56–73
[38] Mondy, R.R., Noe, R.M., 2005, Human Resource Management, *Prentice Hall*, New Jersey
[39] Lilley D., Hinduja S., 2007, Police Officer Performance Appraisal and Overall Satisfaction, *Journal of Criminal Justice*, 35, 137–150
[40] Johnston, R., Brignall S., Fitzgerald L., 2002, Good Enough Performance Measurement: A Trade-Off Between Activity and Action, *Journal of the Operational Research Society*, 53 (3), 256–262
[41] Leeuw S., Van den Bergb J.P., 2011, Improving Operational Performance By Influencing Shop Floor Behavior Via Performance Management Practices, *Journal of Operations Management,* 29, 224–235
[42] Fletcher C., Perry E.L., 2001, Performance Appraisal And Feedback: A Consideration Of National Culture And A Review Of Contemporary Research and Future Trends, In N. Anderson, D. S. Ones, H. K. Sinangil, C. Viswesvaran (Eds.), *Handbook of industrial, work, and organizational psychology*,1,127−144, Thousand Oaks, CA: Sage Publications
[43] Andrés R., García-Lapresta J.L., González-Pachón J.,2010, Performance Appraisal Based On Distance Function Methods, *European Journal of Operational Research*, 207, 1599–1607
[44] Waldman D.A., 1994, The Contributions Of Total Quality Management To a Theory of Work Performance, *Academy of Management Review*, 19, 510-536
[45] Westeman J.W., 1996, Rethinking the role of performance appraisals in total quality management. An argument for the use of peer raters, Employee Responsibilities and rights Journal, 9,4, 273-285
[46] Masterson S.S., Taylor M.S., 1996, Total Quality Management and Performance Appraisal: An Integrative Perspective, *Journal of Quality Management* ,1, 1, 67-89
[47] Deadrick D.L., Gardner D.G., 2000, Performance Distributions: Measuring Employee Performance Using Total Quality Management Principles, *Journal of Quality Management*, 4,2, 225- 241
[48] Cardy R.L., Carson K.P., 1996, Total Quality and the Abandonment of Performance Appraisal: Taking a Good Thing too Far?, *Journal of Quality Management*, 1, 2, 193-206
[49] Kurtzberg T.R., Naquin C.E., Belkin L.Y., 2005, Electronic performance appraisals: The Effects Of E-Mail Communication On Peer Ratings In Actual And Simulated Environments, *Organizational Behavior and Human Decision Processes*, 98, 216–226

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Performance Comparison of Box-Cox Transformation and Weighted Variance Methods with Weibull Distribution

Bahar Sennaroğlu [1], *Özlem Şenvar* [2]

Abstract

A standard process capability index is calculated based on the assumption that the quality characteristic of the process follows the normal distribution. But there are many cases in which the quality characteristic comes from a non-normal distribution. This paper studies Box-Cox transformation method and Weighted Variance method to calculate process capability indices for Weibull distributed quality characteristic and compares performances of these methods. Weibull distribution is extensively used as a lifetime distribution model because of its flexible shape. The data sets used in performance comparison are randomly generated from Weibull distribution for two different shape and scale parameters through a simulation study. The results indicate that Box-Cox transformation method produces better estimates for process capability than Weighted Variance method.

Keywords: Process Capability Index, Box-Cox Transformation Method, Weighted Variance Method

Introduction

Process capability is a performance measure to compare process variation with the product specifications. Process capability indices (PCIs) are widely used in industry to measure the ability of the process of the firm or its supplier to manufacture product that meets quality specifications.
Several PCIs including C_p, C_{pu}, C_{pl}, C_{pk}, and C_{pm} (Equation (1)) have been used in the manufacturing industry to provide common quantitative measures on process potential and performance [1].

$$C_p = \frac{\mathrm{USL}-\mathrm{LSL}}{6\sigma}$$
$$C_{pu} = \frac{\mathrm{USL}-\mu}{3\sigma}$$
$$C_{pl} = \frac{\mu-\mathrm{LSL}}{3\sigma} \qquad (1)$$
$$C_{pk} = \min\left\{\frac{\mathrm{USL}-\mu}{3\sigma}, \frac{\mu-\mathrm{LSL}}{3\sigma}\right\}$$
$$C_{pm} = \frac{\mathrm{USL}-\mathrm{LSL}}{6\sqrt{\sigma^2+(\mu-T)^2}}$$

where USL is the upper specification limit, LSL is the lower specification limit, μ is the process mean, σ is the process standard deviation (overall process variation), and T is the target value. Product specification limits are set with respect to product design (customer) requirements, while the process variation is a function of the process, materials, equipment, tooling, operation methods, and so forth. Hence, capability indices link the product design related specifications to the process related results [2]. A process is called inadequate if process capability index (either C_{pu} or C_{pl}) PCI<1.00, capable if 1.00≤PCI<1.33, satisfactory if 1.33≤PCI<1.50, excellent if 1.50≤PCI<2.00, and super if PCI≥2.00 [1].
The assumptions of stability (statistical control) of the process and a normal distribution of process output are essential to the correct interpretation of any process capability index. But there are many cases in which the quality characteristic comes from a non-normal distribution. If the distribution is non-normal, the estimate of process capability is unlikely to be correct [3]. Therefore, several methods have been proposed to deal with non-normal distributions [4]-[5].

[1] Bahar Sennaroglu, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, bsennar@marmara.edu.tr
[2] Özlem Şenvar, Université de Technologie de Troyes, Institut Charles Delaunay, LOSI, Troyes cedex - France, ozlem.senvar@utt.fr

There are two approaches to deal with non-normal quality characteristics in order to obtain reliable estimates of process capability indices:

1. Transform non-normal data to normal data and use normally-based process capability indices.
2. Use the process capability indices defined for non-normal data.

In this study, Box-Cox transformation (BCT) method is used to calculate process capability indices corresponding to the first approach and Weighted Variance (WV) method corresponding to the second approach. The data sets used in performance comparison of the methods are randomly generated from Weibull distribution for two different shape and scale parameters through a simulation study. Due to its flexible shape, Weibull distribution is extensively used as a lifetime distribution model and hence, it is preferred as the distribution of quality characteristic in this study. Simulations and computations are performed using Minitab 16 and MS Excel 2010 software packages.

Box-Cox Transformation (BCT) Method

Box and Cox [6] proposed a family of power transformations of a necessarily positive response variable X. If there are negative values, a constant value can be added in order to make the values positive. BCT uses the parameter λ (Equation (2)). In order to transform the data as closely as possible to normality, the best possible transformation should be performed by selecting the most appropriate value of λ.

$$X^{(\lambda)} = \begin{cases} \dfrac{X^{\lambda}-1}{\lambda} & \text{, for } \lambda \neq 0 \\ \ln X & \text{, for } \lambda = 0 \end{cases} \qquad (2)$$

The maximum likelihood estimator of λ is obtained as the value of λ that maximizes log-likelihood function L_{max} (Equation (3)) after evaluating several values of λ within a pre-assigned range.

$$L_{\max} = -\frac{1}{2}\ln\hat{\sigma}^2 + \ln J(\lambda, X) = -\frac{1}{2}\ln\hat{\sigma}^2 + (\lambda - 1)\sum_{i=1}^{n}\ln X_i \qquad (3)$$

where $J(\lambda, X) = \prod_{i=1}^{n}\frac{\partial W_i}{\partial X_i} = \prod_{i=1}^{n} X_i^{\lambda-1}$ for all λ. The estimate of σ^2 for fixed λ is $\hat{\sigma}^2 = S(\lambda)/n$, where $S(\lambda)$ is the residual sum of squares in the analysis of variance of $X^{(\lambda)}$.

When the optimum value of λ is obtained, the quality characteristic X, upper and lower specification limits are transformed using Equation (2). After the transformation, process capability is evaluated using normally-based capability indices.

Weighted Variance (WV) Method

The weighted variance method was first introduced by Choobineh and Ballard to construct control charts when the underlying population is skewed and afterwards it was utilized by Bai and Choi to adjust capability index values in order to account for the degree of skewness of non-normal process data [4]. Wu et al. [7] have modified the original WV method used by Bai and Choi. However, the main idea of both WV methods is to divide a skewed or asymmetric (non-normal) distribution into two normal distributions from its mean.

For a non-normal distribution with the mean of μ and a standard deviation of σ, there are n_1 observations out of n total observations which are less than or equal to μ. And there are n_2 observations out of n total observations which are greater than μ. The two new distributions have the same mean (μ) but different sample sizes (n_1 and n_2) and different standard deviations (σ_1 and σ_2). The sample size for each new distribution is determined by values of the skewness and kurtosis of the non-normal distribution.

μ, σ_1^2, and σ_2^2 are estimated by $\bar{X}$, S_1^2, and S_2^2, respectively (Equation (4)).

$$\bar{X} = \sum_{i=1}^{n} \frac{X_i}{n}$$
$$S_1^2 = \frac{2\sum_{i=1}^{n_1}(X_i - \bar{X})^2}{2n_1 - 1} \quad (4)$$
$$S_2^2 = \frac{2\sum_{i=1}^{n_2}(X_i - \bar{X})^2}{2n_2 - 1}$$

The modified WV method defines C_p, C_{pu}, C_{pl}, and C_{pk} indices as in Equation (5) [7].

$$\hat{C}_p = \frac{\mathrm{USL} - \mathrm{LSL}}{3(S_1 + S_2)}$$
$$\hat{C}_{pu} = \frac{\mathrm{USL} - \bar{X}}{3S_2} \quad (5)$$
$$\hat{C}_{pl} = \frac{\bar{X} - \mathrm{LSL}}{3S_1}$$
$$\hat{C}_{pk} = \min\left\{\frac{\mathrm{USL} - \bar{X}}{3S_2}, \frac{\bar{X} - \mathrm{LSL}}{3S_1}\right\}$$

Simulation Study

50 data sets (r=50) each having a sample size of 100 (n=100) with subgroup size of 1 are randomly generated from Weibull distributions with shape and scale parameters of (1,1), (1,2), (2,1), and (2,2). Figure 1 shows the probability density functions (PDFs) of these distributions. The cumulative distribution function (CDF) of a Weibull distribution having shape parameter α and scale parameter β is expressed as in Equation (6).

$$F(x;\alpha,\beta) = 1 - e^{-\left(\frac{x}{\beta}\right)^{\alpha}}, \; x \geq 0 \quad (6)$$

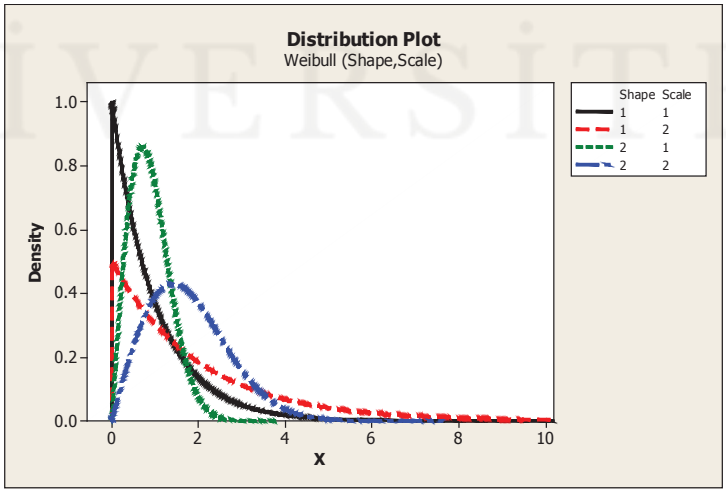


Figure 1. PDFs of Weibull distributions

Weibull (1,1) and (1,2) distributions with their shape parameter values of 1 are at the same time Exponential distributions. When its shape parameter is equal to 1, the Weibull distribution reduces to the Exponential distribution with its parameter equal to the reciprocal of the scale parameter of the Weibull distribution. The skewness and kurtosis values give information about tail behavior of a distribution. The average values of skewness and kurtosis calculated from 50 data sets generated from Weibull distribution with specified parameters are given in Table 1.

Table 1. Skewness and kurtosis values

Weibull (α,β)	Skewness	Kurtosis
Weibull (1,1)	1.676698	3.413711
Weibull (1,2)	1.747334	3.982865
Weibull (2,1)	0.562298	0.104820
Weibull (2,2)	0.590805	0.212021

In this study one-sided specification interval with an upper specification limit is considered. USL is calculated through Equation (9) for the targeted *Cpu* values of 1.0 and 1.5 and theoretical quantiles of the Weibull distribution with the specified shape and scale parameters.

$$C_{pu} = \frac{\mathrm{USL} - x_{0.50}}{x_{0.99865} - x_{0.50}} \tag{9}$$

where $x_{0.99865}$ and $x_{0.50}$ quantiles correspond to 0.99865 and 0.50 cumulative probabilities of the Weibull distribution, respectively.

Results and Discussion

In order to compare performances of BCT and WV methods, box plots of estimated process capability indices ($\hat{C}_{pu}$ values) corresponding to the targeted *Cpu* values of 1.0 and 1.5 are used. A box plot is used to show the shape of a distribution, its central value (median=$x_{0.50}$), variability (interquartile range=$x_{0.75}$–$x_{0.25}$), and outliers by star symbols if exist.

Based on the box plots for targeted *Cpu* values of 1.0 and 1.5 (Figure 2 and Figure 3) it is observed that while BCT method underestimates the targeted values, WV method overestimates them. It is also observed that BCT method provides more accurate estimates and less variability than WV method. The worst estimates of WV method are observed when Weibull distribution is at the same time Exponential distribution. These results can also be confirmed with descriptive statistics presented in Table 2.

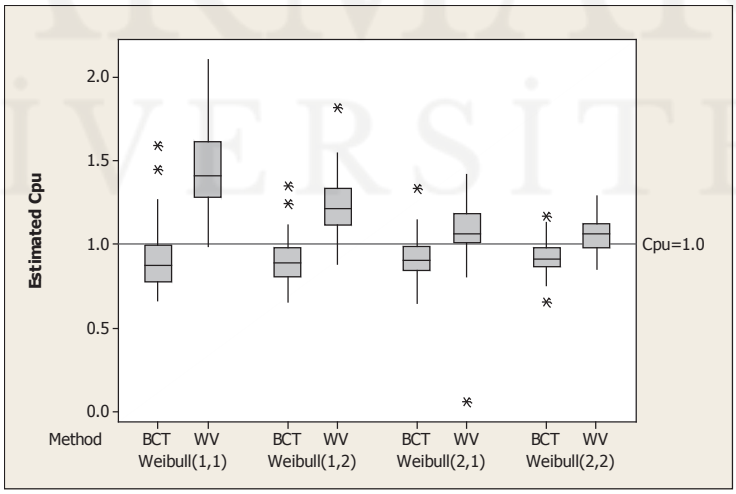


Figure 2. Box plots of BCT and WV methods for targeted *Cpu*=1

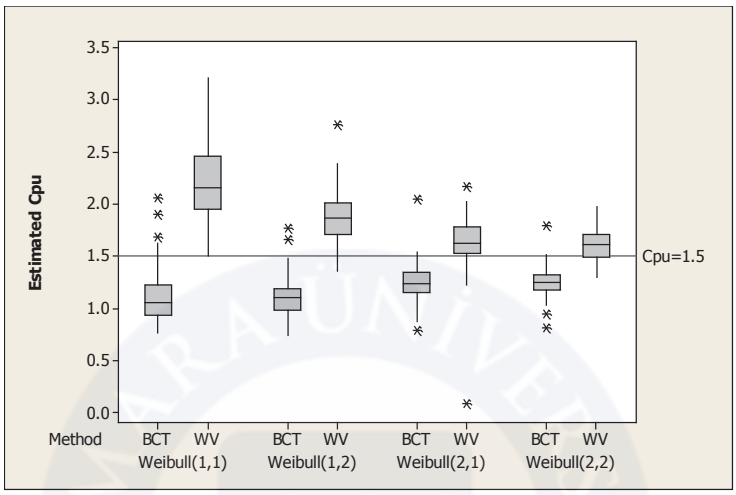


Figure 3. Box plots of BCT and WV methods for targeted *Cpu*=1.5

Table 2. Descriptive statistics for WV and BCT methods

Target C_{pu}	Statistics	Method	Weibull (1,1)	Weibull (1,2)	Weibull (2,1)	Weibull (2,2)
1.0	Mean	WV	1.4494	1.2338	1.0646	1.0659
		BCT	0.9155	0.9016	0.9111	0.9159
	Standard Deviation	WV	0.2336	0.1779	0.1945	0.1079
		BCT	0.1904	0.1368	0.1129	0.1001
1.5	Mean	WV	2.2111	1.8863	1.6149	1.6164
		BCT	1.1214	1.1023	1.2411	1.2453
	Standard Deviation	WV	0.3486	0.2697	0.2969	0.1609
		BCT	0.2718	0.1976	0.1799	0.1543

The root-mean-square deviation (*RMSD*) is used to measure the differences between the targeted *Cpu* values and the estimates obtained by BCT and WV methods (Equation (10)).

$$RMSD = \sqrt{\frac{\sum_{i=1}^{r}(\text{Estimated } C_{pu} - \text{Targeted } C_{pu})^2}{r}} \quad (10)$$

where r is the number of data sets generated randomly for each Weibull distribution with specified parameters. The results in Table 3 indicate that the higher target value (*Cpu* = 1.5) corresponds to worse estimates for WV method.

Table 3. The root-mean-square deviations for WV and BCT methods

Target C_{pu}	Method	Weibull (1,1)	Weibull (1,2)	Weibull (2,1)	Weibull (2,2)
1.0	WV	0.505	0.293	0.203	0.126
	BCT	0.614	0.614	0.599	0.592
1.5	WV	1.259	0.926	0.682	0.637
	BCT	0.464	0.443	0.314	0.297

The Weibull distributions (1,1) and (1,2) with near values of skewness and kurtosis (Table 1) have similar tail behaviors and as it can be observed in the radar chart (Figure 4), WV method produces much higher *RMSD* values for these distributions than the Weibull distributions (2,1) and (2,2), particularly when the targeted *Cpu* value is higher. This result indicates that the effect of tail behavior is more significant when the process is more capable for WV method, whereas this is not the case for BCT method.

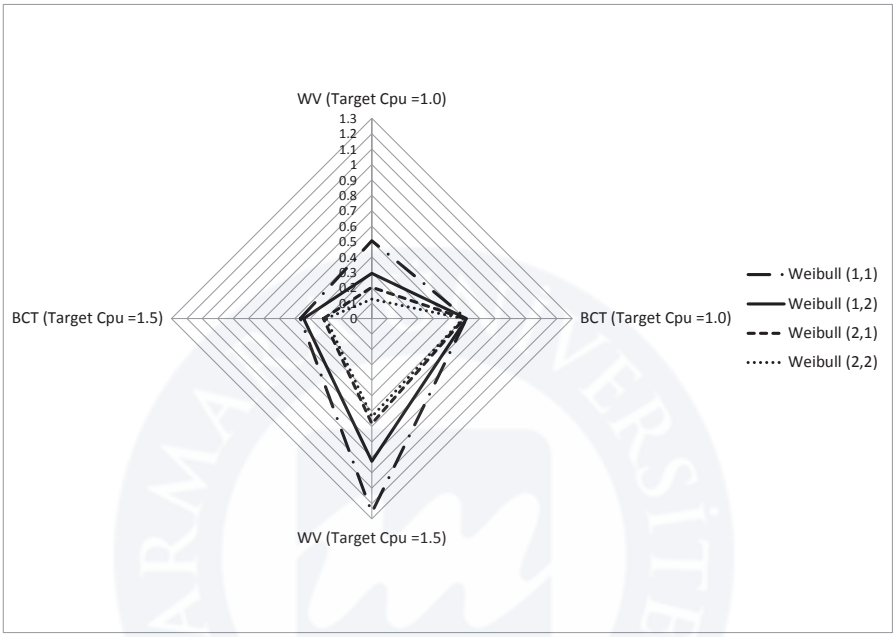


Figure 4. Radar Chart for *RMSD*

Conclusion

This study compares performances of Box-Cox transformation method and Weighted Variance method for process capability estimation when quality characteristic has Weibull distribution. Performance comparison of methods is made in terms of box plots, descriptive statistics, the root-mean-square deviation, and a radar chart. The results indicate that BCT method produces better estimates for process capability than WV method when quality characteristic is Weibull distributed. It is also observed that WV method is more sensitive to tail behavior than the BCT method. Weibull distributions are known to have significantly different tail behaviors, which greatly affects the process capability. Weibull distribution is extensively used as a lifetime distribution model because of its flexible shape. When the distribution of a quality characteristic is non-normal, normally-based PCIs would give unreliable and misleading results as well as incorrect assessment of process capability. Incorrect assessment of process capability can lead incorrect decision making, waste of resources, money, time, and so on. These findings would be helpful for selecting appropriate methods in process capability assessments with non-normal processes, especially with Weibull or Exponential distributed quality characteristic, which have been used extensively in quality and reliability applications.

References

[1] Pearn, W.L., Chen, K.S., 2002, One-sided capability indices Cpu and Cpl: decision making with sample information, *International Journal of Quality & Reliability Management*, 19(3), 221-245.
[2] Kolarik, W.J., 1995, *Creating Quality: Concepts, Systems, Strategies, and Tools*, McGraw-Hill, New York.
[3] Montgomery, D.C., 2009, *Statistical Quality Control: A Modern Introduction*, 6th ed., Wiley, New York.
[4] Pearn, W.L., Kotz, S., 2006, *Encyclopedia and Handbook of Process Capability Indices: A Comprehensive Exposition of Quality Control Measures*, World Scientific Publishing Company, Singapore.
[5] Tang, L.C., Than, S.E., Ang, B.W., 2006, Computing Process Capability Indices for Non-normal Data: A Review and Comparative Study , in *Six Sigma: Advanced Tools for Black Belts and Master Black Belts* (Eds. L.C. Tang, T.N. Goh, H.S. Yam, T. Yoap), John Wiley & Sons, 107–130.
[6] Box, G.E.P., Cox, D.R., 1964, An analysis of transformations, *Journal of the Royal Statistical Society: Series B*, 26, 211–252.
[7] Wu, H.-H., Swain, J.J., Farrington, P.A., Messimer S.L., 1999, A weighted variance capability index for general non-normal processes, *Quality and Reliability Engineering International*,15(5), 397–402.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Quality Oriented Process Development in Manufacturing Sector: An Application in Textile Firm

Ayşenur Erdil [1], *Ahmet Ekerim* [2]

Abstract

One of the most important problem in the business within the scope of manufacturing and services is the sustainability factor of production quality and quality of obtaining the quality norms in produced products.

This factor directs (impels) a strategy which will create competition(rivalry). Quality-oriented process development provides advantages, outmaneuver in the competition, rivalry scope. Determination of errors and error types are in the scope of the risk analysis. Statistical methods, qualitative and quantitative methods which are based on mathematical and simulation are used and implemented in the Risk analysis process. Prioritization of actions is important towards the improvement of the process.
The purpose of this study is to detect errors of negatively affect production in a textile company , to define, decrease the effects of negative factors and it involves which ranked according to their primary factor levels with the calculation of risk priority numbers(RPN) and using RPN(them). According to the ranking the RPNs, FMEA(Failure Mode and Effect Analysis) application in applied and implemented to reduce the risks and finally achieved the results of applications.

Keywords: FMEA(Failure Mode and Effect Analysis), Quality, Process Development, Risk Priority Number(RPN).

Introduction

Failure Modes Effects analysis (FMEA) is a quality control technique which is used during the improvement of new products and processes to identify, define, control and eliminate the causes of failure, while reducing the effects of faults or error conditions that could increase. FMEA is a reliability tool, which requires identifying failure modes of a specific product or system, their frequency and potential causes[1].This is an engineering technique is prevention tool and an important document between experience concerns and quality performance criteria and factors.

The QS 9000 FMEA defines FMEA as a group of activities aimed at recognizing and improving the potential failure of a product/process and its effects, identifying actions that may remove or reduce the potential failure mode occurring [9].

Slack et al., argued that FMEA is an analytical technique through which all possible "potential failure" modes, the effects that will occur if the failure actually happens and all the causes which can bring about the failure are determined [11,19, 20].

Paparella defines that FMEA is a useful tool for risk assesment, identification and error prevention. RPNs(Risk priority numbers) in FMEA methodology can be used as risk factors for errors because these faults cause vitally factors for risk assessment, such as the probability of errors, probabiliy effects, and the detection of faults. In literature review, Sinha et al. (2004) used FMEA as a means to access the criticality of risk factors within the aeroplane manufacturing supply chain. Kumar et al. (2009) defined FMEA applications to sum up the risk of each steps in reverse logistics activities within the pharmaceutical industry. Van Leeuwen et al. (2009)considered that FMEA to identify the rankings of the risk in analytical screening of drugs, while Chiozza and Pozzenti (2009) focused on the key points from applying FMEA in the medicinal sectors. Chuang (2010) analysed and detected the impact of requriements to extend his work to quantify the impact of intangible faults effects, such as customer complaints and loss of market share[7];[13-18].

[1]Ayşenur Erdil, Yalova University, Engineering Faculty, Department of Industrial Engineering, Yalova , Turkey, aysenurerdil@gmail.com

[2]Ahmet Ekerim, Yıldız Technical University, Chemical and Metallurgical Engineering Faculty , Department of Metallurgical and Materials Engineering, Production Metallurgy, Istanbul, Turkey, ekerim@yildiz.edu.tr

Value Analysis

Value analysis or total value analysis is defined as value engineering and it is used a tool and identified as systematic approach to acquire the requirement functions, factors for the lowest cost considering with quality, realibility and performance criteria. Value analysis is very significant and focus on scientific method to develop the product or service from the customer's review, ideas depending the product's cost to provide the desired factors or criteria for the cost of resources.

The flow chart for the planned process on the affected systems and sub-components is shown in Fig. 1,2,3. According to the chart, design verifications of all affected systems and sub components will be observed in detail to understand if there were any other design and process changes that may have intended the problems and faults.

On the other hand, as well as communicating with as many customers as much as possible in order to understand the process of the cotton cloth and trying to understand whether the source of the problem is unique to some enviromental factors, employee situations or climates.

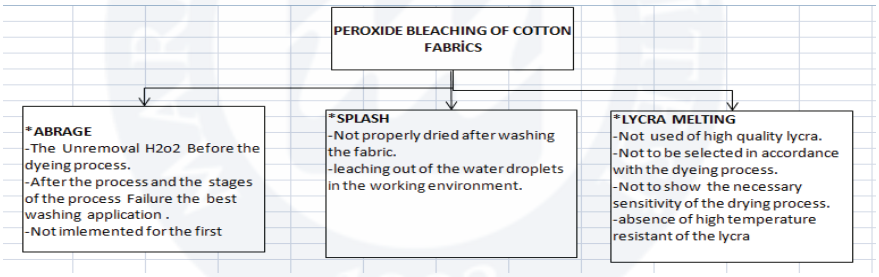


Figure 1. Basic Reasons of Peroxide beleaching of Cotton Fabrics

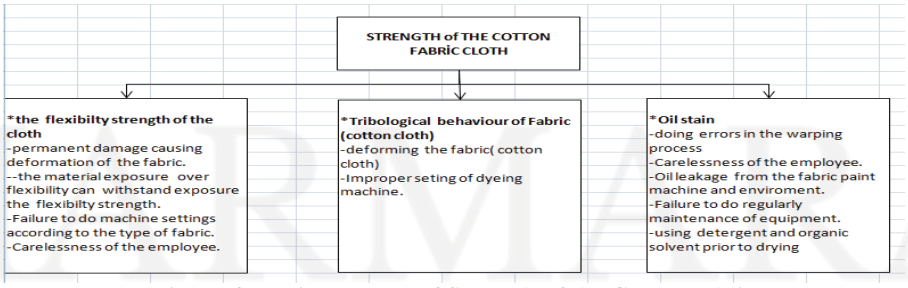


Figure 2. Basic Reasons of Strength of the Cotton Fabric

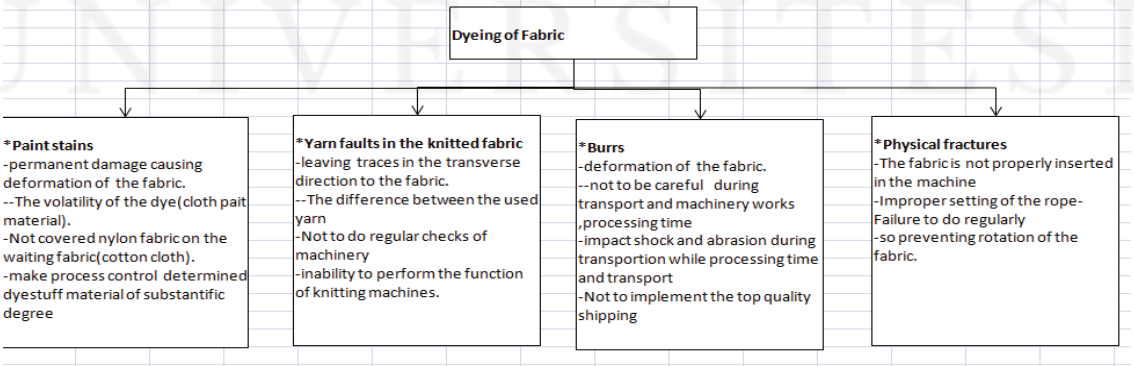


Figure 3. Basic Reasons of Dyeing of Fabric(Cotton Cloth)

All systems and components, as well as the quality of design and production processes, are shown within the fish bone diagram given in Fig. 4. The details of the tests performed on the systems and sub-components are summarized . In the fishbone diagram the most important item is the process component of the cotton cloth and fabric painting system. Therefore, the process was absolutely examined.

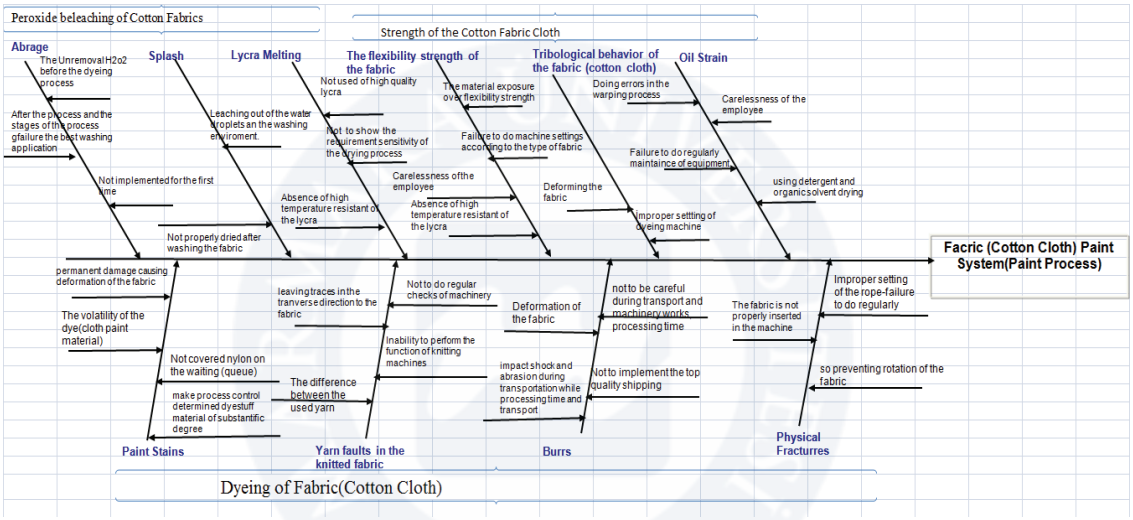


Figure 4. Fishbone Diagram to Detect the Reasons (Errors) for Fabric Cloth Paint

FAILURE MODES AND EFFECTS ANALYSIS

Fmea technique is important to try to improve the above defined compliance at each stage of the Project after completion of these controls and relevant failure mode effect analysis (FMEA), even this may be necessary in this regard for the sake of quick progress of the Project. FMEA risk analysis method is utilized for detecting the failures or defects in the implemented projects before they turn into a hazardous state, and to identify and control the priorities in remedying the failure problems and to eliminate the potential failures and risks before they happen [1, 2, 5,14].

FMEA enables us to detect and evaluate the hazards and accidents in advance. Despite, Failure Mode Effect Analysis (FMEA) has a wide range of usage field, it is also a strong analysis technique toward preventing the failures by estimating the relevant risks [3, 6, 14, 23].

The advantages of the fmea are given like that it is to improve the quality, reliability, and safety of the product or project, to enhance the customer satisfaction , to reduce the product or project development period and cost, to ascertain the priorities in design or process development activities, to discover the whole potential failures modes, their effects and similarities for all products/processes, to assist in analysis of the design requirements and design alternatives, to assist in definition of potential, critical and important characteristics, to assist in analysis of new production or project stages,to maintain an important media for failure prevention, to enable the definition of corrective & preventive actions and to certify and monitor the risk reducing activities.

This technique can both be utilized during the design review stages of the project and in implementation and installation stage. However it is more suitable to use the technique in design review stages. This technique can both be utilized during the design review stages of the project and in implementation and installation stage. However it is more appropriate to use the technique in design review stages [12].
In the Failure Mode Effect Analysis (FMEA) study, estimations of probability, severity and delectability are used for all defined potential failures and defects. At the end of these estimations, relevant solutions are searched by giving priority to the relatively bigger risks.

Failure Mode Effect Analysis (FMEA) Elements and Calculation Method

In FMEA studies, a suitable work team has to be assigned in accordance with the selected Project. Because, the definition of the problems and risk priority values in the studied project requires qualified personal as well as knowledge and experience. At the same time, the work team has to be consisted of selected personal of having different job profiles and from different departments.

The aim of FMEA is to sort the failure modes in order of importance, three indexes are defined for each failure mode: the occurrence rating (O), the severity rating (S), and the detectability rating (D). A ten-point scale is used to score each category, ten being the number indicating the most severe, most frequent and least detectable failure mode, respectively[8].

The priority of a failure mode is determined through the risk priority number(RPN), which is defined as the product of the occurrence(O), severity(S) and detection(D) of the failure,
Those potential causes, with high RPN values, are selected for the corrective action to reduce the risk of failure occurrence. Attention is also given to those parts of a system, where failure would produce adverse customer reaction and loss of company image. Risk priority levels (RPL) for FMEA; is calculated by multiplying the Occurrence (O), Severity (A), and Detectability (S) levels [6, 21, 24].

RPN = O (Occurrence) * A (Severity) * S (Detectability) (1)

Severity(S): Importance of the effect on customer requirements Often can't do anything about this without fundamentally changing the system or design.
Occurrence(O): Frequency with which a given cause occurs and creates failure modes (or probability it will occur)
Detection(D): The ability of the current monitoring and control method to detect before or after occurrence of a given cause

The three factors O, S and D are all estimated using the rankings or scores from1 to 10, as described in Tables 1–3. The failures with higher RPNs are presumed to be more important , vital and must be given higher priorities. FMEA has been proven to be one of the most important early preventative initiatives during the design stage of a system, product, process or service. However, the RPN has been extensively picked apart for various reasons [4,5,7–11]:

When the above mentioned three risk factor elements are assessed altogether, it represents the risk priority level (RPL) for each failure-defect type. And this value defines the numerical level of critical risk [14, 21].

The RPN must be calculated for each cause of failure. RPN shows the relative likelihood of a failure mode, in that the higher the number, the higher the failure mode. From the RPN, a critical summary can be drawn up to highlight the areas where action is mostly needed. Regardless of the resultant RPN, special attention must be given to any cause of failure with a severity rating of "9" or "10" [22].
After calculation of RPN, the company should ensure that the main hazards are removed from the specification by re-engineering. The three remedies in order of desirability, include[16, 17]:

(1) To eliminate the problem altogether through a design change;
(2) to reduce the probability that the failure would occur; and
(3) to improve the chances of detection through improved quality control.

Finally, following the improvement actions, re-evaluation of severity, occurrence and detection must be carried out, and a new RPN should be calculated. The higher the RPN, the higher the chance that the mode will fail, and subsequently, this mode demands higher priority for corrective action [4,10].
Risk priority levels or numbers (RPL), provides the definition of failures to be given priority in failure improvement studies by making priority rating. Risk priority levels (RPL), while enabling the priority rating of failures, on the other hand it provides a useful guidance to the relevant people who take part in the post assessment FMEA analysis, RPL values improvement studies.

Table 1. System FMEA Severity Rating [6,20]

System FMEA Severity Rating		
Effect	**SEVERITY of Effect**	**Ranking**
Hazardous without warning	Very high severity ranking when a potential failure mode affects safe system operation without warning	10
Hazardous with warning	Very high severity ranking when a potential failure mode affects safe system operation with warning	9
Very High	System inoperable with destructive failure without compromising safety	8
High	System inoperable with equipment damage	7
Moderate	System inoperable with minor damage	6
Low	System inoperable without damage	5
Very Low	System operable with significant degradation of performance	4
Minor	System operable with some degradation of performance	3
Very Minor	System operable with minimal interference	2
None	No effect	1

Table 2. General Severity Ranking Table [6,20]

General SEVERITY RANKING TABLE		
Rank	Category	External and Internal Effect
10	Liability	Failure will affect safety or compliance to law
9	Reliability / Reputation at risk	Catastrophic customer impact
		Moderate to major reliability failures
		End user recalls
		Premature end-of-life (wear out)
		Increased early life failures
		Intermittent functionality
8	Customer quality inconveniences	Major customer impact
		Minor reliability failures
7		Customer line impact / lines down
		Impacts the yield of customer
		Wrong package / part / marking
		Products performing marginally
		Involved customer's special handling
		Damaged the customer's equipment
6	Internal yield or special handling required	Product assembly error
5		Equipment cross contamination
		Damaged to down stream equipment
		Major yield hit
4		Significant line yield loss
		Minor yield hit
3		Low line yield loss
2		Special internal handling, effort or annoyance
1	Unnoticed	Unnoticed either internally or externally

Table 3. Probability of Failure [6,20]

PROBABILITY of Failure	Failure Prob	Ranking
Very High: Failure is almost inevitable	>1 in 2	10
	1 in 3	9
High: Repeated failures	1 in 8	8
	1 in 20	7
Moderate: Occasional failures	1 in 80	6
	1 in 400	5
	1 in 2,000	4
Low: Relatively few failures	1 in 15,000	3
	1 in 150,000	2
Remote: Failure is unlikely	<3.4 in 1,000,000	1

These analysis and controls enables healthy progress of the implemented textile firm for quality oriented process development in this study. In Table 6 the encountered potential risks in the Cotton Cloth (Fabric) definition works is given with the aid of failure mode effect analysis (FMEA) method and risk priority calculation values is ascertained on the basis of previous experience. In this table, there have been considered 15 main aspects to be subjected to the control and may cause risk factor during the route selection definition projects. Among these 10 potential failure and risk modes, 4 of them considered as high risk and remaining 8 of them medium level risk as per the calculated risk priority values.

Table 4. Detection by Design Control

Detection	Likelihood of DETECTION by Design Control	Ranking
Cannot Detect	Design control **cannot** detect potential cause/mechanism and subsequent failure mode	10
Very Remote	**Very remote** chance the design control will detect potential cause/mechanism and subsequent failure mode	9
Remote	**Remote** chance the design control will detect potential cause/mechanism and subsequent failure mode	8
Very Low	**Very low** chance the design control will detect potential cause/mechanism and subsequent failure mode	7
Low	**Low** chance the design control will detect potential cause/mechanism and subsequent failure mode	6
Moderate	**Moderate** chance the design control will detect potential cause/mechanism and subsequent failure mode	5
Moderately High	**Moderately High** chance the design control will detect potential cause/mechanism and subsequent failure mode	4
High	**High** chance the design control will detect potential cause/mechanism and subsequent failure mode	3
Very High	**Very high** chance the design control will detect potential cause/mechanism and subsequent failure mode	2
Almost Certain	Design control **will** detect potential cause/mechanism and subsequent failure mode	1

Table 5. Detection Criteria –Additional Ranking

Detection	Additional Detection Criteria	Rank
Cannot Detect	Absolute certainty of non-detection of defective product prior to shipment	10
Very Remote	Test/inspection gates probably will not detect defective product	9
Remote	Test/inspection gates will catch all but 25% of defective product	8
Very Low	Test/inspection gates will catch all but 10% of defective product	7
Low	Test/inspection gates will catch all but 1.00% of defective product	6
Moderate	Test/inspection gates will catch all but 0.25% of defective product	5
Moderately Hight	Test/inspection gates will catch all but 500 DPM of defective product	4
High	Test/inspection gates will catch all but 60 DPM of defective product	3
Very High	Test/inspection gates will catch all but 3.4 DPM of defective product	2
Almost Certain	Test/inspection gates will catch all but 1 DPB of defective product	1

In the implemented failure mode effect analysis work, relevant precautionary measures for reducing the high and medium level risks that have been found as the result of the FMEA studies has been defined by giving reference to relevant actions., By this way it is planned to reduce the risk priority values of the potential risks in the intended construction of Process Fmea in the textile firm, Cotton Cloth (Fabric) Painting workstation. Furthermore, it is aimed that high and medium level risks will be eliminated and the process will progress smoothly.

Table 6. Calculate RPN Before and After Completion of Action Plans to Validate Improvements for Process Fmea in the Paint WorkStation-Textile Firm

PROSES FMEA

Firm Name: X Paint | Product/Item: Cotton Cloth (Fabric) | Model / vehicle: AD-10679 | Process Resp.: A | Core Team: SK/ BK/ NÜ/ NA/ KN | Key Date: | FMEA No: 125-1 | Prepared By :: | FMEA Date: | Security Class: - | Rev: 0

Proses / Steps / Function	Potential Failure Mode	Potential Effect(s) of Failure	Severity (S)	Potential Cause(s)/ Mechanism(s) of Failure	Occurence (O)	Current Process Control Prevention	Current Process Control Detection	Detection (D)	R.P.N	Recommended Action(s)	Responsibility &Target Completion Date	Action Results: Action Taken	Severity	Occurence	Detection	R.P.N
Peroxide beleaching of Cotton Fabrics	Abrage	In the dying stages, leads to color differences in the form of cloud and shadow	6	The Unremoval H2o2 before the dyeing process	4	using antiperokslt (sodium thiosulfate)	It is implemented to the fabric wash well after the processes, if the results does not be taken , Paint remover will be used and implemented	5	120	Using the complex-forming in the dye bath	It is implemeted in the first procution stage.	Control Plan was changed	6	3	3	54
	Splash	Caused the unwanted traces	4	not properly dried after washing	5	To eliminate the water droplets in the workplace	Analysable via the washing process	4	80	To be sensitive for the drying process			4	4	3	48
	Lycra Melting	leads to strength loss	8	the Lycra, not to be resistant to high temperature,	3	using quality lycra and selection the dyeing process according to lycra	It does not have solution.	5	120	using quality lycra		Control Plan was changed	8	3	4	96
Strength of the Cotton Fabric Cloth	The flexibility strength of the fabric	causing permanent damage to deform the fabric	8	The material exposure over flexibility strength	3	Failure to do machine settings according to the type of fabric(cotton cloth)	It does not have solution.	6	144	careful craftsmanship		Control Plan was changed	8	2	4	64
	Tribological behavior of the fabric (cotton cloth)	It is caused deformation of the fabric	8	Be tight compared to the normal setting of the paint machine	3	to circulate freely smooth fabric made of rope adjustment	It does not have solution.	6	144	control plan in certain frequency		Control Plan was changed	8	3	5	120
	Oil Strain	It is caused that Doing errors in the warping process	6	The oil flows (leakage) from the environment or from the machine	7	Doing regularly machinery maintenance	using detergent and organic solvent drying	5	210	Safety working area must be provided for employee and workers		Serious process control	6	5	4	120
Dyeing of Fabric(Cotton Cloth)	Paint Stains	It is caused failure of template fracture.	6	Not covered nylon on the waiting (queue) ,By he flight of the dyes, they stick to the pending fabric	3	covered nylon on the waiting (queue)	However, if you noticed before the painting process., it can be cleared and has solution	5	90	Dye matter which degree of process control substantific identified			6	3	3	54
	Caustic Stain	It causes that the material in some areas staining darker before	8	because of not being given Caustic homogeneously	3	given and implemeted caustic progressively and appropriately	It does not have solution.	6	144	implemnting step by step via controlling stages		Process Control	8	3	5	120
	wing -aerofoil differences	It is caused unrelieved failure	8	Inhomogeneity of the fabric moisture content	3	movement of the fabric has sufficient level andfabric temperature difference hydrophility	It does not have solution.	7	168	Ensuring, providing the circulation of the fabric			8	3	5	120
	Yarn faults in the knitted fabric	leaving traces in the tranverse direction to the fabric	7	Inability to perform the function of knitting machines and The difference between the used yarn	4	minimized by reducing the difference in machine yarn	If it is noticed during knitting , it has solution and cleared	6	168	Regularly machine controls			7	3	5	105
	Physical Fracturres	It leads self-improve malaise and wrinkles on fabric	5	The fabric is not properly inserted in the machine	5	to provide setting of the rope-failure to do regularly, so preventing rotation of the fabric	Moistens the fabric by passing the iron	5	125	Fracture prevention should be used			5	3	4	60
	Burrs	It is caused deformation of the fabric	7	Improper setting of the rope-failure to do regularly,The fabric is not properly inserted in the machine	3	Must be careful during transport and machinery works, processing time	If i is not too much , Quality control is performed, cleared	6	126	Implement the top quality shipping, transportation			7	2	5	70

Conclusion

FMEA analysis in the every sector projects, play an important role especially during the design phase of projects in order to providing the risks to be based on the priority order of importance and for the improvement works for them to be made quickly. However, in the projects of firms(sectors), Risk Priority Level (RPL) values play an important role that are found for post analysis and evaluation of FMEA, will be a good guidance for the people of experts in their field that carry out improvement studies. In this study first 8 important risk items.

The (Risk Priority Number)RPNs is widely used in FMEA for determining the risk prioritization of failure modes. The foregone FMEA cases may be helpful for Design Management to establish the selection principle. Future works will focus on systematic analysis of proper selection for the two indices.
Considering the fact that FMEA is a group decision function and cannot be done on an individual basis and different FMEA team members may provide different assessment information.
Risk factors are aggregated in a highly nonlinear manner which is neither the simple addition nor the simple product of the risk factors.

More risk factors can be included if necessary. The proposed FMEA is not limited to *O*, *S* and *D*, but applicable to any number of risk factors.

Acknowledgement

This study was supported by Yıldız Technical University, Production Metallurgy, Prof.Dr.Ahmet Ekerim and the helpful staff at X Textile firm and the manager of this firm are gratefully acknowledged.

References

[1] Akın B., (1998). Implementation of ISO 9000 in Business, Failure Mode and Effects Analysis (FMEA) , (FMEA) Bilim Teknik Yayınevi, 182s, İstanbul. (in Turkish).
[2] Ben-Daya M, Raouf A. (1996).A revised failure mode and effects analysis model. International Journal of Quality & Reliability Management,13(1):43–7.
[3] Bowles JB. An assessment of PRN prioritization in a failure modes effects and criticality analysis. Journal of the IEST;47:51–6.
[4] Chang DS, Sun KLP (2009). Applying DEA to enhance assessment capability of FMEA. Int. J. Qual. Reliab. Management 26(6): 629-643.
[5] Chin, K.S., Wang, Y.M., Poon, G.K.K., Yang J.B.(2009), Failure mode and effects analysis using a group-based evidential reasoning approach, Computers & Operations Research, 36 pp. 1768–1779.
[6] Chin,K.S., Wang Y.M.., KwaiPoon ,G.., Yang, B.J.(2009), Failuremodeandeffectsanalysisusingagroup-basedevidentialreasoningapproach Computers & Operations Research ,1768 – 1779)
[7] Chiozza ML, Pozzali C (2009). FMEA: a model for reducing medical errors. Clinica Chimia Acta, 404(1): 75-78.
[8] Chuang PT (2010). Incorporating disservice analysis to enhance perceived service quality. Ind.Manage. Data Sys., 110(3): 1-22.
[9] Estorilio C, Posso RK (2010). The reduction of irregularities in the use of process FMEA. Int. J. Qual. Reliab. Management, 27(6): 721-733.
[10] Fiorenzo Franceschini, & Maurizio Galetto. (2001). A New Approach for Evaluation of Risk Priorities of Failure Modes in FMEA. International Journal of Production Research, 39(13): 2991-3002.
[11] Healey J (1994). Failure mode and effects analysis. Eng. Designer, 20(2): 4-7.
[12] Hekmatpanah. C.M., Shahin A., Ravichandran N.,(, 2011). The application of FMEA in the oil industry in Iran: The case of four litre oil canning process of Sepahan Oil. African Journal of Business Management Vol. 5(8), pp. 3019-3027.
[13] Kumar S, Dieveney E, Dieveney A (2009). Reverse logistic Process Control measures for the Pharmaceutical Industry Supply Chain. Int. J. Prod. Perform. Manag., 58(2): 188-204.
[14] Liu, H.-C., Liu, L., Liu, N., (2013) Risk Evaluation Approaches in Failure Mode and Effects Analysis: A Literature Review, Expert Systems with Applications,40(2), pp.828-838
[15] Paparella S.(2004). Failure mode and effects analysis: a useful tool for risk identification and injury prevention. Journal of Emergency Nursing 2007;33(4):367–71.

[16] Pillay A, Wang J. (2003) Modified failure mode and effects analysis using approximate reasoning. Reliability Engineering & System Safety ,79:69–85.
[17] Sankar NR, Prabhu BS.(2001). Modified approach for prioritization of failures in a system failure mode and effects analysis. International Journal of Quality & Reliability Management ,18(3):324–35
[18] Sinha PR, Whitmann LE, Malzan D (2004). Methodology to mitigate supplier risk in an aerospace supply chain. Supply Chain Manag. Int. J., 9(2): 154-168.
[19] Slack N, Chambers S, Johnston R (2001). Operations Management. 2nd ed., Harlow: Financial Times, Prentice-Hall, Inc
[20] Slinger M (1992). To practise QFD with success requires a new approach to product design. Kontinuert Forbedring, 20-21.
[21] Su, X., Deng,Y., Mahadevan, S., Bao, Q., (2012) An Improved Method For Risk Evaluation in Failure Modes and Effects Analysis of Aircraft Engine Rotor Blades, Engineering Failure Analysis, 26, pp.164-174.
[22] Van Leeuwen JF, Nauta MJ, de-Kaste D, Odekerken-Rombouts YMCF, Oldenhof MT, Vredenbert MJ, Barends DM (2009). Risk Anaysis by FMEA as an Element of Analytical Validation. J. Pharm. Biomed. Anal., 50(5): 1085-1087.
[23] Wang, Y.-M.,Chin, K.-S.,Poon, G. K. K.,,Yang, J.-B. (2009) Risk Evaluation in Failure Mode and Effects Analysis Using Fuzzy Weighted Geometric Mean, Expert Systems with Applications,36(2) Part 1 pp.1195-1207.
[24] Xiao, N., Huang, H-Z., Li, Y., He, L., Jin, T., (2011) Multiple Failure Modes Analysis And Weighted Risk Priority Number Evaluation in FMEA, Engineering Failure Analysis, 18(4) pp.1162-11.

MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

An Analysis of Statistical Control Charts with Fuzzy Set Theory

Zeynep Ceylan[1], İlayda Ülkü[2], Özalp Vayvay[3]

Abstract

Process control, product control and quality improvement are crucial for manufacturing companies to survive in competitive environment. The aim of quality control is to provide that the products, services, or processes supplied meet customer specifications. In the manufacturing process, it is not always possible to satisfy the customer specifications due to problems related variations in process, materials, machines, etc. Therefore monitoring a process to ensure control is required to manufacture products that close to target value and with little variation and in desired amount is very important. In this study, quality characteristics of items packaging process were investigated using statistical quality control and fuzzy set theory. For this purpose, product samples were taken and classified into four categories as the quality grades such as "Bad", "Medium", "Good", and "Excellent". Fuzzy logic and probability theory approaches were used for constructing control charts for quality assurance. With the help of these theories, flexibility of the system was improved. Consequently, the based on fuzzy set theory results are discussed with the existing approach to see the difference in performance.

Keywords: Quality Control Charts, Probability Theory, Fuzzy Theory

Introduction

Manufacturing firms are being under pressure on the basis of quality in the competition in the world for the last few years. Therefore, manufacturing firms make an effort to use quality improvement programs to survive in this competitive environment. Statistical process control basically SPC is used as a method that is applied by monitoring and controlling the processes in the quality control. The process is analyzes if it works in its full potential by monitoring and controlling the process. SPC aims to produce conforming product with a minimum rework. Observation, evaluation, diagnosis, decision and implementation are the stages of SPC. Marcucci (1985) proposed two procedures, first one detects the differences in any of the quality proportions by the help of Pearson X^2, on the other hand, the last one uses the multinomial distribution. In the consideration of fuzzy theory Raz and Wang (1988, 1990a, b) applied fuzzy sets by converting them to the linguistic term. After that, each sample is associated by the use of fuzzy rules. After that process, Shewhart control charts are used to plot the fuzzy set.

Quality control includes to check all steps in a process. Finding defects, testing the output which can be product or service, improving the process, minimizing the defects take first place in the quality control processes to meet specific requirements to be in a satisfactory level. [2] Control charts are the main tools used in the SPC which are generated by Shewhart in 1924. The control charts have upper and lower specification limits where the data is plotted and need to be between the specification limits. In control charts there are an upper control limit, a lower control limit, and a center line that are shown basically as UCL, LCL, CL respectively. Also, three sigma (3σ) control limits are used. When the process plotted above and below the mean by three times of process's standard deviation. When the process is in control or not, control charts are very useful to detect this nonconforming conditions by monitoring the process. If the data is plotted with little variation around the target value, and if it is between the specification limits, then the process is "in control".

[1] Zeynep CEYLAN, Ondokuz Mayıs University, Faculty of Engineering, Department of Industrial Engineering, Samsun, Turkey, mailto:zeynep.dokumaci@omu.edu.tr
[2] İlayda Ülkü, Istanbul Kültür University, Faculty of Engineering, Department of Industrial Engineering, Istanbul, Turkey, mailto:i.karabulut@iku.edu.tr
[3] Özalp VAYVAY, Marmara University, Faculty of Engineering, Department of Industrial Engineering, Istanbul, Turkey, mailto:ozalp@marmara.edu.tr

On the other hand, if the data is plotted with a pattern or if it exceeds the specification limits, then the process is "out of control" which need to take a preventive action to decrease the variability.

In 1999, fuzzy logic is considered as an approximate value which can be achieved instead of a fixed value. That is fuzzy logic variables can take a real value between 0 and 1. [4] In 2014, Ahlawat, N., Ashu G., and Nidhi S. represent a study which is known as the fuzzjective. They mentioned that when linguistic variables are used the degrees of specific functions can be controlled [3].

In other respects, Zadeh and Klaua explained the fuzzy sets as elements have degrees of membership then the fuzzy sets occur. [5-6] Fuzzy set theory allows the incremental consideration of the elements' membership in a set that is valued in the real unit interval [0, 1] with an aid of a membership function. When information is not completed or imprecise, the fuzzy set theory is very useful with a numerous domains.

In this study, quality characteristics of items packaging process were investigated using statistical quality control and fuzzy set theory. For this purpose, product samples were taken and classified into four categories such as "Bad", "Medium", "Good", and "Excellent" as quality grades. Fuzzy logic and probability theory approaches were used for constructing control charts for quality assurance. With the help of these theories, flexibility of the system was improved. Consequently, the based on fuzzy set theory results are bench marked to see the diversity between the current situation and the proposed one.

The rest of the paper is organized as follows: Methodology of the study is detailed in next section. After representing the methodology section of the study, there is an application and numerical results of the application. Finally the paper concludes with a summary and outlines scope of research.

In addition, an overview of scientific literature on fuzzy logic and probability theory approaches for control charts are represented in the Table 1.

Table 1. Several Studies in the Literature by Considering the Fuzzy Control Charts

Reference/Year	Name of the Study	Method
[10] / (2013)	"Fuzzy Approach to Statistical Control Charts"	Attribute quality characteristics are monitored.
[11] / (2013)	"Basic Developments of Quality Characteristics Monitoring"	Bias of quality characteristics are monitored
[12] / (2007)	"An alternative approach to fuzzy control charts: direct fuzzy approach"	A proper α- cut is applied as the difficulty of the inspection.
[13] / (2006)	"Development of fuzzy process control charts and fuzzy unnatural pattern analyses"	Direct fuzzy approach (DFA) is used with none transformation method.
[14] / (2006)	"α-cut fuzzy control charts for linguistic data"	A proper α-level is applied as the difficulty of the inspection.
[15] / (2010)	"Comparing Fuzzy Charts with Probability Charts and Using Them in a Textile Company"	The quality is monitored in terms of conformance and nonconformance in a textile company.
[16] / (2009)	"Construction of quality control charts by using probability and fuzzy approaches and an application in a textile company"	The quality is monitored in terms of conformance in a textile company.

Methodology

In this study, quality characteristics of items packaging process were investigated using statistical quality control and fuzzy set theory. For this purpose, product samples were taken and classified into four categories such as "Bad", "Medium", "Good", and "Excellent" as quality grades. Fuzzy logic and probability theory approaches were used for constructing control charts for quality assurance. With the help of these theories, flexibility of the system was improved. Consequently, the based on fuzzy set theory results are bench marked to see the diversity between the current situation and the proposed one.

While monitoring multinomial processes, there are several procedures proposed as mutually exclusive categories for classified products. One of the useful proposed procedures is Marcucci's procedure that use Shewart type control charts. This type of control chart has separated into two types. The first one is used when specific values are developed for quality proportions. In this first type procedure, with the monitoring process the change can be detected. The second type procedure is designed to detect quality proportions when there is an increase. However, goodness-of-fit statistic of the Pearson cannot be possible to apply when the process proportions are not given. Therefore, proportions' homogeneity among the beginning period, 0 and for every observing period, as shown in Equation (1).

$$Z_i^2 = \sum_{k=i,0} \sum_{j=1}^{1} \frac{n_k\left(\frac{X_{kj}}{n_k} - \frac{X_{ij}+X_{0j}}{n_i+n_0}\right)}{\frac{X_{ij}+X_{0j}}{n_i+n_0}} = n_i n_0 \sum_{j=1}^{1} \frac{(p_{ij}-p_{0j})^2}{X_{ij}+X_{0j}} \tag{1}$$

where the sample proportions are $k=\{0,1\}$, $p_{kj} = \frac{X_{kj}}{n_k}$, $j=1,2,3,\ldots,t$ and the sample size is n_i.

When fuzzy theory is considered, in 1990 a study is suggested where fuzzy sets are converted to linguistic term with the single fuzzy set result. With the help of Shewart-type control chart, the fuzzy set is generated and the measure centrality of the fuzzy set can be seen easily. Scalar values are generated by the transformation of the fuzzy sets which are assigned to the linguistic values. This is an important point, instead of using the standard format of control charts. [7]. There are a couple of way to see the variety of the in the fuzzy set that includes the base variable. The following four ways is represented as in descriptive statistics.

Fuzzy average, f_{avg} **:**, gives the fuzzy average according to Zadeh [7].

$$f_{avg} = Av(x:F) = \frac{\int_{x=0}^{1} x\mu_F(x)dx}{\int_{x=0}^{1} x\mu_F(x)dx} \tag{2}$$

Fuzzy mode, f_{mode} **:** represents the base variable value where F is equal to 1 as the membership function.

$$f_{\text{mod}} = \{x \mid \mu F(x) = 1\}, \forall x \in F \tag{3}$$

Fuzzy median, f_{med} **:** shows the membership function parts under the fuzzy set. The following formula gives the results of the equal regions where the end points in the base variable of the fuzzy set F is defined as a and b, as $a < b$.

$$\int_{a}^{f_{med}} \mu_F(x)dx = \int_{f_{med}}^{b} \mu_F(x)dx = \frac{1}{2}\int_{a}^{b} \mu_F(x)dx \tag{4}$$

α-Level fuzzy midrange, $f_{mr}(\alpha)$**:** A_α is the center of the α level cut where α level cut is a non-fuzzy set. Here the membership of each element is greater than or equal to α. When b_α and a_α are the final points of α level cut, A_α then the following expression is given to determine $f_{mr}(\alpha)$.

$$f_{mr}(\alpha) = \frac{1}{2}(a_\alpha + b_\alpha) \tag{5}$$

There are two approaches which are proposed by Wang and Raz, as every fuzzy subset value is transformed in the member values. The approaches are the fuzzy probabilistic and the membership approach.

For ***the membership approach*** the following equations are considered.

Equation (7) calculates the sample mean for the jth sample is where average sample mean is the $\overline{M_j}$, and initial number of sample is the m. Also, the number of products as linguistic term L with j sample is defined as k_{ij}; the fuzzy value as the linguistic term i is represented as r_i and the size of sample j is shown as n_j.

$$M_j = \frac{\sum_{j=1}^{m} k_{ij} r_i}{n_j}, i = 1,2,3,...,t \tag{6}$$

The centerline (CL) for sample m of size n is given as follows:

$$CL = \overline{M_j} = \frac{\sum_{j=1}^{m} M_j}{m} \tag{7}$$

Equation (8) represents the control limits for the below and above the central line as each sample will be at a range between 0, and 1.

$$\begin{aligned} MembershipLCL &= Max\{0, [CL - k\delta(GMF)]\} \\ MembershipUCL &= Min\{0, [CL - k\delta(GMF)]\} \end{aligned} \tag{8}$$

Also, α is the value of membership and the mean deviation for a given fuzzy set A is $\left(\delta(A)\right)$. Equation (9) represents the sum of the right mean deviation $\left(\delta r\right)$, and the right mean deviation $\left(\delta r\right)$.

$$\begin{aligned} &\delta_l = \int_{\alpha=0}^{1} [x_m - x_1(\alpha)] d\alpha \quad \text{And} \quad \delta_r = \int_{\alpha=0}^{1} [x_r - x_m(\alpha)] d\alpha \\ &\delta(A) = \delta_1(A) = \delta_r(A) = \int_{\alpha=0}^{1} [x_r - x_m(\alpha)] d\alpha \end{aligned} \tag{9}$$

For the ***fuzzy probabilistic approach*** the following equations are considered.

Equation (10) shows the sample mean M_j, for each sample j. Moreover, F_i which is the fuzzy subset which shows the r_i value that is transformed from the linguistic terms L_i.

$$M_j = \sum_{i=1}^{t} r_i k_{ij} \tag{10}$$

The mean of the representative of the m samples, MSD is given as follows.

$$MSD = \frac{1}{m}\sum_{j=1}^{m} SD_j \tag{11}$$

The standard deviation SD_j is determined for each sample j in Equation (12).

$$SD_j = \sqrt{\frac{1}{n-1}\sum_{i=1}^{t} k_{ij}(r_i - M_j)^2} \tag{12}$$

The centerline is represented in Equation (13) as the grand mean of the sample means M_j.

$$CL = \frac{\sum_{j=1}^{m} M_j}{m} = \frac{\sum_{j=1}^{m}\sum_{i=1}^{t} r_i k_{ij}}{mn} \tag{13}$$

As the data is generated with sample means on the charts which are member values, the data must be distributed between 0, and 1. Thus, there are two assumptions for control limits. One of them is the sample distribution is normal, and the second one is when the sample size n is large enough such as, it is greater than 25, control limits are represent in the Equation (14) [8].

$$\begin{aligned} LCL &= Max\{0, (CL - A_3 MSD)\} \\ UCL &= Min\{0, (CL + A_3 MSD)\} \end{aligned} \tag{14}$$

Comparison Study

In frozen food production, packaging of products is one of the important quality feature that has to be checked continuously [18]. Therefore, for control of the quality, product packaging process was analyzed with 30 samples of size 50. Items packaging are classified by experts using four linguistic terms: Excellent (E), Good (G), Medium (M), and Bad (B). *Generalized p chart* proposed by Marcucci [19], *Probabilistic* and *Memberships approaches* proposed by Wang and Raz [7], [8] were evaluated in this comparison study. Table 2 shows dataset for 30 samples [20].

Table 2. Dataset [20]

Sample No	Bad	Medium	Good	Excellent	Sample No	Bad	Medium	Good	Excellent
1	8	9	25	8	16	5	9	28	8
2	10	8	25	7	17	7	9	27	7
3	6	8	28	8	18	3	9	30	8
4	6	8	28	8	19	9	9	26	6
5	3	9	28	10	20	7	8	27	8
6	5	9	27	9	21	12	15	20	3
7	10	8	24	8	22	11	11	22	6
8	6	9	27	8	23	17	9	20	4
9	9	9	26	6	24	10	9	24	7
10	7	8	27	8	25	6	9	28	7
11	3	9	30	8	26	7	10	25	8
12	4	10	29	7	27	5	12	25	8
13	11	9	24	6	28	9	8	26	7
14	7	10	26	7	29	5	12	25	8
15	16	9	20	5	30	4	9	28	9

Marcucci Approach

Since the proportions are unknown before; the data conforms to second type of Marcucci case where the Pearson goodness of fit test is not appropriate. Therefore, we supposed that the process is in control in the period 4, and calculated sample proportions of the base period (p_{01}= 0.12, p_{02}=0.16, p_{03}= 0.56, p_{04}=0, 16). Then, generalized p chart was tested between base period and other periods of the process. The upper control limit was taken as 95th percentile of the $X^2(3)$ distribution which is equal to 7,815. The generalized p-chart for the 30 samples was illustrated on Figure 1.

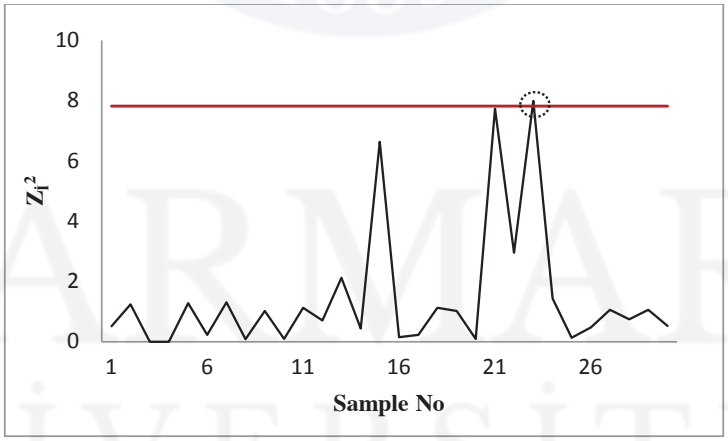


Figure 1. The Generalized P-Chart for the 30 Samples

As seen Figure 1, the process is out of control only one occasion: Samples 23.

Wang and Raz Approaches

In this study, the approaches suggested by Raz and Wang [7], [8] were applied to the dataset. Bad (B), Medium (M), Good (G), and Excellent (E) quality characteristics were defined as the term set. Membership functions was used for each term as shown in Table 3 [17]

Table 3. Membership Functions [17]

$$M_B(x) = \begin{cases} 0, & x \le 0 \\ -x+1, & 0 \le x \le 1 \\ 0, & x \ge 1 \end{cases} \qquad M_M(x) \begin{cases} 0, & x \le 0 \\ 4x, & 0 \le x \le \frac{1}{4} \\ -\frac{4}{3}x + \frac{4}{3}, & \frac{1}{4} \le x \le 1 \\ 0, & x \ge 1 \end{cases}$$

$$M_G(x) \begin{cases} 0, & x \le 0 \\ 2x, & 0 \le x \le \frac{1}{2} \\ 2-2x, & \frac{1}{2} \le x \le 1 \\ 0, & x \ge 1 \end{cases} \qquad M_E(x) \begin{cases} 0, & x \le 0 \\ x, & 0 \le x \le 1 \\ 0, & x \ge 1 \end{cases}$$

The triangular-shaped membership functions of each term were also constructed on Figure 2.

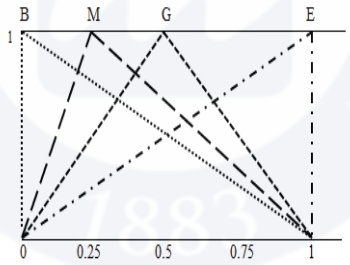


Figure 2. Triangular-shaped Membership Functions for 4 Linguistics Terms

By using fuzzy mode and fuzzy median transformation, the representative values of the four linguistic terms were calculated, and shown Table 4.

Table 4. Representative Values of Linguistic Terms

	Linguistic Terms			
Transformation Method	**Bad (B)**	**Medium (M)**	**Good (G)**	**Excellent (E)**
Fuzzy Mode	0	0.25	0.5	1
Fuzzy Median	0.293	0.387	0.5	0.5

Probabilistic Approach

First, mean and standard deviation calculated of each sample were calculated. The center line which is the grand mean and the mean of the sample standard deviations (MSD) were also calculated. The value of the constant A3, was taken 0.606 for sample size 50. Therefore, upper control limits (UCL) and lower control limits (LCL) were obtained. The results of these values were shown in Table 5.

Table 5. Fuzzy Probabilistic Approach Results

Transformation method		
Parameters	**Fuzzy Mode**	**Fuzzy Median**
CL	0.45	0.447
MSD	0.287	0.077
UCL	0.624	0.494
LCL	0.276	0.401
Width	0.348	0.093
A3	0.606	0.606

The fuzzy probabilistic control charts using fuzzy mode and fuzzy median can be seen on Figure 3.

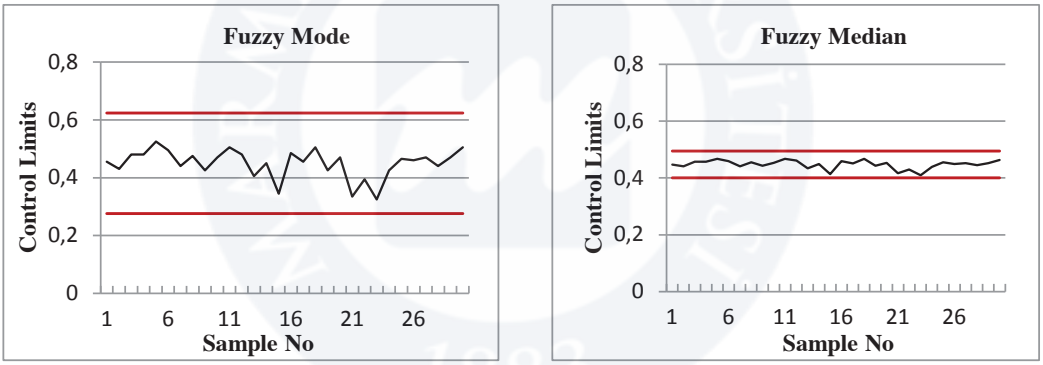


Figure 3. Fuzzy Mode and Fuzzy Median Probabilistic Control Charts

As seen on graphics, the process is in control for two transformation methods. Using fuzzy median and fuzzy mode for determining fuzzy probabilistic chart in our dataset does not give any different results.

Membership Approach

First, fuzzy membership control chart was obtained by applying membership approach to dataset. As seen on figure 4, the process is out of control at three occasions: Samples 15, 21 and 23. It can be clearly seen that the membership chart constructed using fuzzy mode as a transformation approach gives smaller interval between control limits than fuzzy probabilistic approach.

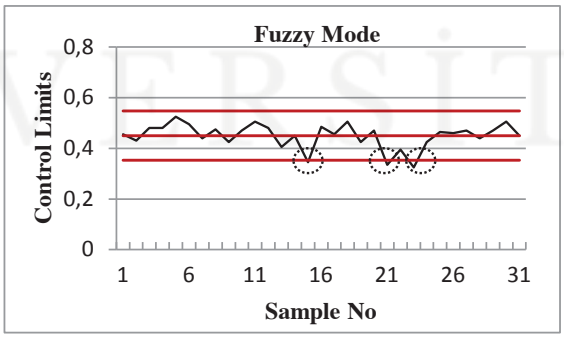


Figure 4. Fuzzy Mode Membership Control Chart

While calculating limits, the mean deviation was calculated approximately 0.338. Thus, CL, UCL, LCL and width were obtained as 0.45, 0.547, 0.353, and 0.194 respectively.

Conclusion

Control chart is a graphical tool which improves the quality level of the process by decreasing the variability and increasing the stability. It is an efficient tool to hold the process at control. Classical process control charts are appropriate if the data is exactly known and absolute. However, in some situations, we cannot have such certain data when human subjectivity plays a substantial role. Fuzzy set is inevitable in representing uncertainty, vagueness and human subjectivity. It is widely used if the data is expressed in linguistic terms such as "excellent", "good", "medium", and "bad".

In this study, quality characteristics of items packaging process were investigated using traditional statistical quality control and fuzzy logic. At first, generalized p chart, which is based on probability theory was applied. Then, fuzzy set theory in the study of control charts was applied to the same data to represent the uncertainty. Fuzzy set theory results are compared with the traditional approach to notice the difference in performance. The results of study showed that fuzzy control charts has better performance and more suitable than control chart approach. Because, it can detect abnormal status in the process than traditional quality chart technique. Therefore, by the aid of this theory, flexibility of the process was improved.

References

[1] ISO 9000:2005, Clause 3.2.10

[2] Juran, Joseph M., ed., 1995, A History of Managing for Quality: The Evolution, Trends, and Future Directions of Managing for Quality, *Milwaukee, Wisconsin: The American Society for Quality Control*.

[3] Nishant, A., Gautam, A., Sharma, N., 2014, Use of Logic Gates to Make Edge Avoider Robot, *International Journal of Information & Computation Technology*. 4(6), 630.

[4] Novák, V., Perfilieva, I., Močkoř, J., 1999, Mathematical principles of fuzzy logic, *Dodrecht: Kluwer Academic*. ISBN 0-7923-8595-0

[5] Zadeh, L., A., 1965, Fuzzy sets, *Information and Control*, 8(3), 338–353.

[6] Jump, U., Klaua, D., 1965, An early approach toward graded identity and graded membership in set theory, *Fuzzy Sets and Systems*, 161(18), 2369–2379.

[7] Wang, J. H., Raz, T., 1990a, On the construction of control charts using linguistic variables, *International Journal of Production Research*, 28(3), 477–487.

[8] Raz, T., Wang, J. H., 1990b, Probabilistic and membership approaches in the construction of control charts for linguistic data, *Production Planning & Control: The Management of Operations*, 1(3), 147-157.

[9] Kanagawa, A., Tamaki, F., Ohta, H., 1993, Control charts for process average and variability based on linguistic data, *The International Journal of Production Research*, 31(4), 913–922.

[10] Sorooshian, S., 2013, Fuzzy Approach to Statistical Control Charts, *Journal of Applied Mathematics*, 2013.

[11] Sorooshian, S., 2013, Basic Developments of Quality Characteristics Monitoring, *Journal of Applied Mathematics*, 2013.

[12] Gulbay, M., Kahraman, C., 2007, An alternative approach to fuzzy control charts: direct fuzzy approach, *Information Sciences*, 177, (6), 1463–1480.

[13] Gulbay, M., Kahraman, C., 2006, Development of fuzzy process control charts and fuzzy unnatural pattern analyses, *Computational Statistics & Data Analysis*, 51(1), 434–451.

[14] Gulbay, M., Kahraman, C., Ruan, D., 2004, α-cut fuzzy control charts for linguistic data, *International Journal of Intelligent Systems,* 19 (12), 1173–1195.

[15] Feili, H., R., Fekraty, P., 2010, Comparing Fuzzy Charts with Probability Charts and Using Them in a Textile Company, *The Journal of Mathematics and Computer Science,* 1 (4), 258-272.

[16] Ertugrul, I., Aytaç, E., 2009, Construction of quality control charts by using probability and fuzzy approaches and an application in a textile company, *Journal of Intell Manuf*, 20, 139–149.

[17] Taleb, H., Limam, M., 2002, On fuzzy and probabilistic control charts, *International Journal of Production Research*, 40(12), 2849-2863.

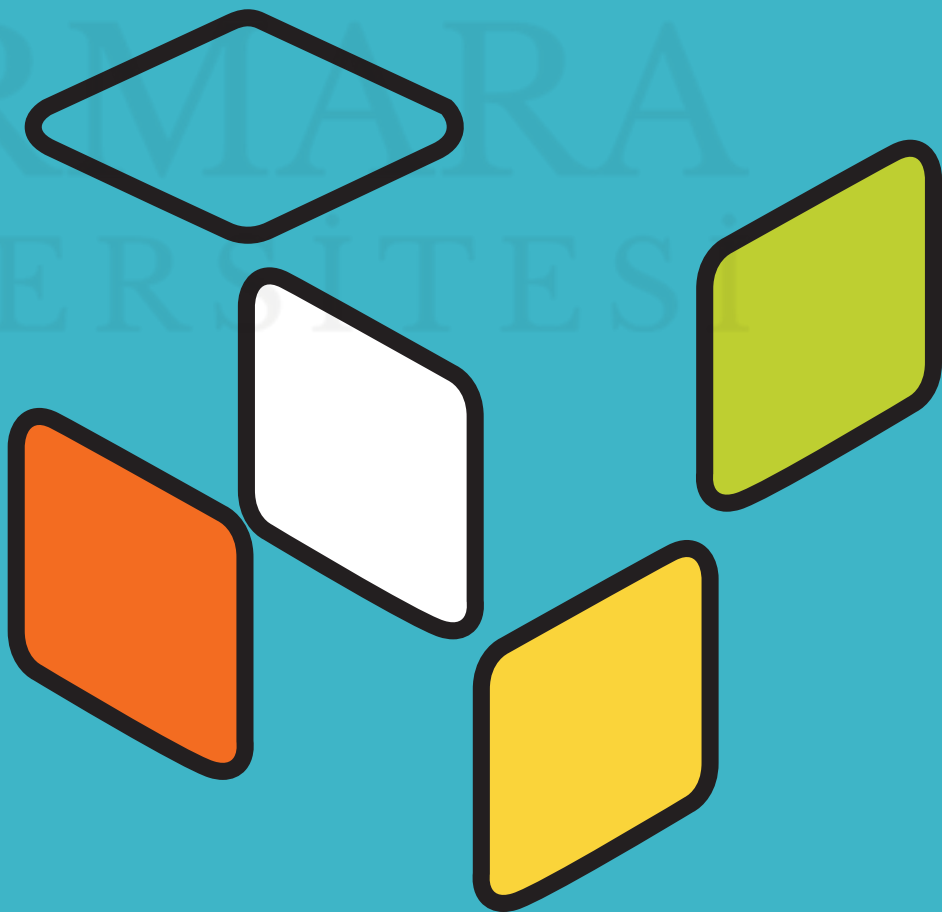
[18] Montgomery, D.C., 2005, Introduction to Statistical Quality Control (5th ed.), *John Wiley and Sons*, New York.

[19] Marcucci, M., 1985, Monitoring multinomial processes, *Journal of Quality Technology*, 17,86-91.

[20] Amirzadeh, V., Mashinchi, M., Yaghoobi, M. A., 2008, Construction of Control Charts Using Fuzzy Multinomial Quality, *Journal of Mathematics and Statistics*, 4 (1), 26-31.

MARMARA ÜNİVERSİTESİ YAYINEVİ

OPERATIONS MANAGEMENT



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

An Analytical Approach to Automative Industry

İlayda Ülkü [1], Serol Bulkan[2], Fadime Üney-Yüksektepe[3]

Abstract

Inventory control helps to manage or locate materials and any information through the processes in the company. The aim of the inventory management in the companies is to optimize inventory control. Especially, for the manufacturing companies, inventory control has an important goal which satisfies the product to the customer on time. Therefore, the system in the production processes should not have any trouble during the production. This study aims to optimize the production system of a two stage production processes where the bumpers are produced for different type of cars and different colors due to the model of the car. In the first stage there is three injection machines which are parallel, and in the second stage, there is a dying station. A mixed-integer linear programming model is proposed to optimize the production process. With the proposed model, the production of the injection processes is optimized and the lot sizes for each stage is determined. Also, front and back bumpers for each same model is dyed concurrently which prevents the color difference for the same model of each type of car.

Keywords: Inventory Control, Lot Size, Mixed-Integer Linear Programming

Introduction

Inventory control helps to manage or locate materials and any information through the processes in the company. The aim of the inventory management in the companies is to optimize inventory control. Especially, for the manufacturing companies, inventory control has an important goal which satisfies the product to the customer on time. The motivation behind this study is to see the inventory control, when some important constraints are changed, such as inventory balance equation. The obtained data [3] is used in an automotive manufacturer that produces bumpers for different type of car models and different colors. The problem has two stages, in the first stage there is three injection machines with unequal production rates, and the dying station is the second stage. In the first stage, there are different moulds used by injection machines. Different than the study in the literature, we try to use the dying station for the same type of bumpers to prevent color differentiation between bumper types which are front and back. This proposed model helps to increase the customer satisfaction at the same time with the balancing the inventory.

Inventory control has an important goal which satisfies the product to the customer on time for the manufacturing companies. Therefore, the system in the production processes should not have any trouble during the production. This study aims to optimize the production system of a two stage production processes where the bumpers are produced for different type of cars and different colors due to the model of the car. In the first stage there is three injection machines which are parallel, and in the second stage, there is a dying station.

[1]İlayda ÜLKÜ, Istanbul Kültür University, Faculty of Engineering, Department of Industrial Engineering, Istanbul, Turkey, mailto:i.karabulut@iku.edu.tr
[2]Serol BULKAN, Marmara University, Faculty of Engineering, Department of Industrial Engineering, Istanbul, Turkey, mailto:sbulkan@marmara.edu.tr
[3]Fadime ÜNEY-YÜKSEKTEPE, Istanbul Kültür University, Faculty of Engineering, Department of Industrial Engineering, Istanbul, Turkey, mailto:f.yuksektepe@iku.edu.tr

In this study, a mixed-integer linear programming model is proposed to optimize the production process. With the proposed model, the production of the injection processes is optimized and the lot sizes for each stage are determined. Also, front and back bumpers for each same model is dyed concurrently which prevents the color difference for the same model of the car. The remaining part of this paper is organized as follows. In the methodology part, proposed optimization model is described in detail. In comparison study part, data related to the compared study is used and the proposed study results are compared with the current study. Paper concludes with conclusion and suggestions in conclusion part.

Methodology

The parameters below are used to solve the mixed-integer linear programming model. The demand for model i in color k for day g is d_{ikg}, required setup time for injection machine r to produce model i of type j is defined as s_{ijr}. Available time of injection machine r in micro period t is at, available time of dying station in micro period t is atd. Dying time of model i with color k is td_{ik}, required process time for unit product of model i of type j by injection machine r is defined as tp_{ijr}, inventory cost and setup costs are ic and sc respectively. Backlogging costs and idleness cost of dying station are bc and idc respectively. Maximum number of products that can be kept in available inventory $MaxINX$.

The following decision variables are used to solve the two-stage production processes to find optimal lot sizes for each stage.

X_{ijrt} is the number of products of model i of type j produced by injection machine r in micro period t, Y_{ikt} is the number of products of model i dyed by dying station with color k in micro period t, INY_{ikg} is the number of products of model i with color k held in buffer stock II at the end of day g, INX_{ijt} is the number of products of model i of type j held in buffer stock I at the end of in micro period t, BL_{ikg} is the number of backlogged products of color k of model i in day g, IDL_t is the idle time of the dying station in micro period t.

$$S_{ijrt} = \begin{cases} 1 \text{ if model } i \text{ of type } j \text{ is produced by machine } r \text{ micro period } t; \\ 0 \text{ otherwise} \end{cases}$$

$$SI_{ijrt} = \begin{cases} 1 \text{ setup for model } i \text{ of type } j \text{ is produced by machine } r \text{ micro period } t; \\ 0 \text{ otherwise} \end{cases}$$

The following the mixed-integer linear programming model is used to solve the optimal lot sizes for two stages production problem.

$$\min z = \sum_i \sum_j \sum_t INX_{ijt} + \sum_i \sum_j \sum_r \sum_t sc.SI_{ijrt} + \sum_i \sum_k \sum_g bc.BL_{ikg} + \sum_t idc.IDL_t + \sum_i \sum_k \sum_g ic.INY_{ikg} \quad (1)$$

Subject to

$$X_{ijrt} \le M.S_{ijrt} \qquad \forall ijrt \qquad (2)$$

$$S_{ijrt} - S_{ijr(t-1)} \le SI_{ijrt} \qquad \forall ijrt \qquad (3)$$

$$\sum_r S_{ijrt} \le 1 \qquad \forall ijt \qquad (4)$$

$$\sum_i \sum_j S_{ijrt} \le 1 \qquad \forall rt \qquad (5)$$

$$\sum_i \sum_j (tp_{ijr}.X_{ijrt} + st_{ijr}.SI_{ijrt} \le at \qquad \forall rt \qquad (6)$$

$$\sum_i \sum_j INX_{ijt} \le MaxINX \qquad \forall t \qquad (7)$$

$$INX_{ij(t-1)} + \sum_r X_{ijrt} - INX_{ijt} = \sum_k Y_{ikt} \qquad \forall ijt \qquad (8)$$

$$INY_{ik(g-1)} + \sum_t Y_{ikt} + BL_{ikg} = d_{ikg} + INY_{ikg} + BL_{ik(g-1)} \qquad \forall ikg \qquad (9)$$

$$\sum_i \sum_k td_{ik}.Y_{ikt} + IDL_t \le atd \qquad \forall t \qquad (10)$$

$$INX\max_{it} \ge INX_{ijt} \qquad \forall ijt \qquad (11)$$

$$X\max_{irt} \ge X_{ijrt} \qquad \forall ijrt \qquad (12)$$

$$INX\max_{i(t-1)} + \sum_r X\max_{irt} - INX\max_{it} = \sum_k Y_{ikt} \qquad \forall ijt \qquad (13)$$

$$X_{ijrt}, Y_{ikt} \ge 0 \qquad \forall ijrkt \qquad (14)$$

$$INX_{ijt}, INY_{ikg}, BL_{ikg}, IDL_t \ge 0 \qquad \forall ikgt \qquad (15)$$

$$SI_{ijrt}, SI_{irt} \in 0,1 \qquad \forall ijrt \qquad (16)$$

The objective function (1) is to minimize the total cost which includes inventory cost, setup cost, backordering cost, and idleness cost. Inventory cost includes number of products held in inventory after injection process and number of products held in inventory after the dying process. There are *i* type of car models and *j* type of bumpers on each injection machine, therefore, if there is any production S_{ijrt} will take 1 value in the equation, if there is no production then S_{ijrt} value will take 0 for constraint (2). Constraint (3) helps to determine number of setups for each micro period *t*. Constraint (4) is used to show that each model has one mould to be used. That is each injection machine has different mould to produce different type of bumpers in each micro period. This restriction is given by constraint (5). Constraint (6) is valid to see the capacity constraint where total available time should not exceed total process and setup time. Constraint (7) represents that total inventory level after injection process should not be exceeded. Constraint (8) gives the production

balance equation of injection processes for dying station. In constraint (9) demand is balanced with both stages injection and dying. Also, available time of dying station is restricted with constraint (10). Constraint (11), (12), and (13) give restriction for bumpers in dying station. To prevent color differentiation for each model *i*, each model's bumpers-front and back should enter at the same time in the dying station in each micro period *t*. Therefore, it is important to held in inventory both type *j* of model *i*. Constraint (14), (15), and (16) satisfy the non-negativity of the decision variables.

Comparison Study

In this study, real data is used to see the efficiency of the model. [3] There are five different type of bumpers with front and back for each model. The problem has two stages, in the first stage there is three injection machines with unequal production rates. For defined models the production rates are 45, 57, 56, 45, 45 unit/hour respectively. Setup time is considered as one hour and setup cost is 600 TL, for the injection machines. The dying station is the second stage where the production rate is 70 bumpers, front and back. In the literature [3] bumpers are put on the hangers and dyed on the hangers. If a color change is occurred a single hanger stays empty. In this study, to reduce the color differentiation between front and back bumpers, the bumper pairs are dyed at the same time together. Therefore, there is no need to leave a hanger empty. The dying station will be used efficiently with this approach. The setup time is ignored, because the production rate of dying station is higher than the setup time. Moreover, setup cost related to the color change is not necessary to be included in the model at the dying station. Idleness cost is taken as 80 TL, as it is not preferred to be idle at the dying station. Also, there is a capacity for 2472 unit products after the injection processes. Inventory holding cost is 10 TL/day both for the products after injection process which are not finished and for the products after dying station. As backlogging is not preferred, the backlogging cost is 1000 TL per day. In addition, there are nineteen types of colors for the bumpers. There is a daily demand value which is obtained before the start of a week. Proposed model is formulated in GAMS 23.1.2 and solved by using CPLEX 11 solver in order to obtain the optimal results. The runs were executed on a 1.70GHz Intel Core i5 notebook with 6 GB of RAM. The micro period lengths of 4 hours that is 36 micro period length is obtained in a day. [3].

Table 1 gives a brief information about the number of products of model *i* of type *j* produced by injection machine *r*.

Table 1. Number of products of model *i* of type *j* produced by injection machine *r* for the proposed model

		Injection Machine							
		1		2		3		Total Production	
		Bumper 1	Bumper 2	Bumper 1	Bumper 2	Bumper 1	Bumper 2	Bumper 1	Bumper 2
Model	1	500	500	600	500	300	400	1400	1400
	2	400	800	300	100	500	300	1200	1200
	3	200	0	200	800	500	100	900	900
	4	400	400	200	0	0	200	600	600
	5	400	0	300	700	0	300	700	1000
	Total Production	1900	1700	1600	2100	1300	1300		

For each model *i*, in each injection machine *r*, total number of produced bumpers are shown in Table 1. For instance, for model 1

- ✓ The production amount for bumper 1 and bumper 2 for injection machine 1 is 500 units.
- ✓ For injection machine 2, the production amount for bumper 1 is 600 units, and for bumper 2 is 500 units.
- ✓ For injection machine 3, the production amount for bumper 1 is 300 units, and for bumper 2 is 400 units.

Figure 1 represents a detailed histogram of each model *i* produced by each injection machine *r*.

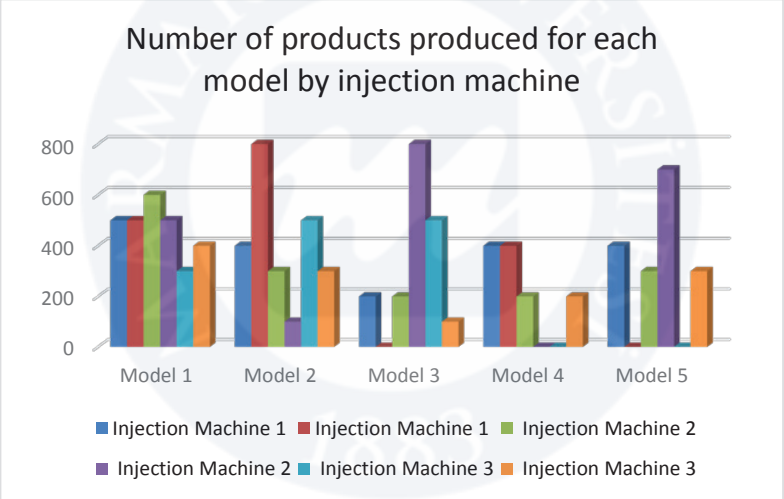


Figure 1. Number of products of model *i* of type *j* produced by injection machine *r* for the proposed model

When the model is compared with the current study [3] the following production rates are obtained. Table 2 represents the production amount of model *i* of type *j* produced by injection machine *r* for the current model.

Table 2. Number of products of model *i* of type *j* produced by injection machine *r* for the current model

		Injection Machine							
		Injection Machine 1		Injection Machine 2		Injection Machine 3		Total	
		Bumper 1	Bumper 2	Bumper 1	Bumper 2	Bumper 1	Bumper 2	Bumper 1	Bumper 2
Model	Model 1	1100			500	700	1300	1800	1800
	Model 2	600	100	300	900	200	100	1100	1100
	Model 3	500	400	100	300	100		700	700
	Model 4	100			100	100	100	200	200
	Model 5	600	200	500	900	500	500	1600	1600
	Total	2900	700	900	2700	1600	2000		

Figure 2 shows a detailed histogram of each model *i* produced by each injection machine *r*. When proposed model and current model is compared, proposed model has significant effect in the production amount of model 2, 3 and 4.

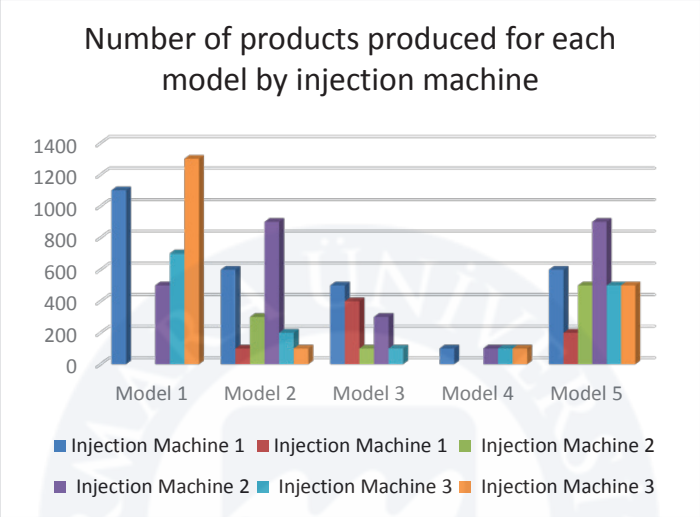


Figure 2. Number of products of model *i* of type *j* produced by injection machine *r* for the current model

Table 3 shows the comparison of number of products of each model *i* of type *j* from injection machines held in inventory for the proposed model. After the production process in injection machines, semi-products for model 1 is as follows, for the first type of bumper 500 units and for the second type of bumoer 600 units are held in inventory for the dying station.

Table 3. The comparison of number of products of model *i* of type *j* from injection machines held in inventory

		Bumper	Proposed Model	Current Model
Model	1	Bumper 1	500	200
		Bumper 2	600	100
	2	Bumper 1	200	200
		Bumper 2	1300	400
	3	Bumper 1	500	0
		Bumper 2	200	900
	4	Bumper 1	100	0
		Bumper 2	700	200
	5	Bumper 1	31	718
		Bumper 2	1131	1518

Figure 3 gives an information to see easily each type of model *i* and *j* type of bumpers held in inventory. When the proposed situation is compared with the current situation, the bumper pairs-front and back are dyed together for each model. Therefore, there are both front and back bumpers together as the semi-products in the inventory.

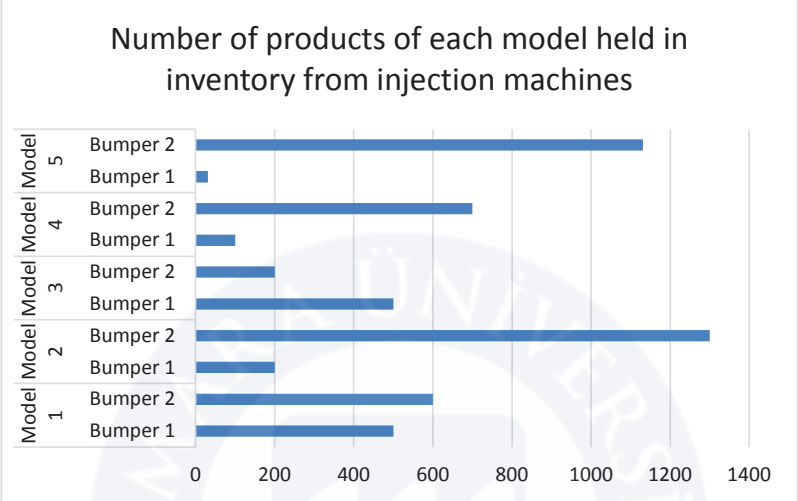


Figure 3. The comparison of number of products of model *i* of type *j* from injection machines held in inventory for the proposed study

Table 4 represents number of products of each model dyed by painting station with nineteen different color. For instance, for model 1,

- ✓ There 75 units dyed by color number 3,
- ✓ 10 unit dyed by color 18 etc.

Table 4. The comparison of number of products of model *i* dyed by painting station with color *k*

		Proposed Model					Current Model				
		1	2	3	4	5	1	2	3	4	5
Color	1				8	57					57
	2				120	185				23	288
	3	75	137	141	118	105	108	167	124	47	178
	4	297	388	112	12	6	287	486	110		7
	5	53			19	5	53			10	5
	6	9	83	22	71	167	70	83	18	20	214
	7	71					58			16	
	8				9	48					60
	9	28			92	347	43			17	413
	10	726	142	213			957	185	121		
	11		9	5	31	90			4	11	108
	12	108	29	135			158	22	80		
	13		68	47	32	158			43	32	200
	14	16	100	150	61	33	35	71	134	28	10
	15	7	46	38			16	35	29		
	16		37	13				31	13		
	17		23	24	25	23		20	24	13	62
	18	10			2	8	15				8
	19										

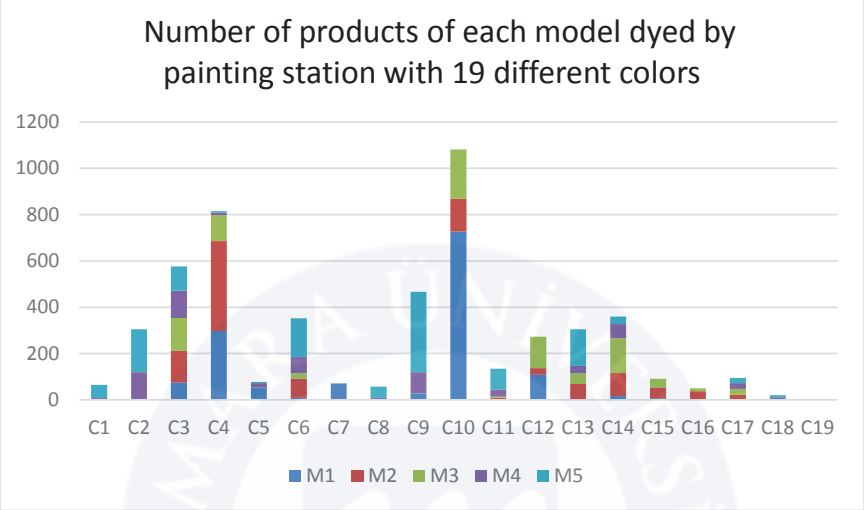


Figure 4. Number of products of model *i* dyed by painting station with color *k* for the proposed study

In Figure 4, number of products of each model dyed by painting station with different colors for the proposed study are represented. In the proposed model, bumper pairs are dyed for model 1, 2, and 3 in eleven different colors, and for model 4 and 5, thirteen different colors bumper pairs are dyed. On the other hand in the current study, for model 1 and 3-eleven different colors, for model 2-nine different colors, for model 4-ten different colors, and for model 5-thirteen different colors are dyed. In the proposed study, the color type is enlarged 18.18% for model 2, and also for model 4 dyed different color types are increased in 23.08%.

Table 5. Daily Idle Time (min.)

Daily Idle Time (min.)	Day 1	11.689
	Day 2	12.227
	Day 3	9.833
	Day 4	11.250
	Day 5	11.250
	Day 6	11.250
	Total Idle Time	67.499
	Average Idle Time	11.250

Table 5 shows the summary information about the proposed model. Idle time for dying station of each day is given in minutes. For instance, at the end of day 1, dying station is idle 11.689 minutes, and the average idle time of dying station is 11.250 minutes. Also, in figure 5, idle time for dying station of each day is given as percentages. For instance, minimum daily idle day is day 3 with 14%.

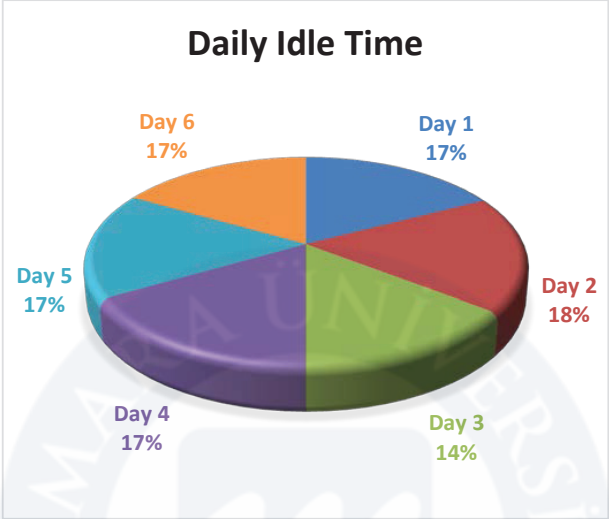


Figure 5. Daily Idle Time (%)

Conclusion

In this paper, real data from an automotive supplier is used. A mixed-integer linear programming model is proposed to optimize the production process. With the proposed model, the production of the injection processes is optimized and the lot sizes for each stage is determined. Also, front and back bumpers for each type of model is dyed concurrently which prevents the color difference for the same model of the car. This study helps to increase the customer satisfaction at the same time with the balancing the inventory. Moreover, the characteristics of the proposed model are given. As the possible future work, micro period lengths can be changed instead of using a fixed micro period. In addition, as comparison the run time of the model can be changed to see the effects to the model. Also, objective function can be changed to see the influence to the proposed model.

References

[1] Brooke, A., Kendrick, D., Meeraus, A., Raman, R., 1998. GAMS:A User's Guide. GAMS, De-velopment Co., Washington, DC.
[2] Ilog, 2010. CPLEX 12.0 User's Manual , ILOG S. A. See website www.cplex.com
[3] Uney, Yuksektepe, F., Ozdemir, R., G., 2011, Synchronized Two-Stage Lot Sizing and Scheduling Problem in Automotive Industry, *Operations Research Proceedings*, 477.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Profit Based Scheduling Using Agent Based Architecture: A Single Machine Problem

Banu Çalış

Abstract

Today's manufacturing enterprises need to measure the capability to able to improve their profit-earning capacity. Profit-earning capacity of a manufacturing system can be defined as ability of generate profits. Aim of this study is to develop a methodology to increase profitability. For that purpose a profit based scheduling model is generated using agent-based architecture in an integrated manufacturing environment to increase responsiveness, and flexibility of the manufacturing system. Results of profit based scheduling and the advantages for Small and Medium size Enterprise (SME) are introduced.

Keywords: Scheduling, Agent Based Systems, Profit, Single Machine

Introduction

Recently, global environmental challenges as well as the development of advanced computer-based modeling and analysis tools have expanded interest in the use of computational approaches to the study of human systems. As a computer based modeling and analysis tool, simulation techniques introduces the possibility of a new way of thinking about social and economic processes, based on ideas about the emergence of complex behavior from relatively simple activities [1]. Although computer simulation has been used widely since the 1960s, Agent based systems only became popular in the early 1990s. Agent based systems can be used to study how micro-level processes affect macro level outcomes. A complex system is represented by a collection of agents that are programmed to follow simple behavioral rules. Agents can interact with each other and with their environment to produce complex collective behavioral patterns. Macro behavior is not explicitly modeled; it emerges from the micro-decisions of individual agents [2], so Agent Based Modeling Simulation (ABMS) still requires research attention. With the availability of more sophisticated modeling tools, ABMS, can be extensively used by the game and film industry to develop realistic simulations of individual characters and societies. ABMS are also applied in different areas, some of them are about scientific domain; chemistry [3], physics [4], biology [5], ecology [6] etc, some of them are applied to various micro simulation [7], object oriented [8] or individual-based simulation techniques [9], as useful tool for decision making [10], computer games, for example The SIMS™ [11], enterprise improvement [12], military applications [13] etc.

Some features of MABS can be list as follow;

1. *Multi-threading*; the autonomous behavior of each simulation agent can be modeled using a program code executed with in its own thread of control. [14].
2. *High communication-to-computation ratio*. The 'social' behavior of agents embodied in MABS requires that agents communicate with each other or with information directory services to update their knowledge (beliefs) and accomplish a collective task. [14].

Banu Çalış, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, bcalis@marmara.edu.tr

3. *Time*-step *synchronization*. For the simulation to reflect the chronological sequence of events in the real world problem and guarantee causality, a central reference clock needs to be established. The interval between successive 'ticks' of the clock is the smallest possible indivisible period of time for the simulation [18]. The execution of the simulation advances in steps of this unit of time. Each agent executes some task (defined as granularity) corresponding to what the simulated entity accomplishes in the real world between two successive clock ticks [14].

Control of manufacturing functions such as order management has some difficulties when planning operations dynamically. Multi agent-based system is a popular developing area of distributed artificial intelligence that provides integration and coordination between distributed manufacturing function for the management of manufacturing environments. This paper proposes a multi-agent based single machine scheduling model concerning the profit based approach within a manufacturing system. The difference between cost-based approach and profit-based approach could be summarizing as instead of reducing the cost, a profit-based scheduling refers to the profit margin to schedule for the manufacturing orders. The proposed multi-agent based approach works under a real-time environment and generates feasible and most profitable schedules using negotiation/bidding mechanisms between agents. Model components and agent principles are defined in section2

Profit Based Scheduling Model

Single machine scheduling problem is consists of a single machine to process n jobs. In this study is objective function defined as maximization of the profit of these n jobs.

Model is constructed for small reference production system whit n independent job on a single machine under the time constraint. Purposed model is including a set of three integrated agent based modules namely, Order Analysis Agent (OAA), Profit Analysis Agent (PAA), and Reporting and Scheduling Agent (RSA) Figure 1 shows the relationship of these agents where the arcs are indicating the work flow.

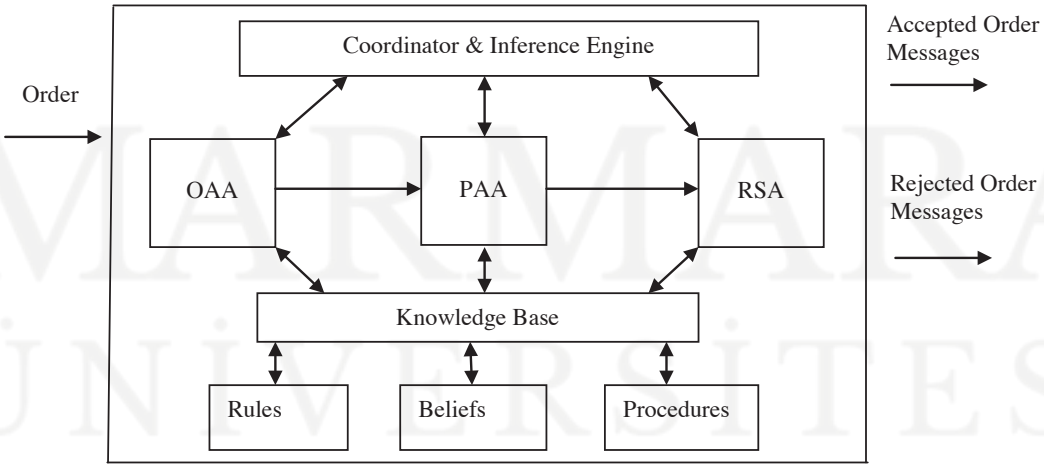


Figure 1. Component of PBSM

Each agent architecture is detailed in respective section

Order Analysis Agent (OAA): Primary task of OAA is to identify predefined set of order of small manufacturing system and support the assessment with respect to whether those are acceptable or not.

After customer orders are generated depends on a given distribution, OAA uses three analysis methods for decision of accepting or rejecting of an order and related production sequence of the orders. First analysis technique is "Model-1: Unit Profit Model (UPM)" which is defined as most profitable product is produced first.

Business rules of UPM are;

- Prepare a list of orders with respective order quantity
- Compute the needed production time of each order
- Elaborate unit profits of each order
- Define most profitable order list from up to down
- Generate a production sequence to report

Second analysis technique is "Model 2: Daily Profit Model (DPM)" which considers that the most daily profitable product is selected to produce first.

Business rules of DPM are;

- Prepare a list of orders with respective order quantity
- Compute the needed production time of each order
- Elaborate daily profits of each order depends on machine capacity
- Define most profitable order list from up to down
- Generate a production sequence to report

And last analysis technique is "Model 3: Total Profit Model (TPM)" where the most profitable order is processed.

Business Rules of DPM are;

- Prepare a list of orders with respective order quantity
- Compute the needed production time of each order
- Elaborate Total profits of each order depends on order quantity
- Define most profitable order list from up to down
- Generate a production sequence to report

Figure 2 shows OAA components where each model represents a different analysis approach.

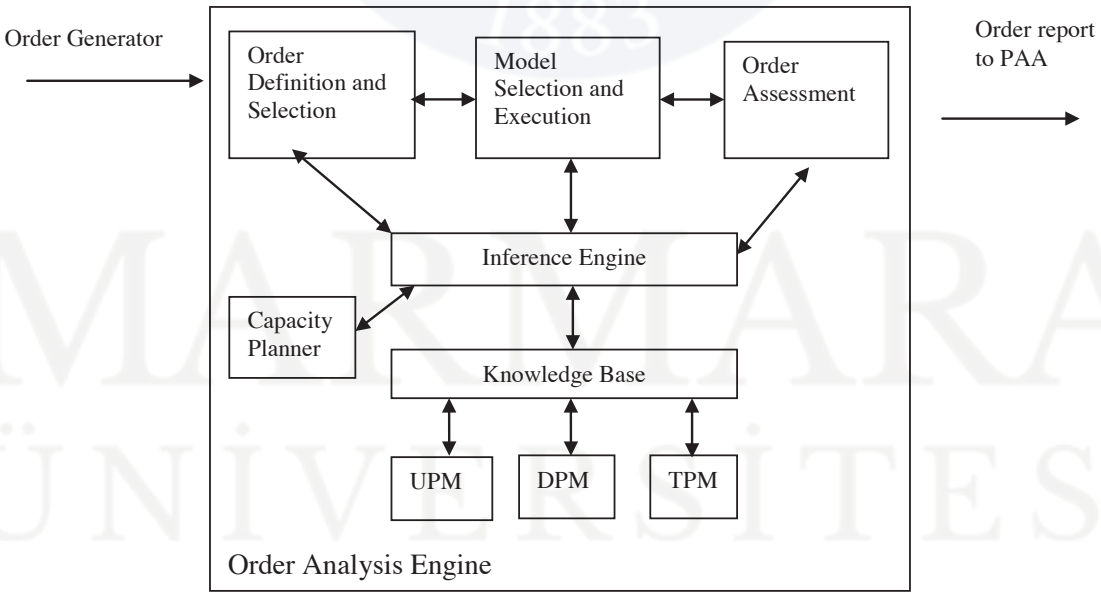


Figure 2. Order Analysis Agent Architecture

OAA engine defines the 3 different manufacturing sequence of orders depends on 3 different models explained above. This information is transmitted to Profit Analysis Agent to make profit analysis

Profit Analysis Agent (PAA): PAA is responsible to selection of most profitable sequence of three different models. After an order report is prepared by OAA, this information is carried out by Profit Analysis Agent. PAA composed of multiple autonomous agents. Negotiation is a key function of PAA which is satisfies interaction in groups of agents that enables mutual agreement including belief, goal or plan. In this study the simplest case of negotiation is used which could be define as the structure and

contents of the agreement are fixed. For that purpose calculation of accepted order profits for each 3 three sequence is elaborated by PAA and the agents' reasoning models provide the decision making which model attempt to achieve objectives.
Business Rules of PAA are;

- Calculate total profits of 3 types order sequence (UPM, DPM and TPM)
- Select most profitable sequence to schedule manufacturing
- if total profits of three models are equal send this information to order elaborator
- Order elaborator selects the technique which has maximum number of order in it to satisfy more customers and sends the selected profit model schedule to scheduler
- When all total profit values and number of accepted orders are same for each 3 models. Select the model randomly.

After analysis is done, PAA sends related information (selected model and related production schedule) to Scheduling Agent to preparation of a job order and sends to Reporting Agent to preparation of a form to inform customers. Figure 3 shows its components where each component represents model selection and amount determination.

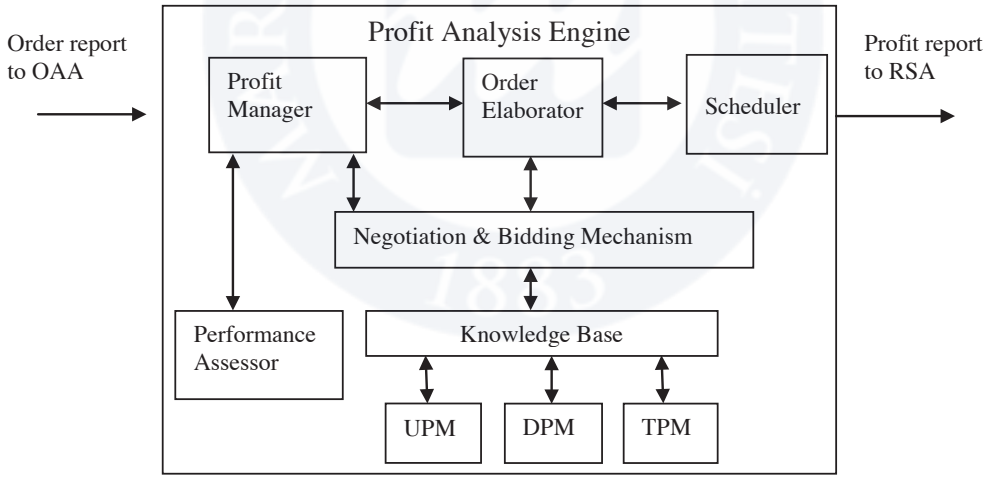


Figure 3. Profit Analysis Agent Architecture

Reporting and Scheduling Agent (RSA): RSA is responsible for preparing a form indicating the status of order acceptation or rejection messages as well as due dates for accepted orders to inform customers. After received selected model information by RSA, Scheduling engine prepares a job order form to use manufacturing which is including accepted order schedule and related due dates.
Business rules of RSA are;

- Prepare job order list for accepted orders.
- Check scheduled delivery date of orders and give an approval form
- if there is a late job send this information to Coordinator & Inference Engine to start new scheduling process
- Prepare an order acceptance report to send customers including delivery date or rejection of given order

Figure 4 shows it's the architecture of RSA

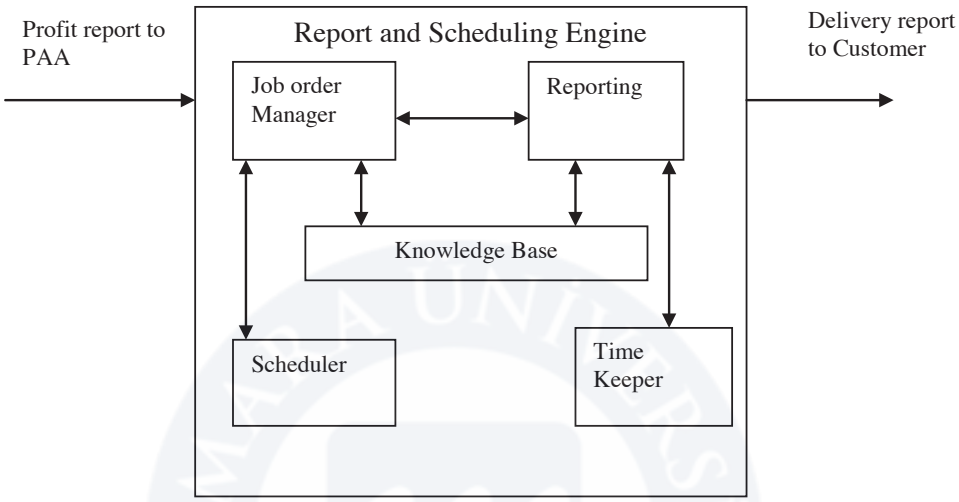


Figure 4. Reporting and Scheduling Agent Architecture

In this section a prototype profit based scheduling model based on agent based architecture is introduced. Model execution of the proposed model is outlined in next section.

Model Execution

In this part of study the capability of the proposed model in a single machine manufacturing environment will be detailed and respective issues will be discussed. First step of the implementation is identification of the model parameters;

J : set of scheduled operations,
J^d : candidate to schedule jobs at time t,
J^c : set of unscheduled jobs at time t
t : scheduling time
P_j : unit processing time of job j
d_j : due date of job j
C_j : completion time of job j
Pr_j : unit profit of job j
Dmj : amont of demand of job j
PR_i : product type i

The problem is identified as $1 \mid\mid Pr_{max}$. The jobs may not be preempted and each job j is characterized by its processing time P_j, its due date d_j and its profit value Pr_j.

Second step of implementation is definition of assumptions which are;

1. In order to measure the capability of reference model a hypothetic database is constructed which is explained in section 3.1
2. Simulation parameters are; Problem considers n independent jobs (j=1,2,…,n) on a single machine to maximize total profit. There are no precedence constraints between jobs and each job has a nonnegative due dates d_j ($d_j \geq 0$). Machine is continuously available and can process one job at a time.
    a. P_j is generated from a discrete uniform distribution between 5 to 250 (in terms of second)

b. d_j is generated from a discrete uniform distribution between 1 and 9 (in terms of day)
c. Dm_j is generated from a discrete uniform distribution between 5 and 900 units
d. Pr_j is calculated from the database (for the calculation method see next section)
e. Schedule period is assumed 10 day

3. Product range is restricted with 9 different product.
4. It could be more than one order which is included same product.
5. An order could be involve only one type of product order

Model database is prepared including the following information.; Product types (A, B, C, D, E, F, G, H, I) and related product specifications which are given below;

- Maintenance Unit/day, Maintenance Time (min), Setup Time (min), Breaking Unit/day and Breaking Duration (min.) to calculation of lost time of a day;
  - Lost Time is calculated as ;
    Lost Time=Maintenance Unit * Maintenance Time + Setup Time + Breaking * Breaking Time
- Daily available Working Time;
  - Daily Working Time = 8 hour*60 minutes = 480 minutes for a day (for each type product.
  - Daily Available Time is calculated as ; Daily Working Time – Lost Time
    For Example Product A is calculated as; 480-39 = 441 hour
- Mean Standard Time to calculation of daily production capacity.
  - Daily Capacity is calculated as ; (Daily Available Time * 60) / Mean Standard Time (sec)
    For Example Product A is calculated as; (441*60)/ 210=126
- Unit Cost is calculated as ;((worker cost daily + Fixed Cost) / Daily Capacity +Row Material Cost/Unit)
  - Worker Unit which is necessary to produce each type of product
  - Worker Cost (daily) is calculated as; (1500*Worker Unit)/20 (1500 is the salary for one worker, assumed that each worker will take same salary. And 20 is number work day in a month.)
    For Example Product A is calculated as; (1500*1)/20 =75
  - Fixed Cost Daily (includes management cost for company)
  - Row Material Cost for each type of product is given

  For Example Product A is calculated as; ((75+1.000)/126) + 30) = 38, 13
- Unit Profit for each type of product is given
  Unit price- unit cost
  - Daily Profit is calculated as; Daily Capacity * Unit Profit
    For Example Product A is calculated as; 126*50 = 6.300 $

Model execution;
In this part of study, execution of the purposed model is illustrated on a small example in order to demonstrate the algorithm. Sample order data is given in Table 1.

Table 1. Sample Order Data

PR_i		A	B	C	D	E	F	G	H	I
Dm_j		245	825	701	838	746	904	171	698	621
d_j		5	8	7	4	9	4	8	7	6

OAA engine selection mechanism of Unit Profit Model is shown in Table 2.

Table 2. Unit Profit Model Order Sequence Definition

Pri		A	B	C	D	E	F	G	H	I	Needed production Time (day)	Decision for due date (*)	Used Time (day)
Dmj		519	631	13	716	503	526	779	229	682			
d_j		6	7	8	3	8	6	3	3	8			
UPM Order Production Sequence	1	0	0	0	0	0	0	0	1	0	5,5	0	0,0
	2	0	0	0	2	0	0	0	0	0	2,2	1	2,2
	3	3	0	0	0	0	0	0	0	0	7,1	0	2,2
	4	0	4	0	0	0	0	0	0	0	1,0	1	3,2
	5	0	0	0	0	0	5	0	0	0	2,6	1	5,8
	6	0	0	0	0	6	0	0	0	0	0,8	0	5,8
	7	0	0	7	0	0	0	0	0	0	1,7	0	5,8
	8	0	0	0	0	0	0	8	0	0	0,4	1	6,2
	9	0	0	0	0	0	0	0	0	9	0,8	0	6,2

*Decision for due date is an integer variable; 1 for accepted order, 0 for rejected order.

=EĞER(C6<>0;C4/spesifications!C13;EĞER(D6<>0;D4/specifications!D13;EĞER('orders analysis'!E6<>0;E4/spesifications!E13;EĞER(F6<>0;F4/specifications!F13;EĞER('orders analysis'!G6<>0;'orders analysis'!G4/spesifications!G13;EĞER(H6<>0;'orders analysis'!H4/spesifications!H13;EĞER(I6<>0;I4/spesifications!I13;EĞER(J6<>0;J4/spesifications!J13;K4/spesifications!K13))))))))

=EĞER(C6<>0;EĞER(L6<=C5;1;0);0)+EĞER(D6<>0;EĞER(L6<=D5;1;0);0)+EĞER(E6<>0;EĞER(L6<=E5;1;0);0)+EĞER(F6<>0;EĞER(L6<=F5;1;0);0)+EĞER(G6<>0;EĞER(L6<=G5;1;0);0)+EĞER(H6<>0;EĞER(L6<=H5;1;0);0)+EĞER(I6<>0;EĞER(L6<=I5;1;0);0)+EĞER(J6<>0;EĞER(L6<=J5;1;0);0)+EĞER(K6<>0;EĞER(L6<=K5;1;0);0)

=EĞER(M14<>0;N13+L14;N13)

Orders of Product H is produced first than orders of E and G will be produced respectively. After OAA completed the decision process, PAA starts to calculation of total profit of each model as can be seen in Table 3.

Table 3. Total Profit of Unit Profit Model

	A	B	C	D	E	F	G	H	I
Profit:	0	7965	0	12870	0	12480	2530	0	0
Total Profit	35845				**Number of accepted order**			4	

=EĞER(TOPLA(K6:K14)>=1;'orders analysis'!K4*spesifications!K19;0)

Related data for this sample trial including three model are summarized in Table 4.

Table 4. Summary Information of PAA

UPM	Total Profit	35480
	Number of Accepted Order	4
DPM	Total Profit	23365
	Number of Accepted Order	3
TPM	Total Profit	27880
	Number of Accepted Order	3
DECISION MODEL :		**UPM**
PROFIT		**35480**

After this step is completed RSA prepares a report for customer a job order for manufacturing. Report page for sample date is given in Table 5.

Table 5. Report Page of the PBSM

Product Type / Spesifications	A	B	C	D	E	F	G	H	I
Customer Order	519	631	13	716	503	526	779	229	682
Customer Due date	6	7	8	3	8	6	3	3	8
Order Acceptance	reject	accept	reject	accept	reject	accept	accept	reject	reject
Delivery dates	0,00	0,00	6,35	0,00	8,59	0,00	6,64	5,00	0,00
Model Check	model consistent	model consistent	model consistent	model consistent	model consistent	model consistent	model consistent	model consistent	model consistent
Messages	Order rejected	Order accepted	Order rejected	Order accepted	Order rejected	Order accepted	Order accepted	Order rejected	Order rejected
Profit	35480	$							

=EĞER(C7<=C5;"model consistent";"checkmodel")

=EĞER(TOPLA(J17:J25)>=1;"accept";"reject")

Reference model is operated 100 times (each trial has for 9 jobs) and results are recorded. Success frequency of each profit model is summarized in Figure 5. Model success defined as selected production sequence after each trial. Figure 5 shows that unit profit model gives better solution than others. 57 times of 100 trial total profit of UPM model gives portable solution for the manufacturing system. Contrary to expectations TPM gives only 17 times best solution in others.

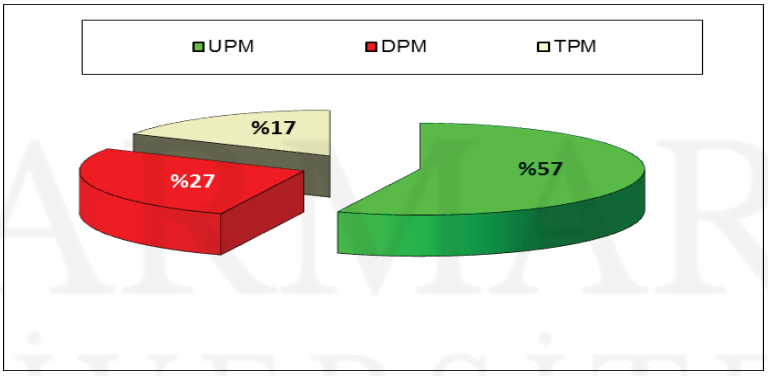


Figure 5. Frequency of the selected profit models
1. Unit Profit Model: %57 2. Daily Profit Model: % 27 3. Total Profit Model :% 17

Table 6 Indicates a hypothetical example including Unit Profit Model, Daily Profit Model, Total Profit Model and Opportunity Cost values calculated after 20 times Simulation run. As can be seen from the Table 6, each trial results are different than others depending on random orders and random due dates. As a result of 20 trials it can be said that 126.008$ total money will lose that is opportunity cost (if comparison of 3 models is not used and if lowest profit techniques were selected, company will lose this amount of money) for the manufacturing company.

Table 6. Results of the first 20 trials

TRIALS	UPM	DPM	TPM	Opportunity Cost
1	48456	48456	39456	9000
2	42853	42853	42853	0
3	45463	45463	44983	480
4	37690	43225	37690	5535
5	42380	51292	46572	8912
6	52260	52260	52260	0
7	30438	30438	30438	0
8	39805	47151	39805	7346
9	31926	31926	31926	0
10	29340	29340	43405	14065
11	38765	49440	48890	10675
12	42747	42747	42747	0
13	32741	17831	32741	14910
14	41530	41070	41070	460
15	40150	44500	44500	4350
16	30730	28094	32074	3980
17	38235	48003	54258	16023
18	42400	24428	37000	17972
19	40270	51610	51610	11340
20	30027	30987	30987	960
Total	778206	801114	825265	**126008**

An example calculation of Opportunity Cost for trial 1;
= Maximum profit of – Minimum profit
= 48456 – 39 456 = $ 9000
"=BÜYÜK(B10:D10;1)-BÜYÜK(B10:D10;3)"

Discussion and Conclusions

In the reference model a profit based scheduling algorithm is prepared and operated for a small and non-complex system. The current problem is different than Knapsack problem since each order has a different due date . For execution of the model Excel is selected. Reference model could maximize the profit of the given orders depends on three profit techniques under the time constraint. For the short execution time applicability of the reference model is very high. It is seen that if the increase in number of constraints or number of machine excel will not an appropriate tool to solve this problem because of the practicable number of if then loops. This study shows that profit based schedule depends on agent based algorithm gives efficacious solutions for manufacturing systems. Feature work of this study is contraction of a new Java model with increase in number of machine and number of Job.

References

[1] Simon, H.A. , 1996, The Sciences of the Artificial (3rd Ed.). *MIT Press: Cambridge, MA*.
[2] Pourdehnad, J., Maani, K. and Sedehi, H., 2002, System Dynamics and Intelligent Agent-Based Simulation: Where is the Synergy?. *Proceedings of the 20th International Conference of the System Dynamics Society. 28 July – 1 August Palermo, Italy.*
[3] M. Resnick, 1994, Turtles, Termites and Traffic Jams, *MIT Press, Cambridge, US*
[4] Schweitzer F., Zimmermann J, 2001, Communication and Self-Organization in Complex Systems: A Basic Approach, in: Knowledge, Complexity and Innovation Systems (*Eds. M. M. Fischer, J. Fröhlich), Springer, Berlin*
[5] Drogoul A., Corbara B., Fresneau D., MANTA ,1995,: New Experimental Results on the Emergence of (Artificial) Ant Societies, in Artificial Societies: the computer simulation of social life, Gilbert N. & Conte R. (Eds), *UCL Press, London*.

[6] Huberman, B. & Glance, N., 1993, Evolutionary games and computer simulations. *In: Proceedings of the National Academy of Science USA. 7716 – 7718*
[7] Orcutt, G.H., 1957, A new type of socio-economic system. *Review of Economics and Statistics 39 116—123*
[8] Troitzsch, K.G., 1997, Social science simulation - origins, prospects, purposes. *Simulating Social Phenomena 456 41—54*
[9] Harding, A., 1999, Modeling techniques for examining the impact of population ageing on social expenditure. *In: Conference on the Policy implications of the Ageing of Australia's Population, Melbourne, NATSEM*
[10] Tesfatsion, L., 2002, Agent-based computational economics: Growing economies from the bottom up. *Articial Life* 8(1) , 55-82
[11] ZDNet. 2000. "ZDNet Complexity Digest 2000.10: The Sims and Agent Based Modeling". Available via *<http://www.comdig.com/index.php?id_issue=2000.10>. [Accessed February 1,2009].*
[12] Kahveci T.C.& Taşkın H ,2006, The Agent-Oriented Enterprise Improvement Based On Enterprise Modeling *In: Proceedings of 5th International Symposium on Intelligent Manufacturing Systems, Sakarya University, Department of Industrial Engineering May 29-31, 247-257*
[13] Cioppa T.M., Lucas T.W.,& Sanchez S.M., 2004, military applications of agent-based models , *Winter Simulation Conference, In: Proceedings of the 36th conference on Winter simulation Washington, D.C. Year of Publication: 171 - 180*
[14] Mengistu D., Lundberg L., & Davidson P., 2007, Performance Prediction of Multi-Agent Based Simulation Applications on the Grid, *Proceedıngs Of World Academy Of Scıence, Engıneerıng And Technology Volume 21 May ISSN 1307-6884*

MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Literature Review for Data Mining and Industrial Applications

Tuğba Efendigil [1], İnci Elif Sağlam [1]*

Abstract

Along with rapid improvement in data collection and storage technology, organizations have faced with vast amount of data. However, extracting useful and significant information has presented extremely challenging. For this reason, data mining techniques including generalization, characterization, classification, clustering, association, evolution, pattern matching, and data visualization increase in importance for solving a variety of industry problems. Data mining facilitates to search a huge database without any specific pre-determined hypothesis to obtain implicit, previously unknown, and potentially useful information. In literature, data mining techniques are applied a variety of area such as finance to detect fraud or risk to early warning system, customer relationship management (CRM) to analyze customer profile and behavior, manufacture to predict defections and quality improvement, banking to forecast bankruptcy, marketing and direct marketing, healthcare, information systems and so on. This study aims to reveal an overview about application of data mining techniques occurred in literature. Thus, a wide perspective related to various data mining techniques and its applications is gained for the researchers who are willing to study of future works.

Keywords: Big Data, Data Mining, Data Mining Applications, Data Mining Techniques

Introduction

In last decades, data gathering and storing technology has progressed rapidly. Although the collected huge amount of data includes considerable information, interpretation of the data is getting hard day by day. Data mining has emerged to benefit from increasing information to better understand the markets, customers, suppliers, operations, internal business processes, patients, students/teachers and so forth. It provides valid, comprehensible, and potentially useful knowledge from large data sets and thus facilitates decision making process. Data mining integrates concepts from modern statistics, intelligent information systems, machine learning, pattern recognition, decision theory, data engineering, and database management[1]. It provides beneficial tools to find out complex and hidden relationships in large amounts of data.

Data mining contains several algorithms that serve a variety of purposes such as prediction, description, and association etc. Classification techniques, especially decision tree, neural network (NN), support vector machine (SVM), naïve bayes, clustering, regression models, association rule algorithms are widely preferred to fulfill the goals.

In literature, there are several data mining applications which are preferred for different areas such as CRM, medicine, finance and banking, manufacturing, education, marketing, information technology etc. This study focuses on four main areas as; finance/banking, CRM, manufacturing and marketing. Within this context,260 published papers in English were reviewed which have been presented in several journal data bases like Science Direct, Scopus, IEEE Xplore, Wiley, Springer Link, and Emerald. The review, which includes conference proceedings and journal publications, states a general outlook as follows.

[1] Tuğba EFENDİGİL, Yıldız Technical University, MechanicalFaculty, Department of Industrial Engineering, Istanbul, Turkey, tugbae@yildiz.edu.tr
[1*] İnci Elif SAĞLAM, Yıldız Technical University, MechanicalFaculty, Department of Industrial Engineering, Istanbul, Turkey, iesaglam@yildiz.edu.tr

Literature Review

Although a few data mining reviews have been provided in different times, all they referred only one aspect of data mining. Ngai et al. (2011) [2] made a review related to financial fraud detection, Rygielski et al. (2002) [3] and Ngai et al. (2009) [4] touched on data mining techniques used to CRM, Choudhary et al. (2009) [5] and Köksal et al. (2011) [6] tackled manufacturing applications and quality improvement in manufacturing. There is not any literature survey related to industrial applications of data mining. To fill the gap, this study gives an insight about data mining implementations in industries.

Even though first application was made in 1993, most of data mining studies belong to 2000s. Number of these studies have increased in progress of time and reached maximum number in between 2004-2006 years. CRM is becoming a widespread application area while it is followed by manufacturing and finance. In recent years, with the development in service industry, marketing applications have accelerated along with CRM.

This section presents a detailed literature review related to data mining and its applications. The research is arranged based on practices of data mining in various industries such as finance and banking, CRM, manufacture and marketing respectively. Moreover different data mining techniques like that Artificial Neural Network (ANN), Decision Tree (DT), CHAID Decision Tree and Logistic Regression are discussed in detail in terms of their usage rate.

Finance and Banking Sector

Data mining has already a major impact on business and finance. Financial markets generate large volumes of data. Analyzing these data to reveal valuable information and making use of the information in decision making present great opportunities and grand challenges for data mining[1].A great variety of data mining techniques has been widely applied to solve problems in finance fields, including financial early warning system[7, 8], fraud detection, financial distress and bankruptcy prediction[9], financial performance estimation[10, 11], credit risk management[12, 13], bank lending, and so on.

Data mining techniques have been widely used to accomplish task of management fraud detection in credit card, insurance fraud and general fraud problem. In literature there are some researches that giving an insight about the use of data mining techniques[2, 14] and investigate usefulness of data mining techniques in fraud detection area [15]. Kotsiantis et al. [16] used a variety of techniques including Artificial Neural Network (ANN), Decision Tree (DT), Logistic Regression, Bayesian Network, Support Vector Machine (SVM) to forecast fraudulent financial system and compare performance of these techniques with together. Similarly, Ravisankar et al.[17]utilize Multilayer Feed Forward Neural Network (MLFF), Support Vector Machines (SVM), Genetic Programming (GP), Group Method of Data Handling (GMDH), Logistic Regression (LR), and Probabilistic Neural Network (PNN) techniques to identify companies that resort to financial statement fraud. Neural Network [18-20], Classification and Regression Tree (CART) [21], and text mining techniques [22] are preferred to detect fraud. Especially credit card fraud is serious and growing problem so detection of this fraud has gained importance. Decision Tree (DT) [23, 24], Neural Network (NN) [25, 26], Self-Organization Map (SOM) [27, 28], and Support Vector Machine (SVM) and Logistic Regression [29] techniques are frequently preferred to serve this purpose. Also, commentators within the insurance sector have also pointed to the difficulties in estimating the prevalence and costs of insurance fraud[30]. Thus, disclosure of this fraud has become important for academic researches and several data mining techniques are applied to a variety of insurance sectors such as automobile[31-36], healthcare[37], medical insurance fraud [38]etc.

Prediction of financial distress has been a topic of interest over the decades because of its great importance to listed companies, interested stakeholders and even the economy of a country[39]. If financial distress is predicted effectively, managers of companies can initiate proactive measures to avoid deterioration before the crisis. Thus investors can grasp the profitability situation of the listed companies and adjust their investment strategies to reduce anticipated investment related losses. Support Vector Machine (SVM)[40-42] and Radial Basis Function Support Vector Machine (RSVM)[43], Neural Network (NN) [44, 45] and Probabilistic Neural Network [46], Decision Tree (DT) [47, 48] and Ada Boosted Decision Tree [49] and k-Nearest Neighbors Techniques [50] are widely used in literature to predict and analyze financial distress. In addition to estimating of financial distress, predicting bankruptcy [51-59] and financial performance [60-62] has been applied as well.

Customer Relationship Management (CRM)

Many organizations have collected and stored numerous data about their current customers, potential customers, suppliers and business partners. However, the inability to discover valuable information which is hidden in data prevents the organizations from transforming these data into valuable and useful knowledge [63]. Data mining tools could help the organizations discover the hidden knowledge in this enormous data.
Analyzing and understanding of customer behaviors and profiles is foundation of development for a competitive CRM strategy, so as to acquire and maintain potential customers and maximize customer value. Hence, application of data mining in CRM is an emerging trend in global market and academic researches. Particularly data mining enables the extraction of hidden predictive information from large databases, thus organizations can identify valuable customers, predict future behaviors, and make companies proactive with knowledge-driven decisions.

According to Kracklauer et al. [64] CRM consists of four dimensions such as customer identification, customer attraction, customer retention and customer development.

- *Customer identification:* CRM begins with customer identification that involves targeting the population who are most likely to become customers or most profitable to the company. Elements for customer identification include customer segmentation, target customer analysis and customer profile/behavior analysis. Data mining is a widely used technique in customer identification under different focus points with different techniques. In customer segmentation area there are a large number of publications including decision tree [65, 66], SOM and Markov Chain[67-70], SOM and NN [71, 72], regression [73], k-means [74], k-means and SOM [75-77], k-means and rough set theory [78], k-means and association rule [79], SOM and fuzzy clustering and NN [80] and other clustering techniques [81-84]. Decision tree [85-87], SOM [88] and k-means [89] are preferred for target customer analysis tasks. Finally, in customer profile/behavior analysis decision tree [90, 91], decision tree and sequential pattern mining [92, 93], decision tree, naïve bayes and SVM [94, 95], backpropagation NN [96] and fuzzy clustering [97] are widely utilized techniques.
- *Customer attraction*: Customer attraction is the phase following customer identification [4]. After identifying the segments of potential customers, organizations can give the effort and resources into attracting the target customer segment. A component of customer attraction is direct marketing which is a promotion process motivating customers to place orders through various channels [98-101].Avast number of researches that applied data mining techniques such as logistic regression [101], NN [102-104], decision tree [105] and genetic algorithm [106, 107]are presented in literature.
- *Customer retention:* Customer retention is the central concern for CRM. Customer satisfaction, which refers to the comparison of customers' expectations with the perception of being satisfied, is the essential condition for retaining customers[64]. Customer retention includes loyalty programs, one-to-one marketing, and complaints management [4].Loyalty programs involve campaigns or supporting activities which aim at maintaining a long term relationship with customers. Data mining techniques, especially decision tree [108-111], SOM [112, 113], SOM and association rule mining[114], logistic regression[115, 116], NN, decision tree and k-nearest neighbor[117], genetic algorithm [118], k-means [119] are preferred to analyze and improve customer loyalty. Specifically, churn analysis, credit scoring, service quality or satisfaction constitutes part of loyalty programs. Under those subtitles, logistic regression [120-124], logistic regression and some combined techniques such as SVM [120, 125], NN and decision tree [126, 127] are widely used. In addition to these techniques, decision tree [128], decision tree and NN [129], NN and SOM [130] are preferred. One-to-one marketing refers to personalized marketing campaigns which are supported by analyzing, detecting and predicting changes in customer behaviors[131].Association rule mining (ARM) [131-140], ARM and SOM [67, 141], ARM and NN [142]are frequently applied to one-to-one marketing implementation. SOM [143-145], SVM [98], decision tree [146], NN [147, 148], nearest neighbor

[149] are also used to fulfill the purposes. A variety of data mining techniques as SOM [150], ARM [151, 152], SVM [153] are referred to complaints management which is another inseparable part of customer retention.

- *Customer development*: Customer development involves consistent expansion of transaction intensity, transaction value and individual customer profitability [4]. Customer lifetime value analysis, value analysis, up/cross selling and market basket analysis are components of customer development. For life time value analysis tasks, classification techniques, particularly NN [154], NN and decision tree [155], SVM [156], nearest neighbor and ARM [157], linear regression [158], bayesian network classifier [159] are applied. As distinct from life time value analysis, customer value refers to the potential customer contributions to an enterprise during specific periods. There are a few publications [160-162] related to value analysis in comparison with the life time value analysis. ARM [163] and hybrid model including ARM [164, 165] most popular techniques to up/cross selling implementation. Similar to up/cross selling phase, ARM [166-170] is overly applied to market basket analysis.

Manufacture

In modern manufacturing systems, huge amounts of data are stored in database management systems and data warehouses from all involved areas such as product and process design, assembly, materials planning, quality control, scheduling, maintenance, fault detection etc. [5]. Data mining techniques have been utilized in manufacture environment to analyze the enormous data and getting useful information.

This part follows on literature research based on six categories that are widely mentioned in literature.

- *Product design:* Kusiak and Smith [171] focused on product design and its data mining applications providing a variety of industrial cases and scenarios related to clustering techniques. K-means [172] and c-means clustering [173] are extensively preferred as clustering techniques. Also, some classification techniques such as neural network [174-176], decision tree [177, 178] and association rule analyze techniques [179] and sequential pattern [180] are used to product design process. In addition to common data mining techniques text mining [181] and semantic data mining [182]are applied to component design.
- *Manufacturing process design, monitoring and control:* Relationship among machines may be necessary to design of production process. Chen [183] found certain sets of machines by using association rule and developed an effective configuration of cellular manufacturing. Also Cunha et al. [184]applied association rule to make assembly schedule. Monitoring and control and defect detection have vital importance to manufacturing process. Monitoring and control help to analyze abnormal condition and avoid loss. Along with advance in monitoring technology, automated monitoring and control system is adapted, thus analyzing of this process has become so complicate and difficult in time. Artificial neural network, genetic algorithm [185], support vector machine [186], self-organizing map [187], regression analysis [188], rough set theory [189] c-means clustering[190] are applied manufacture data to aim of monitoring and controlling. In addition to these, association rule mining [191] and clustering techniques like k-means [192] and k-nearest neighbor [193] are utilized to detect certain product defect.
- *Job-shop scheduling:* Job shop scheduling is an important and complex activity in manufacturing. A job shop model, typical in manufacturing, can be described as a set of jobs composed of sequences of operations that are processed on a set of machines. It is a decision making process which allocates limited resources over time to perform a set of jobs to meet objectives[194]. Decision tree [195], regression tree [196], neural network [197], rough set theory[198] and genetic algorithm [194, 198]are used to make effective decision.
- *Fault diagnosis:* As data sets increase in size, exploration, manipulation and analysis become more complicated and resource consuming to evaluate probability of failure data relating to environment and operation condition. To deal with these situations identifying classes of process faults decision tree

[199-201] and support vector machine [202, 203], rough set theory and neural network [204] and k-medoids and Gustafson-Kessel algorithm [205] are widely used.

- *Quality monitoring, analysis and improvement:* Quality improvement of industrial products and processes requires collection and analyses of data to cope with quality related manufacturing problems. [6]. Owing to advances in data collection systems and analysis tools, data mining (DM) has widely been applied the quality problem in manufacturing. Neural network [206], association rule mining [207], support vector machine and k-means [208] for quality improvement, fuzzy clustering techniques [209] for quality improvement, back propagation neural network [210], self-organizing map, k-means, decision tree [211] for quality prediction, decision tree, k-nearest neighbor and naïve bayes[212] for quality control, neural network [213] for quality performance assessing are used extensively.
- *Yield improvement:* Data mining has proved to be important for yield improvement which is a key element to maintain efficiency of semiconductor manufacturing[5]. A variety of classification techniques such as decision tree [214],[215, 216], hybrid form decision tree with neural network [217, 218], neural network [219-221] and hybrid form neural network with spatial statistics [222], regression analysis [223], genetic programming [224], a combination of neural network, self-organizing map and pattern recognition [225], decision tree and sequential pattern [226] are preferred in semiconductor manufacture to improve yield. In addition to semiconductor sector, decision tree technique [227],[228] is used to enhance productivity in other electronic manufacture sector.

Marketing

Marketing is one of leading areas where data mining techniques have been applied. Data mining enables organizations to sort through vast amounts of customer data by discovering purchase behavior of customer [67], [229]pattern of price information [230], interest group [231] and forecast sales [232], [233], [234], demand [235] and product availability [236] and so on. This is a vital importance for marketing departments of any organization in any sector. If an organization knows what their customers require and are able to predict what their spending patterns will be, remarkable amounts of time and money can be saved[237].

Understanding customers' buying habits and identifying their profiles are essential in marketing. Data mining can provide that information[237]. K-means and apriori algorithm are extensively used together to discover customer profile [238], to mine customer knowledge [239], [240], [241], to discover purchase pattern [242], to analyze return pattern [243]and store segmentation [244]. Also, other clustering techniques such as hierarchical clustering with association rule [245], CAVE clustering algorithm to identify similarity between categorical values [246], fuzzy c-means with neural network to explore customer profile [247] are preferred. Market basket analysis [248] is utilized on the purpose of segmentation. In addition to these, as we mentioned in CRM part, the general incidence of data mining use for direct marketing[249],[239], [250], cross-selling[251], [252]and one-to-one marketing[253]has grown day by day.

According to Chen et al. [254]recent marketing research has suggested that in-store environmental stimuli, such as shelf-space allocation and product display, has a great effect on consumer buying behavior and may induce substantial demand. And also retail industry is also realizing that it is possible to gain a competitive advantage utilizing data mining. Association rule mining technique [255], [254], [256], [167, 257] and sequential pattern [258]are frequently preferred to self-space allocation in retail. Market basket analysis[259], [167], [260] is a marketing method used by many retailers to determine the optimal locations to promote products and develop efficient store layout.

Conclusion

Aim of this review is to give an insight about data mining applications in different industries. Popular areas and applications are presented and gaps are discovered. In our research, 260 studies are viewed by scanning several journal databases. Although first application made in 1993, most of data mining studies belong to 2000s. Number of these studies has increase in progress of time and reached maximum number in between 2004-2006 years. According to the literature research, CRM is the most popular area over others in every year by being involved in 108 studies after 2000. CRM is followed by manufacturing which many of studies were

published in the middle of 2000s. Earliest manufacturing application was presented in 1993and from that time 60 studies related to manufacturing have been appeared in literature. Contrary to CRM and manufacturing, finance and baking applications have flourished during the recent years. Totally, 57 publications are found and the first study in this area was written in 1997. Lastly, marketing applications have increasingly developed in time and 40 papers were submitted in between 1997-2014. When examining the data mining techniques; classification techniques, especially, decision tree, neural network, support vector machine, naïve bayes are more preferred in comparison with other techniques. Also, hybrid models that are used for classification, clustering and rule based techniques together, have come in to prominence.

As a conclusion, mining of data is a young field to be improved by both industries and universities. Especially dealing with big data analytics will help organizations learn the expectations and satisfaction of their customers via their feedbacks and behaviors. After investigating many publications, marketing is determined to have a potential as an emerging trend for data mining while considering the profitability of its implementations and the virginity in academic approaches.

References

[1] H. Wang and A. S. Weigend, "Data Mining for Financial Decision Making," Decision Support Systems, vol. 37, pp. 457-460, 2004.
[2] E. W. T. Ngai, Y. Hu, Y. H. Wong, Y. Chen, and X. Sun, "The application of data mining techniques in financial fraud detection: A classification framework and an academic review of literature," Decision Support Systems, vol. 50, pp. 559–569, 2011.
[3] C. Rygielski, J.-C. Wang, and D. C. Yen, "Data mining techniques for customer relationship management," Technology in Society, vol. 24, pp. 483-502, 2002.
[4] E. W. T. Ngai, L. Xiu, and D. C. K. Chau, "Application of data mining techniques in customer relationship management:A literature review and classification," Expert Systems with Applications, vol. 36, pp. 2592–2602, 2009.
[5] A. K. Choudhary, J. A. Harding, and M. K. Tiwari, "Data mining in manufacturing: a review based on the kind of knowledge," Journal of Intelligent Manufacturing, vol. 20, pp. 501-521, 2009.
[6] G. Köksal, İ. Batmaz, and M. C. Testik, "A review of data mining applications for quality improvement in manufacturing industry," Expert Systems with Applications, vol. 38, pp. 13448–13467, 2011.
[7] L. Zhang, L. Zhang, W. Teng, and Y. Chen, "Based on InformationFusion Technique with Data Mining in the Application of Finance Early-Warning," Procedia Computer Science, vol. 17, pp. 695-703, 2013.
[8] W. L. Tung, C. Quek, and P. Cheng, "GenSo-EWS: a novel neural-fuzzy based early warning system for predicting bank failures," Neural Networks, vol. 17, pp. 567–587, 2004.
[9] C. Sevim, A. Oztekin, O. Bali, S. Gumus, and E. Guresen, "Developing an early warning system to predict currency crises," European Journal of Operation Research, vol. 237, pp. 1095–1104, 2014.
[10] T. Y. Kim, K. J. Oh, I. Sohn, and C. Hwang, "Usefulness of artificial neural networks for early warning system of economic crisis," Expert System with Applications, vol. 26, pp. 583–590, 2004.
[11] S.-H. Liao and S.-Y. Chou, "Data mining investigation of co-movements on the Taiwan and China stock markets for future investment portfolio," Expert Systems with Applications, vol. 40, pp. 1542–1554, 2013.
[12] A. S. Koyuncugil and N. Ozgulbas, "Financial early warning system model and data mining application for risk detection," Expert System with Applications, vol. 6, pp. 6238–6253, 2012.
[13] A. Khashman, "Neural networks for credit risk evaluation: Investigation of different neural models and learning schemes," Expert Systems with Applications, vol. 37, pp. 6233-6239, 2010.
[14] G. L. Gray and R. S. Debreceny, "A taxonomy to guide research on the application of data mining to fraud detection in financial statement audits," International Journal of Accounting Information Systems, vol. 15, pp. 357–380, 2014.
[15] E. Kirkos, C. Spathis, and Y. Manolopoulos, "Data Mining techniques for the detection of fraudulent financial statements," Expert Systems with Applications, vol. 32, pp. 995–1003, 2007.
[16] S. Kotsiantis, E. Koumanakos, D. Tzelepis, and V. Tampakas, "Forecasting fraudulent financial statements using data mining," International Journal of Computational Intelligence, vol. 3, pp. 104-110, 2006.
[17] P. Ravisankar, V. Ravi, G. Raghava Rao, and I. Bose, "Detection of financial statement fraud and feature selection using data mining techniques," Decision Support Systems, vol. 50, pp. 491–500, 2011.
[18] K. M. Fanning and K. O. Cogger, "Neural network detection of management fraud using published financial data."
[19] M. J. Cerullo and V. Cerullo, "Using neural networks to predict financial reporting fraud: Part 2," Computer Fraud&Security, vol. 1999, pp. 14-17, 1999.
[20] J. W. Lin, M. I. Hwang, and J. D. Becker, "A fuzzy neural network for assessing the risk of fraudulent financial reporting," Managerial Auditing Journal, vol. 18, pp. 657-665, 2003.

[21] B. Bai, J. Yen, and X. Yang, "False Financial Statements: Characteristics of China' s Listed Companies and Cart Detecting Approach," International Journal of Information Technology & Decision Making, vol. 07, pp. 339-359, 2008.
[22] C. Holton, "Identifying Disgruntled Employee Systems Fraud Risk Through Text Mining: A Simple Solution for a Multi-billion Dollar Problem," Decision Support Systems, vol. 46, pp. 853–864, 2009.
[23] P. K. Chan, F. Wei, A. L. Prodromidis, and S. J. Stolfo, "Distributed data mining in credit card fraud detection," IEEE Intelligent Systems, pp. 67-74, 1999.
[24] I. G. N. N. Mandala, C. B. Nawangpalupi, and F. R. Praktikto, "Assessing Credit Risk: An Application of Data Mining in a Rural Bank," Procedia Economics and Finance, vol. 4, pp. 406–412, 2012.
[25] J. R. Dorronsoro, F. Ginel, C. Sgnchez, and C. S. Cruz, "Neural fraud detection in credit card operations," IEEE Transactions on Neural Networks vol. 8, pp. 827-834, 1997.
[26] I. C. Yeh and C.-h. Lien, "The comparisons of data mining techniques for the predictive accuracy of probability of default of credit card clients," Expert Systems with Applications, vol. 36, pp. 2473–2480, 2009.
[27] J. T. S. Quah and M. Sriganesh, "Real-time credit card fraud detection using computational intelligence," Expert Systems with Applications, vol. 35, pp. 1721–1732, 2008.
[28] D. Olszewski, "Fraud detection using self-organizing map visualizing the user profiles," Knowledge-Based Systems, vol. 70, pp. 324–334, 2014.
[29] S. Bhattacharyya, S. Jha, K. Tharakunnel, and J. C. Westland, "Data mining for credit card fraud: A comparative study," Decision Support Systems, vol. 50, pp. 602–613, 2011.
[30] S. Jou and B. Hebenton, "Insurance fraud in Taiwan: Reflections on regulatory effort and criminological complexity," International Journal of the Sociology of Law, vol. 35, pp. 127–142, 2007.
[31] S. Viaene, G. Dedene, and R. A. Derrig, "Auto claim fraud detection using Bayesian learning neural networks," Expert Systems with Applications, vol. 29, pp. 653–666, 2005.
[32] P. L. Brockett, R. A. Derrig, L. L. Golden, A. Levine, and M. Alpert, "Fraud Classification Using Principal Component Analysis of RIDITs," The Journal of Risk and Insurance, vol. 69, pp. 341–371, 2002.
[33] L. Bermúdez, J. M. Pérez, M. Ayuso, E. Gómez, and F. J. Vázquez, "A Bayesian dichotomous model with asymmetric link for fraud in insurance," Insurance: Mathematics and Economics, vol. 42, pp. 779–786, 2008.
[34] S. Tennyson and P. Salsas-Forn, "Claims Auditing in Automobile Insurance: Fraud Detection and Deterrence Objectives," The Journal of Risk and Insurance, vol. 69, 2002.
[35] S. Viaene, R. A. Derrig, and G. Dedene, "A case study of applying boosting naive Bayes to claim fraud diagnosis," IEEE Transactions on Knowledge and Data Engineering, vol. 16, 2004.
[36] D. Enke and S. Thawornwong, "The use of data mining and neural networks for forecasting stock market returns," Expert Systems with Applications, vol. 29, pp. 927-940, 2005.
[37] W.-S. Yang and S.-Y. Hwang, "A process-mining framework for the detection of healthcare fraud and abuse," Expert Systems with Applications, vol. 31, pp. 56–68, 2006.
[38] H. He, J. Wang, W. Graco, and S. Hawkins, "Application of neural networks to detection of medical fraud," Expert System with Applications, vol. 13, pp. 329–336, 1997.
[39] P. Wanke, C. P. Barros, and J. R. Faria, "Financial distress drivers in Brazilian banks: A dynamic slacks approach," European Journal of Operational Research, vol. 240, pp. 258–268, 2015.
[40] S.-W. Lin, Y.-R. Shiue, S.-C. Chen, and H.-M. Cheng, "Applying enhanced data mining approaches in predicting bank performance: A case of Taiwanese commercial banks," Expert Systems with Applications, vol. 36, pp. 11543–11551, 2009.
[41] H. Li, C.-J. Li, X.-J. Wu, and J. Sun, "Statistics-based wrapper for feature selection: An implementation on financial distress identification with support vector machine," Applied Soft Computing, vol. 19, pp. 57–67, 2014.
[42] S.-C. Huang, Y.-C. Tang, C.-W. Lee, and M.-J. Chang, "Kernel local Fisher discriminant analysis based manifold-regularized SVM model for financial distress predictions," Expert Systems with Applications, vol. 39, 2012.
[43] J. K. Bae, "Predicting financial distress of the South Korean manufacturing industries," Expert Systems with Applications, vol. 39, pp. 9159–9165, 2012.
[44] W.-S. Chen and Y.-K. Du, "Using neural networks and data mining techniques for the financial distress prediction model," Expert Systems with Applications, vol. 36, pp. 4075–4086, 2009.
[45] R. Geng, I. Bose, and X. Chen, "Prediction of financial distress: An empirical study of listed Chinese companies using data mining," European Journal of Operational Research, vol. 241, pp. 236–247, 2015.
[46] D. Wu, L. Liang, and Z. Yang, "Analyzing the financial distress of Chinese public companies using probabilistic neural networks and multivariate discriminate analysis," Socio-Economic Planning Sciences, vol. 42, pp. 206–220, 2008.
[47] J. Sun and H. Li, "Data mining method for listed companies' financial distress prediction," Knowledge-Based Systems, vol. 21, pp. 1–5, 2008.
[48] M.-Y. Chen, "Predicting corporate financial distress based on integration of decision tree classification and logistic regression," Expert Systems with Applications, vol. 38, pp. 11261–11272, 2011.
[49] S. Y. Kim and A. Upneja, "Predicting restaurant financial distress using decision tree and AdaBoosted decision tree models," Economic Modelling, vol. 36, pp. 354–362, 2014.

[50] H. Li, J. Sun, and B.-L. Sun, "Financial distress prediction based on OR-CBR in the principle of k-nearest neighbors," Expert Systems with Applications, vol. 36, pp. 643–659, 2009.
[51] T. Xiong, S. Wang, A. Mayers, and E. Monga, "Personal bankruptcy prediction by mining credit card data," Expert Systems with Applications, vol. 40, pp. 665–676, 2013.
[52] A. Chaudhuri and K. De, "Fuzzy Support Vector Machine for bankruptcy prediction," Applied Soft Computing, vol. 11, pp. 2472–2486, 2011.
[53] H.-L. Chen, B. Yang, G. Wang, J. Liu, X. Xu, S.-J. Wang, et al., "A novel bankruptcy prediction model based on an adaptive fuzzy k-nearest neighbor method," Knowledge-Based Systems, vol. 24, pp. 1348–1359, 2011.
[54] J. De Andrés, P. Lorca, F. J. de Cos Juez, and F. Sánchez-Lasheras, "Bankruptcy forecasting: A hybrid approach using Fuzzy c-means clustering and Multivariate Adaptive Regression Splines (MARS)," Expert Systems with Applications, vol. 38, pp. 1866–1875, 2011.
[55] P. du Jardin and E. Séverin, "Predicting corporate bankruptcy using a self-organizing map: An empirical study to improve the forecasting horizon of a financial failure model," Decision Support Systems, vol. 51, pp. 701–711, 2011.
[56] D. L. Olson, D. Delen, and Y. Meng, "Comparative analysis of data mining methods for bankruptcy prediction," Decision Support Systems, vol. 52, pp. 464–473, 2012.
[57] T. Van Gestel, B. Baesens, and D. Martens, "From linear to non-linear kernel based classifiers for bankruptcy prediction," Neurocomputing, vol. 73, pp. 2955–2970, 2010.
[58] P. Ravisankar and V. Ravi, "Financial distress prediction in banks using Group Method of Data Handling neural network, counter propagation neural network and fuzzy ARTMAP," Knowledge-Based Systems, vol. 23, pp. 823–831, 2010.
[59] C.-F. Tsai, "Feature selection in bankruptcy prediction," Knowledge-Based Systems, vol. 22, pp. 120–127, 2009.
[60] A. Costea, "Applying Fuzzy Logic and Machine Learning Techniques in Financial Performance Predictions," Procedia Economics and Finance, vol. 10, 2014.
[61] M. Lam, "Neural network techniques for financial performance prediction: integrating fundamental and technical analysis," Decision Support Systems, vol. 37, pp. 567–581, 2004.
[62] S.-H. Chun and S. H. Kim, "Data mining for financial prediction and trading: application to single and multiple markets," Expert Systems with Applications, vol. 26, pp. 131–139, 2004.
[63] A. Berson, S. Smith, and K. Thearling, Building data mining applications for CRM: McGraw-Hill, 2000.
[64] A. Kracklauer, D. Q. Mills, and D. Seifert, "Customer Management as the Origin of Collaborative Customer Relationship Management," Collaborative Customer Relationship Management, pp. 3-6, 2004.
[65] S.-Y. Kim, T.-S. Jung, E.-H. Suh, and H.-S. Hwang, "Customer segmentation and strategy development based on customer lifetime value: A case study," Expert Systems with Applications, vol. 31, pp. 101–107, 2006.
[66] S. H. Han, S. X. Lu, and S. C. H. Leung, "Segmentation of telecom customers based on customer value by decision tree model," Expert Systems with Applications, vol. 39, pp. 3964–3973, 2012.
[67] S. H. Ha, S. M. Bae, and S. C. Park, "Customer's time-variant purchase behavior and corresponding marketing strategies: an online retailer's case," Computers & Industrial Engineering, vol. 43, pp. 801–820, 2002.
[68] F. Fessant, J. François, and F. Clérot, "Characterizing ADSL customer behaviours by network traffic data-mining," Annales Des Télécommunications, vol. 62, pp. 350-368, 2007.
[69] S. M. Bae, S. C. Park, and S. H. Ha, "Fuzzy Web ad selector based on Web usage mining," Intelligent Systems, IEEE, vol. 18, pp. 62 - 69, 2003.
[70] S. V. Verdu, M. O. Garcia, C. Senabre, A. G. Marin, and F. J. G. Franco, "Classification, Filtering, and Identification of Electrical Customer Load Patterns Through the Use of Self-Organizing Maps," IEEE Transactions on Power Systems, vol. 21, pp. 1672	- 1682 2006.
[71] S. Hosseini and A. Ziaei Bideh, "A data mining approach for segmentation-based importance-performance analysis (SOM–BPNN–IPA): a new framework for developing customer retention strategies," Service Business, vol. 8, pp. 295-312, 2014.
[72] J. H. Lee and S. C. Park, "Intelligent profitable customers segmentation system based on business intelligence tools," Expert Systems with Applications, vol. 29, pp. 145–152, 2005.
[73] H. Hwang, T. Jung, and E. Suh, "An LTV model and customer segmentation based on customer value: a case study on the wireless telecommunication industry," Expert Systems with Applications, vol. 26, pp. 181–188, 2004.
[74] C. Dennis, D. Marsland, and T. Cockett, "Data mining for shopping centres – customer knowledge-management framework," Journal of Knowledge Management, vol. 5, pp. 368-374, 2001.
[75] J.-T. Wei, M.-C. Lee, H.-K. Chen, and H.-H. Wu, "Customer relationship management in the hairdressing industry: An application of data mining techniques," Expert Systems with Applications, vol. 40, pp. 7513–7518, 2013.
[76] M. Khajvand and M. J. Tarokh, "Estimating customer future value of different customer segments based on adapted RFM model in retail banking context," Procedia Computer Science, vol. 3, pp. 1327–1332, 2011.
[77] M. Khajvand, K. Zolfaghar, S. Ashoori, and S. Alizadeh, "Estimating customer lifetime value based on RFM analysis of customer purchase behavior: Case study," Procedia Computer Science, vol. 3, pp. 57–63, 2011.

[78] C.-H. Cheng and Y.-S. Chen, "Classifying the segmentation of customer value via RFM model and RS theory," Expert Systems with Applications, vol. 36, pp. 4176–4184, 2009.
[79] S.-H. Liao, C.-M. Chen, and C.-H. Wu, "Mining customer knowledge for product line and brand extension in retailing," Expert Systems with Applications, vol. 34, pp. 1763–1776, 2008.
[80] A. Hiziroglu, "Soft computing applications in customer segmentation: State-of-art review and critique," Expert Systems with Applications, vol. 40, pp. 6491–6507, 2013.
[81] Y. Yang and B. Padmanabhan, "GHIC: A Hierarchical Pattern-Based Clustering Algorithm for Grouping Web Transactions," IEEE Transactions on Knowledge and Data Engineering, vol. 17, pp. 1300 - 1304, 2005.
[82] Z. Wang, L. Tu, Z. Guo, L. T. Yang, and B. Huang, "Analysis of user behaviors by mining large network data sets," Future Generation Computer Systems, vol. 37, pp. 429–437, 2014.
[83] F.-M. Hsu, L.-P. Lu, and C.-M. Lin, "Segmenting customers by transaction data with concept hierarchy," Expert Systems with Applications, vol. 39, pp. 6221–6228, 2012.
[84] R.-S. Wu and P.-H. Chou, "Customer segmentation of multiple category data in e-commerce using a soft-clustering approach," Electronic Commerce Research and Applications, vol. 10, pp. 331–341, 2011.
[85] Y.-L. Chen, C.-L. Hsu, and S.-C. Chou, "Constructing a multi-valued and multi-labeled decision tree," Expert Systems with Applications, vol. 25, pp. 199–209, 2003.
[86] C.-H. Wu, S.-C. Kao, Y.-Y. Su, and C.-C. Wu, "Targeting customers via discovery knowledge for the insurance industry," Expert Systems with Applications, vol. 29, pp. 291–299, 2005.
[87] J. X. Yu, O. Yuming, C. Zhang, and S. Zhang, "Identifying interesting visitors through Web log classification," IEEE Intelligent Systems, vol. 20, pp. 55-59, 2005.
[88] S. C. Lee, Y. H. Suh, J. K. Kim, and K. J. Lee, "A cross-national market segmentation of online game industry using SOM," Expert Systems with Applications, vol. 27, 2004.
[89] Y.-S. Chen, C.-H. Cheng, C.-J. Lai, C.-Y. Hsu, and H.-J. Syu, "Identifying patients in target customer segments using a two-stage clustering-classification approach: A hospital-based assessment," Computers in Biology and Medicine, vol. 42, pp. 213–221, 2012.
[90] G. Mansingh, L. Rao, K.-M. Osei-Bryson, and A. Mills, "Profiling internet banking users: A knowledge discovery in data mining process model based approach," Information Systems Frontiers, 2013.
[91] C.-W. Chang, C.-T. Lin, and L.-Q. Wang, "Mining the text information to optimizing the customer relationship management," Expert Systems with Applications, vol. 36, pp. 1433–1443, 2009.
[92] T. Nakahara and K. Yada, "Analyzing consumers' shopping behavior using RFID data and pattern mining," Advances in Data Analysis and Classification, vol. 6, pp. 355-365, 2012.
[93] C.-K. Huang, T.-Y. Chang, and B. Narayanan, "Mining the change of customer behavior in dynamic markets," Information Technology and Management, 2014.
[94] E. Apeh and B. Gabrys, "Detecting and Visualizing the Change in Classification of Customer Profiles based on Transactional Data," Evolving Systems, vol. 4, pp. 27-42, 2013.
[95] E. Apeh, B. Gabrys, and A. Schierz, "Customer profile classification: To adapt classifiers or to relabel customer profiles?," Neurocomputing, vol. 132, pp. 3–13, 2014.
[96] L. B. Romdhane, N. Fadhel, and B. Ayeb, "An efficient approach for building customer profiles from business data," Expert Systems with Applications, vol. 37, pp. 1573–1585, 2010.
[97] I. Mahdavi, N. Cho, B. Shirazi, and N. Sahebjamnia, "Designing evolving user profile in e-CRM with dynamic clustering of Web documents," Data & Knowledge Engineering, vol. 65, pp. 355–372, 2008.
[98] K.-W. Cheung, J. T. Kwok, M. H. Law, and K.-C. Tsui, "Mining customer product ratings for personalized marketing," Decision Support Systems, vol. 35, pp. 231–243, 2003.
[99] Z. He, X. Xu, J. Z. Huang, and S. Deng, "Mining class outliers: concepts, algorithms and applications in CRM," Expert Systems with Applications, vol. 27, pp. 681–697, 2004.
[100] S.-H. Liao and Y.-J. Chen, "Mining customer knowledge for electronic catalog marketing," Expert Systems with Applications, vol. 27, pp. 521–532, 2004.
[101] A. Prinzie and D. Van den Poel, "Constrained optimization of data-mining problems to improve model performance: A direct-marketing application," Expert Systems with Applications, vol. 29, pp. 630–640, 2005.
[102] B. Baesens, S. Viaene, D. Van den Poel, J. Vanthienen, and G. Dedene, "Bayesian neural network learning for repeat purchase modelling in direct marketing," European Journal of Operational Research, vol. 138, pp. 191–211, 2002.
[103] Y. Kim and W. N. Street, "An intelligent system for customer targeting: a data mining approach," Decision Support Systems, vol. 37, pp. 215–228, 2004.
[104] X. Hu, "A Data Mining Approach for Retailing Bank Customer Attrition Analysis," Applied Intelligence, vol. 22, pp. 47-60, 2005.
[105] W. Buckinx, E. Moons, D. Van den Poel, and G. Wets, "Customer-adapted coupon targeting using feature selection," Expert Systems with Applications, vol. 26, pp. 509–518, 2004.
[106] H. Ahn, K.-j. Kim, and I. Han, "Hybrid genetic algorithms and case-based reasoning systems for customer classification," Expert Systems with Applications, vol. 23, pp. 127–144, 2006.

[107] C. Chiu, "A case-based customer classification approach for direct marketing," Expert Systems with Applications, vol. 22, pp. 163–168, 2002.
[108] L. A. Cox, Jr., "Data Mining and Causal Modeling of Customer Behaviors," Telecommunication Systems, vol. 21, pp. 349-381, 2002.
[109] S. Douglas, D. Agarwal, T. Alonso, R. M. Bell, M. Gilbert, D. F. Swayne, et al., "Mining Customer Care Dialogs for "Daily News"," IEEE Transactions on Speech and Audio Processing, vol. 13, pp. 652-660, 2005.
[110] B. Larivière and D. Van den Poel, "Predicting customer retention and profitability by using random forests and regression forests techniques," Expert Systems with Applications, vol. 29, pp. 472–484, 2005.
[111] Y.-F. Wang, D.-A. Chiang, M.-H. Hsu, C.-J. Lin, and I. L. Lin, "A recommender system to avoid customer churn: A case study," Expert Systems with Applications, vol. 36, pp. 8071–8075, 2009.
[112] B.-H. Chu, M.-S. Tsai, and C.-S. Ho, "Toward a hybrid data mining model for customer retention," Knowledge-Based Systems, vol. 20, pp. 703–718, 2007.
[113] Y. A. Kim, H. S. Song, and S. H. Kim, "Strategies for preventing defection based on the mean time to defection and their implementations on a self-organizing map," Expert Systems with Applications, vol. 22, pp. 265–278, 2005.
[114] H. Song, J. Kim, Y. Cho, and S. Kim, "A Personalized Defection Detection and Prevention Procedure based on the Self-Organizing Map and Association Rule Mining: Applied to Online Game Site," Artificial Intelligence Review, vol. 21, pp. 161-184, 2004.
[115] H. Cassab and D. L. MacLachlan, "Interaction fluency: a customer performance measure of multichannel service," International Journal of Productivity and Performance Management, vol. 55, pp. 555-568, 2006.
[116] W. Buckinx and D. Van den Poel, "Customer base analysis: partial defection of behaviourally loyal clients in a non-contractual FMCG retail setting," European Journal of Operational Research, vol. 164, pp. 252–268, 2005.
[117] P. Datta, B. Masand, D. R. Mani, and B. Li, "Automated Cellular Modeling and Prediction on a Large Scale," Artificial Intelligence Review, vol. 14, pp. 485-502, 2000.
[118] E. Kim, W. Kim, and Y. Lee, "Combination of multiple classifiers for the customer's purchase behavior prediction," Decision Support Systems, vol. 34, pp. 167–175, 2003.
[119] S. M. S. Hosseini, A. Maleki, and M. R. Gholamian, "Cluster analysis using data mining approach to develop CRM methodology to assess the customer loyalty," Expert Systems with Applications, vol. 37, pp. 5259–5264, 2010.
[120] K. Coussement and D. Van den Poel, "Integrating the voice of customers through call center emails into a decision support system for churn prediction," Information & Management, vol. 45, pp. 164–174, 2008.
[121] J. Burez and D. Van den Poel, "Handling class imbalance in customer churn prediction," Expert Systems with Applications, vol. 36, pp. 4626–4636, 2009.
[122] N. Lu, H. Lin, J. Lu, and G. Zhang, "A Customer Churn Prediction Model in Telecom Industry Using Boosting," Ieee Transactions on Industrial Informatics, vol. 10, pp. 1659-1665, May 2014.
[123] B. Larivière and D. Van den Poel, "Investigating the role of product features in preventing customer churn, by using survival analysis and choice modeling: The case of financial services," Expert Systems with Applications, vol. 27, pp. 277–285, 2004.
[124] A. Lemmens and C. Croux, "Bagging and Boosting Classification Trees to Predict Churn," Journal of Marketing Research, vol. 43, pp. 276-286, 2006.
[125] K. Coussement and D. Van den Poel, "Churn prediction in subscription services: An application of support vector machines while comparing two parameter-selection techniques," Expert Systems with Applications, vol. 34, pp. 313–327, 2008.
[126] S. A. Neslin, S. Gupta, W. Kamakura, J. Lu, and C. H. Mason, "Defection Detection: Measuring and Understanding the Predictive Accuracy of Customer Churn Models," Journal of Marketing Research vol. 43, pp. 204-211, 2006.
[127] M. C. Mozer, R. Wolniewicz, D. B. Grimes, E. Johnson, and H. Kaushansky, "Predicting subscriber dissatisfaction and improving retention in the wireless telecommunications industry," IEEE Transactions on Neural Networks, vol. 11, pp. 690	- 696, 2000.
[128] C.-P. Wei and I. T. Chiu, "Turning telecommunications call details to churn prediction: a data mining approach," Expert Systems with Applications, vol. 23, pp. 103–112, 2002.
[129] S.-Y. Hung, D. C. Yen, and H.-Y. Wang, "Applying data mining to telecom churn management," Expert Systems with Applications, vol. 31, pp. 515–524, 2006.
[130] C.-F. Tsai and Y.-H. Lu, "Customer churn prediction by hybrid neural networks," Expert Systems with Applications, vol. 36, pp. 12547–12553, 2009.
[131] M.-C. Chen, A.-L. Chiu, and H.-H. Chang, "Mining changes in customer behavior in retail marketing," Expert Systems with Applications, vol. 28, pp. 773–781, 2005.
[132] G. Adomavicius and A. Tuzhilin, "Expert-Driven Validation of Rule-Based User Models in Personalization Applications," Data Mining and Knowledge Discovery, vol. 5, pp. 33-58, 2001.
[133] W.-H. Au and C. C. C. Chan, "Mining fuzzy association rules in a bank-account database," IEEE Transactions on Fuzzy Systems, vol. 11, pp. 238 - 248, 2003.

[134] A. Demiriz, "Enhancing Product Recommender Systems on Sparse Binary Data," Data Mining and Knowledge Discovery, vol. 9, pp. 147-170, 2004.
[135] J. Jiao, Y. Zhang, and M. Helander, "A Kansei mining system for affective design," Expert Systems with Applications, vol. 30, pp. 658–673, 2006.
[136] C. H. Lee, Y. H. Kim, and P. K. Rhee, "Web personalization expert with combining collaborative filtering and association rule mining technique," Expert Systems with Applications, vol. 21, pp. 131–137, 2001.
[137] Y.-F. Wang, Y.-L. Chuang, M.-H. Hsu, and H.-C. Keh, "A personalized recommender system for the cosmetic business," Expert Systems with Applications, vol. 26, pp. 427–434, 2004.
[138] S.-H. Liao, C.-M. Chen, C.-L. Hsieh, and S.-C. Hsiao, "Mining information users' knowledge for one-to-one marketing on information appliance," Expert Systems with Applications, vol. 36, pp. 4967–4979, 2009.
[139] H. S. Song, J. k. Kim, and S. H. Kim, "Mining the change of customer behavior in an internet shopping mall," Expert Systems with Applications, vol. 21, pp. 157–168, 2001.
[140] I. S. Y. Kwan, J. Fong, and H. K. Wong, "An e-customer behavior model with online analytical mining for internet marketing planning," Decision Support Systems, vol. 41, pp. 189–204, 2005.
[141] Y. B. Cho, Y. H. Cho, and S. H. Kim, "Mining changes in customer buying behavior for collaborative recommendations " Expert Systems with Applications, vol. 28, pp. 359–369, 2005.
[142] N.-C. Hsieh, "An integrated data mining and behavioral scoring model for analyzing bank customers," Expert Systems with Applications, vol. 27, pp. 623–633, 2004.
[143] J. H. Lee and S. C. Park, "Agent and data mining based decision support system and its adaptation to a new customer-centric electronic commerce," Expert Systems with Applications, vol. 25, pp. 619–635, 2003.
[144] S.-H. Min and I. Han, "Detection of the customer time-variant pattern for improving recommender systems. ," Expert Systems with Applications, vol. 28, pp. 189–199, 2005.
[145] S. H. Ha, "Digital content recommender on the Internet," IEEE Intelligent Systems, vol. 21, pp. 70 - 77, 2006.
[146] J. K. Kim, H. S. Song, T. S. Kim, and H. K. Kim, "Detecting the change of customer behavior based on decision tree analysis," Expert Systems, vol. 22, pp. 193–205, 2005.
[147] S. E. Chang, S. W. Changchien, and R.-H. Huang, "Assessing users' productspecific knowledge for personalization in electronic commerce " Expert Systems with Applications, vol. 30, pp. 682–693, 2006.
[148] R. J. Kuo, J. L. Liao, and C. Tu, "Integration of ART2 neural network and genetic K-means algorithm for analyzing Web browsing paths in electronic commerce," Decision Support Systems, vol. 40, pp. 355–374, 2005.
[149] Y. H. Cho and J. K. Kim, "Application of Web usage mining and product taxonomy to collaborative recommendations in e-commerce," Expert Systems with Applications, vol. 26, pp. 233–246, 2004.
[150] S. M. Bae, S. H. Ha, and S. C. Park, "A web-based system for analyzing the voices of call center customers in the service industry," Expert Systems with Applications, vol. 28, pp. 29–41, 2005.
[151] B. Shim, K. Choi, and Y. Suh, "CRM strategies for a small-sized online shopping mall based on association rules and sequential patterns," Expert Systems with Applications, vol. 39, pp. 7736–7742, 2012.
[152] K. Ng and H. Liu, "Customer Retention via Data Mining," Artificial Intelligence Review, vol. 14, pp. 569-590, 2000.
[153] Z.-Y. Chen, Z.-P. Fan, and M. Sun, "A hierarchical multiple kernel support vector machine for customer churn prediction using longitudinal behavioral data," European Journal of Operational Research, vol. 223, pp. 461–472, 2012.
[154] J. H. Drew, D. R. Mani, A. L. Betz, and P. Datta, "Targeting Customers with Statistical and Data-Mining Techniques," Journal of Service Research, vol. 3, pp. 205-219, 2001.
[155] C. J. Cheng, S. W. Chiu, C. B. Cheng, and J. Y. Wu, "Customer lifetime value prediction by a Markov chain based data mining model: Application to an auto repair and maintenance company in Taiwan " Scientia Iranica, vol. 19, pp. 849–855, 2012.
[156] Z.-Y. Chen and Z.-P. Fan, "Dynamic customer lifetime value prediction using longitudinal data: An improved multiple kernel SVR approach," Knowledge-Based Systems, vol. 43, pp. 123–134, 2013.
[157] D.-R. Liu and Y.-Y. Shih, "Integrating AHP and data mining for product recommendation based on customer lifetime value," Information & Management, vol. 42, pp. 387–400, 2005.
[158] P. C. Verhoef and B. Donkers, "Predicting customer potential value an application in the insurance industry. ," Decision Support Systems, vol. 32, pp. 189–199, 2001.
[159] B. Baesens, G. Verstraeten, D. Van den Poel, M. Egmont-Petersen, P. Van Kenhove, and J. Vanthienen, "Bayesian network classifiers for identifying the slope of the customer lifecycle of long-life customers," European Journal of Operational Research, vol. 156, pp. 508–523, 2004.
[160] Y.-H. Liang, "Integration of data mining technologies to analyze customer value for the automotive maintenance industry," Expert Systems with Applications, vol. 37, pp. 7489–7496, 2010.
[161] W.-Y. Chiang, "To mine association rules of customer values via a data mining procedure with improved model: An empirical case study," Expert Systems with Applications, vol. 38, pp. 1716–1722, 2011.
[162] K. Wong, S. Zhou, Q. Yang, and J. Yeung, "Mining Customer Value: From Association Rules to Direct Marketing," Data Mining and Knowledge Discovery, vol. 11, pp. 57-79, 2005.

[163] R.-W. Wong, A.-C. Fu, and K. Wang, "Data Mining for Inventory Item Selection with Cross-Selling Considerations," Data Mining and Knowledge Discovery, vol. 11, pp. 81-112, 2005.
[164] S. W. Changchien, C.-F. Lee, and Y.-J. Hsu, "On-line personalized sales promotion in electronic commerce," Expert Systems with Applications, vol. 27, pp. 35–52, 2004.
[165] S.-h. Liao, Y.-J. Chen, and M.-y. Deng, "Mining customer knowledge for tourism new product development and customer relationship management," Expert Systems with Applications, vol. 37, pp. 4212–4223, 2010.
[166] C. C. Aggarwal, C. Procopiuc, and P. S. Yu, "Finding localized associations in market basket data," IEEE Transactions on Knowledge and Data Engineering, vol. 14, pp. 51	- 62 2002.
[167] T. Brijs, G. Swinnen, K. Vanhoof, and G. Wets, "Building an Association Rules Framework to Improve Product Assortment Decisions," Data Mining and Knowledge Discovery, vol. 8, pp. 7-23, 2004.
[168] N. Jukić and S. Nestorov, "Comprehensive data warehouse exploration with qualified association-rule mining," Decision Support Systems, vol. 42, pp. 859–878, 2006.
[169] P. Giudici and G. Passerone, "Data mining of association structures to model consumer behaviour," Computational Statistics & Data Analysis, vol. 38, pp. 533–541, 2002.
[170] Y.-L. Chen, K. Tang, R.-J. Shen, and Y.-H. Hu, "Market basket analysis in a multiple store environment," Decision Support Systems, vol. 40, pp. 339–354, 2005.
[171] A. Kusiak and M. Smith, "Data mining in design of products and production systems," Annual Reviews in Control, vol. 31, pp. 147–156, 2007.
[172] P. Kim and Y. Ding, "Optimal Engineering System Design Guided by Data-Mining Methods," Technometrics, vol. 47, pp. 336-348, 2005.
[173] O. Torkul, I. H. Cedimoglu, and A. K. Geyik, "An application of fuzzy clustering to manufacturing cell design," Journal of Intelligent and Fuzzy Systems, vol. 17, pp. 173-181, 2006.
[174] O. G. Ali and C. Yu-To, "Design quality and robustness with neural networks," IEEE Transactions on Neural Networks, vol. 10, pp. 1518 - 1527, 1999.
[175] J.-H. Park and K.-K. Seo, "A knowledge-based approximate life cycle assessment system for evaluating environmental impacts of product design alternatives in a collaborative design environment," Advanced Engineering Informatics, vol. 20, pp. 147–154, 2006.
[176] C.-Y. Tsai and C. A. Chang, "Fuzzy neural networks for intelligent design retrieval using associative manufacturing features," Journal of Intelligent Manufacturing, vol. 14, pp. 183-195, 2003.
[177] J. K. Bae and J. Kim, "Product development with data mining techniques: A case on design of digital camera," Expert Systems with Applications, vol. 38, 2011.
[178] C. J. Romanowski and R. Nagi, "On comparing bills of materials: a similarity/distance measure for unordered trees," IEEE Transactions on Systems, Man and Cybernetics, Part A: Systems and Humans, vol. 35, pp. 249 - 260, 2005.
[179] B. Agard and A. Kusiak *, "A Data Mining based Methodology for the Design of Product Families," International Journal of Production Research, vol. 42, pp. 2955-2969, 2004.
[180] Y. Jin and Y. Ishino, "DAKA: design activity knowledge acquisition through data-mining," International Journal of Production Research, vol. 44, pp. 2813-2837, 2006.
[181] Y. Liu, W. Feng Lu, and H. Tong Loh, "A framework of information and knowledge management for product design and development — A text mining approach," Information Control Problems in Manufacturing
pp. 635–640, 2006.
[182] N.Morar, R. Roy, J. Mehnen, L. E. Redding, and A. Harrison, "Data Mining and Knowledge Reuse for the Initial Systems Design and Manufacturing: Aero-engine Service Risk Drivers," Procedia CIRP, vol. 11, pp. 130–134, 2013.
[183] M.-C. Chen, "Configuration of cellular manufacturing systems using association rule induction," International Journal of Production Research, vol. 41, pp. 381-395, 2003.
[184] C. Da Cunha, B. Agard, and A. Kusiak, "Data mining for improvement of product quality," International Journal of Production Research, vol. 44, pp. 4027-4041, 2006.
[185] J. Yu, L. Xi, and X. Zhou, "Intelligent monitoring and diagnosis of manufacturing processes using an integrated approach of KBANN and GA," Computers in Industry, vol. 59, pp. 489–501, 2008.
[186] J. Sun, G. S. Hong *, M. Rahman, and Y. S. Wong, "Improved performance evaluation of tool condition identification by manufacturing loss consideration," International Journal of Production Research, vol. 43, pp. 1185-1204, 2005.
[187] J. H. Lee, S. J. Yu, and S. C. Park, "Design of intelligent data sampling methodology based on data mining," IEEE Transactions on Robotics and Automation, vol. 17, pp. 637	- 649 2001.
[188] C.-X. J. Feng and X.-F. Wang, "Data mining techniques applied to predictive modeling of the knurling process," IEEE Transactions, vol. 36, pp. 253–263, 2004.
[189] Z. J. Pasek, "Exploration of Rough Sets Theory Use for Manufacturing Process Monitoring," Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, vol. 220, pp. 365-374, 2006.

[190] I. Abu-Mahfouz and A. Banerjee, "Drill Wear Feature Identification under Varying Cutting Conditions Using Vibration and Cutting Force Signals and Data Mining Techniques," Procedia Computer Science, vol. 36, pp. 556–563, 2014.
[191] W.-C. Chen, S.-S. Tseng, and C.-Y. Wang, "A novel manufacturing defect detection method using association rule mining techniques," Expert Systems with Applications, vol. 29, pp. 807–815, 2005.
[192] C.-H. Wang, W. Kuo, and H. Bensmail, "Detection and classification of defect patterns on semiconductor wafers," 38, vol. 12, 2006.
[193] T. W. Liao, D. M. Li, and Y. M. Li, "Detection of welding flaws from radiographic images with fuzzy clustering methods," Fuzzy Sets and Systems, vol. 108, pp. 145–158, 1999.
[194] D. A. Koonce and S. C. Tsai, "Using data mining to find patterns in genetic algorithm solutions to a job shop schedule," Computers & Industrial Engineering, vol. 38, pp. 361–374, 2000.
[195] C. Kwak and Y. Yih, "Data-mining approach to production control in the computer-integrated testing cell," IEEE Transactions on Robotics and Automation, vol. 20, pp. 107	- 116 2004.
[196] A. Öztürk, S. Kayalıgil, and N. E. Özdemirel, "Manufacturing lead time estimation using data mining," European Journal of Operational Research, vol. 173, pp. 683–700, 2006.
[197] K. J. Wang, J. C. Chen, and Y. S. Lin, "A Hybrid Knowledge Discovery Model Using Decision Tree and Neural Network for Selecting Dispatching Rules of A SemiConductor Final Testing Factory," Production Planning and Control, vol. 16, 2005.
[198] S. Chen, G. Xiaohong, Z. Qianchuan, and Y. C. Ho, "Machine learning approach for determining feasible plans of a remanufacturing system," IEEE Transactions on Automation Science and Engineering, vol. 2, pp. 262	- 275, 2005.
[199] M. K. Jeong, J.-C. Lu, X. Huo, B. Vidakovic, and C. Di, "Wavelet-Based Data Reduction Techniques for Process Fault Detection," Technometrics, vol. 48, pp. 26-40, 2006.
[200] K. Irani, J. Cheng, U. M. Fayyad, and Z. Qian, "Applying machine learning to semiconductor manufacturing," IEEE Expert, vol. 8, pp. 41 - 47, 1993.
[201] V. A. Skormin, V. I. Gorodetski, and L. J. Popyack, "Data mining technology for failure prognostic of avionics," IEEE Transactions on Aerospace and Electronic Systems, vol. 38, pp. 388	- 403 2002.
[202] A. Rojas and A. K. Nandi, "Practical scheme for fast detection and classification of rolling-element bearing faults using support vector machines," Mechanical Systems and Signal Processing, vol. 20, pp. 1523–1536, 2006.
[203] T.-S. Li and C.-L. Huang, "Defect spatial pattern recognition using a hybrid SOM–SVM approach in semiconductor manufacturing," Expert Systems with Applications, vol. 36, pp. 374–385, 2009.
[204] Z. Geng and Q. Zhu, "Rough set-based heuristic hybrid recognizer and its application in fault diagnosis," Expert Systems with Applications, vol. 36, pp. 2711–2718, 2009.
[205] M. Demetgul, K. Yildiz, S. Taskin, I. N. Tansel, and O. Yazicioglu, "Fault diagnosis on material handling system using feature selection and data mining techniques," Measurement, vol. 55, pp. 15–24, 2014.
[206] T.-L. Chiang, C.-T. Su, T.-S. Li, and R. C. C. Huang, "Improvement of Process Capability Through Neural Networks and Robust Design: A Case Study," Quality Engineering, vol. 14, pp. 313-318, 2002.
[207] B. Kamsu-Foguem, F. Rigal, and F. Mauget, "Mining association rules for the quality improvement of the production process," Expert Systems with Applications, vol. 40, pp. 1034–1045, 2013.
[208] T.-N. Tsai, "Development of a soldering quality classifier system using a hybrid data mining approach," Expert Systems with Applications, vol. 39, pp. 5727–5738, 2012.
[209] Y. M. Sebzalli and X. Z. Wang, "Knowledge discovery from process operational data using PCA and fuzzy clustering," Engineering Applications of Artificial Intelligence, vol. 14, pp. 607–616, 2001.
[210] W.-C. Chen, A. H. I. Lee, W.-J. Deng, and K.-Y. Liu, "The implementation of neural network for semiconductor PECVD process," Expert Systems with Applications, vol. 32, pp. 1148–1153, 2007.
[211] D. Lieber, M. Stolpe, B. Konrad, J. Deuse, and K. Morik, "Quality Prediction in Interlinked Manufacturing Processes based on Supervised & Unsupervised Machine Learning," Procedia CIRP, vol. 7, pp. 193–198, 2013.
[212] S. Ferreiro, B. Sierra, I. Irigoien, and E. Gorritxategi, "Data mining for quality control: Burr detection in the drilling process," Computers & Industrial Engineering, vol. 60, pp. 801–810, 2011.
[213] D. S. Chang and S.-T. Jiang, "Assessing quality performance based on the on-line sensor measurements using neural networks," Computers & Industrial Engineering, vol. 42, pp. 417–424, 2002.
[214] C.-F. Chien, W.-C. Wang, and J.-C. Cheng, "Data mining for yield enhancement in semiconductor manufacturing and an empirical study," Expert Systems with Applications, vol. 33, pp. 192–198, 2007.
[215] C.-f. Chien, H.-c. Li, and A. Jeang, "Data mining for improving the solder bumping process in the semiconductor packaging industry," vol. 14, pp. 43–57, 2006.
[216] R. M. Dabbas and H.-N. Chen, "Mining semiconductor manufacturing data for productivity improvement — an integrated relational database approach," Computers in Industry, vol. 45, pp. 29–44, 2001.
[217] B.-S. Kang, J.-H. Lee, C.-K. Shin, S.-J. Yu, and S.-C. Park, "Hybrid machine learning system for integrated yield management in semiconductor manufacturing," Expert Systems with Applications, vol. 15, pp. 123–132, 1998.

[218] D. Braha and A. Shmilovici, "Data mining for improving a cleaning process in the semiconductor industry," IEEE Transactions on Semiconductor Manufacturing, vol. 15, pp. 91	- 101, 2002.
[219] C.-W. Liu and C.-F. Chien, "An intelligent system for wafer bin map defect diagnosis: An empirical study for semiconductor manufacturing," Engineering Applications of Artificial Intelligence, vol. 26, pp. 1479–1486, 2013.
[220] M. Last and A. Kandel, "Discovering useful and understandable patterns in manufacturing data," Robotics and Autonomous Systems, vol. 49, pp. 137–152, 2004.
[221] K.-L. Hsieh, "Incorporating ANNs and statistical techniques into achieving process analysis in TFT-LCD manufacturing industry," Robotics and Computer-Integrated Manufacturing, vol. 26, pp. 92–99, 2010.
[222] S.-C. Hsu and C.-F. Chien, "Hybrid data mining approach for pattern extraction from wafer bin map to improve yield in semiconductor manufacturing," International Journal of Production Economics, vol. 107, pp. 88–103, 2007.
[223] C. J. McDonald, "New tools for yield improvement in integrated circuit manufacturing: can they be applied to reliability?," Microelectronics Reliability, vol. 39, pp. 731–739, 1999.
[224] T.-S. Li, C.-L. Huang, and Z.-Y. Wu, "Data mining using genetic programming for constructionof a semiconductor manufacturing yield rate prediction system," Journal of Intelligent Manufacturing, vol. 17, pp. 355-361, 2006.
[225] M. Gardner and J. Bieker, "Data mining solves tough semiconductor manufacturing problems," presented at the Proceedings of the sixth ACM SIGKDD international conference on Knowledge discovery and data mining, Boston, Massachusetts, USA, 2000.
[226] D.-H. Baek, I.-J. Jeong, and C. H. Han, "Application of Data Mining for Improving Yield in Wafer Fabrication System," Computational Science and Its Applications – ICCSA, vol. 3483, pp. 222-231, 2005.
[227] C. Zhou, P. Nelson, W. Xiao, T. M. Tirpak, and S. A. Lane, "An intelligent data mining system for drop test analysis of electronic products," IEEE Transactions on Electronics Packaging Manufacturing, vol. 24, pp. 222	-231, 2001.
[228] C. Çiflikli and E. Kahya-Özyirmidokuz, "Implementing a data mining solution for enhancing carpet manufacturing productivity," Knowledge-Based Systems, vol. 23, pp. 783–788, 2010.
[229] L. Varga, K. Czinege, and Ieee, "Electricity consumer characterisation in liberalised market based on data mining techniques," 2007 42nd International Universities Power Engineering Conference, Vols 1-3, pp. 78-82, 2007 2007.
[230] Y.-L. Chen, T. C.-K. Huang, and S.-K. Chang, "A novel approach for discovering retail knowledge with price information from transaction databases," Expert Systems with Applications, vol. 34, pp. 2350–2359, 2008.
[231] K.-Y. Wang, I. H. Ting, and H.-J. Wu, "Discovering interest groups for marketing in virtual communities: An integrated approach," Journal of Business Research, vol. 66, pp. 1360–1366, 2013.
[232] Y. Ni and F. Fan, "A two-stage dynamic sales forecasting model for the fashion retail," Expert Systems with Applications, vol. 38, pp. 1529–1536, 2011.
[233] Z. X. Guo, W. K. Wong, and M. Li, "A multivariate intelligent decision-making model for retail sales forecasting," Decision Support Systems, vol. 55, pp. 247–255, 2013.
[234] D. Bhanu and S. P. Madheswari, "Retail Marketing Segmentation and Customer Profiling for Forecasting Sales," Recent Advances in Networking, Vlsi and Signal Processing, pp. 230-239, 2010 2010.
[235] A. Demiriz, "Demand Forecasting based on Pairwise Item Associations," Procedia Computer Science, vol. 36, pp. 261–268, 2014.
[236] D. Papakiriakopoulos, "Predict on-shelf product availability in grocery retailing with classification methods," Expert Systems with Applications, vol. 39, pp. 4473–4482, 2012.
[237] L.-D. Chen, T. Sakaguchi, and M. N. Frolick, "Data Mining Methods, Applications, and Tools," Information Systems Management, vol. 17, pp. 65-70, 2000.
[238] S.-H. Liao, W.-J. Chang, and C.-C. Lee, "Mining marketing maps for business alliances," Expert Systems with Applications, vol. 35, pp. 1338–1350, 2008.
[239] S.-h. Liao, Y.-j. Chen, and H.-h. Hsieh, "Mining customer knowledge for direct selling and marketing," Expert Systems with Applications, vol. 38, pp. 6059–6069, 2011.
[240] S.-h. Liao, Y.-j. Chen, and Y.-t. Lin, "Mining customer knowledge to implement online shopping and home delivery for hypermarkets," Expert Systems with Applications, vol. 38, pp. 3982–3991, 2011.
[241] S.-H. Liao, J.-L. Chen, and T.-Y. Hsu, "Ontology-based data mining approach implemented for sport marketing," Expert Systems with Applications, vol. 36, pp. 11045–11056, 2009.
[242] D. M. Kyun, S. Y. Sohn, and J. S. Kim, "Multi-level association rules for MP3P marketing strategies based on extensive marketing survey data," Expert Systems with Applications, vol. 36, pp. 11582–11588, 2009.
[243] C.-C. Yu and C.-S. Wang, "A hybrid mining approach for optimizing returns policies in e-retailing," Expert Systems with Applications, vol. 35, pp. 1575–1582, 2008.
[244] M. Kargari and M. M. Sepehri, "Stores clustering using a data mining approach for distributing automotive spare-parts to reduce transportation costs," Expert Systems with Applications, vol. 39, pp. 4740–4748, 2012.
[245] I. C. Yeh, C.-h. Lien, T.-M. Ting, and C.-H. Liu, "Applications of web mining for marketing of online bookstores," Expert Systems with Applications, vol. 36, pp. 11249–11256, 2009.

[246] C.-C. Hsu and Y.-C. Chen, "Mining of mixed data with application to catalog marketing," Expert Systems with Applications, vol. 32, pp. 12–23, 2007.
[247] R. F. Chang and C. N. Lu, "Load profile assignment of low voltage customers for power retail market applications," IEE Proceedings-Generation, Transmission and Distribution, vol. 150, pp. 263	- 267 2003.
[248] Y. Boztuğ and T. Reutterer, "A combined approach for segment-specific market basket analysis," European Journal of Operational Research, vol. 187, pp. 294–312, 2008.
[249] A. Seret, T. Verbraken, S. Versailles, and B. Baesens, "A new SOM-based method for profile generation: Theory and an application in direct marketing," European Journal of Operational Research, vol. 220, pp. 199–209, 2012.
[250] Y. A. Kim, H. S. Song, and S. H. Kim, "A new marketing strategy map for direct marketing," Knowledge-Based Systems, vol. 22, pp. 327–335, 2009.
[251] D. Lee, S.-H. Park, and S. Moon, "Utility-based association rule mining: A marketing solution for cross-selling," Expert Systems with Applications, vol. 40, pp. 2715–2725, 2013.
[252] A. Mild and T. Reutterer, "An improved collaborative filtering approach for predicting cross-category purchases based on binary market basket data," Journal of Retailing and Consumer Services, vol. 10, pp. 123–133, 2003.
[253] H. Tang, S. S. Liao, and S. X. Sun, "A prediction framework based on contextual data to support Mobile Personalized Marketing," Decision Support Systems, vol. 56, pp. 234–246, 2013.
[254] Y.-L. Chen, J.-M. Chen, and C.-W. Tung, "A data mining approach for retail knowledge discovery with consideration of the effect of shelf-space adjacency on sales," Decision Support Systems, vol. 42, pp. 1503–1520, 2006.
[255] K.-I. Ahn, "Effective product assignment based on association rule mining in retail," Expert Systems with Applications, vol. 39, pp. 12551–12556, 2012.
[256] M.-C. Chen and C.-P. Lin, "A data mining approach to product assortment and shelf space allocation," Expert Systems with Applications, vol. 32, pp. 976–986, 2007.
[257] T. Brijs, G. Swinnen, K. Vanhoof, and G. Wets, "Using association rules for product assortment decisions: a case study," presented at the Proceedings of the fifth ACM SIGKDD international conference on Knowledge discovery and data mining, San Diego, California, USA, 1999.
[258] G. Aloysius and D. Binu, "An approach to products placement in supermarkets using PrefixSpan algorithm," Journal of King Saud University - Computer and Information Sciences, vol. 25, pp. 77–87, 2013.
[259] I. F. Videla-Cavieres and S. A. Ríos, "Extending market basket analysis with graph mining techniques: A real case," Expert Systems with Applications, vol. 41, pp. 1928–1936, 2014.
[260] I. Cil, "Consumption universes based supermarket layout through association rule mining and multidimensional scaling," Expert Systems with Applications, vol. 39, pp. 8611–8625, 2012.

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Does Lean Underpin Sustainable Supply Chains?

Ecenaz Demirci[1] , *Nevin Balıkçı*[2]

Abstract

In the late 20th century, drivers like growing demands, globalization, and competitiveness have forced entire organizations worldwide to minimize cost and to be more responsive to customer demands. Lean Manufacturing Processes have been as an answer to these requirements since it aims at increasing productivity by diminishing waste in human effort, materials movement, manufacturing space, equipment, time, defects, and inventory. Additionally, it has been seen consequently that lean processes yield considerable number of ecological benefits such as pollution prevention, waste reduction, recycling, and remanufacturing capabilities. Concamitantly, sustainability has emerged as a concept owing to depletion of earth's natural resources and rise of environmental issues, has become an indispensable and vitally important issue for all divisions of society with the inclusion of manufacturing and service industries. Sustainability is a universal methodology that aims at meeting the needs of the present without compromising the ability of future generations to meet their own needs. The primary objective of this philosophy is the accomplishment of benefical results at three distinct aspects: economy, environment, and society. There is an interaction between lean processes and sustainability philosophies particularly in terms of ecological issues. Synthesis of these two approaches can contribute to improvements in eco-friendly supply chains. This paper investigates the link between the two methods; it explores similarities, differences, and conflicts between them.

Keywords: Lean, Sustainability, Lean&Sustainability Relationship

INTRODUCTION

In recent decades, demand increase and high competitiveness of the global economy have leaded enterprises to improve quality with cutting the cost. At this time, sustainability is becoming a crucial point for manufacturing philosophy and rise of customer oriented markets has been a peripeteia about organizations' methodologies. A visible trend comes out to synthesize this philosophy with respect to ecological and social facets. Consequently, to guarantee sustainable business development, integrating environmental, social and economic aspects is a bounden task for majority of industrial firms. Companies have to cope with rapid changes and satisfy sustainability requirements[1]. The main difficulties arose in front of the company management to accomplish perfection in production strategies are defect free(aimed at high quality goods with less internal failure and less external failure), fast(it is related about manufacturing lead time or order processing time), lean(eliminating waste), flexible(meeting more varied the market requirements when demand arises), environment-friendly (manufacturing operations without pollution, goods designed for protecting the environment and preventing the harmful effects of wastes(recylclable, re-manufacturable), to overcome the complexity emergency situations(fire, occupational accidents, explosion, flood, earthquake)). To handle with these difficulties, industries are canalizing safer approaches, which are reengineering and continuous improvement. Among these strategies, "Lean" is the most important one, since sustainability has become one of the significant points in lean particularly from an environmental

[1] Ecenaz Demirci, Okan University, Faculty of Engineering and Architecture, Department of Industrial Engineering, Istanbul, Turkey, ecenaz.demirci@okan.edu.tr
[2] Nevin Balıkci, Okan University, Faculty of Engineering and Architecture, Department of Industrial Engineering, Istanbul, Turkey, nevin.karaarslan@okan.edu.tr

perspective. The ideas of wasting less materials, workforce and avoiding emissions which stem from gaseous chemicals, solvents fit notably well with lean ideas.

"Lean" is the most important continuous improvement tool, the goal of lean is sustaining improvement in the long run. Lean is thought as an ideal, rather than a system that stresses on continuous improvement. During the recent years, the concept of "Lean Manufacturing" has become popular. Various firms have implemented "Lean" to provide customer satisfaction, save cost and reach the desirable quality and production strategies, management practices of organizations are being ammended in a leaner and fitter way to achieve high performance.[1]

Analyzing lean and sustainability concludes that they complement each other in a compatible way.

Lean and sustainability paradigms are not able to survive in isolation within the supply chain, they should exist together. Applying lean to sustainability attempts ensures that a company's green initiatives will have long-term effective power, since it adds value to company's business. Besides, this combination facilitates more competitive value chains that are able to prevail in a volatile and cost-conscious conditions. The purpose of environment-friendly attitude of manufacturing industries, which is seeking to do the right thing for the environment can be achieved more effectively by implementing lean systems. Establishing a culture that supports both methodologies can attain significant results.

The goal of this paper is to finding out whether lean reinforces sustainable supply chains or not. Firstly, we will present the literature review of lean, secondly we will introduce literature review of sustainability and thirdly we will compare "Lean" and "Sustainability"by examining the similarities and contradictions between them.

BRIEF LITERATURE REVIEW

LEAN

History of Lean

The lean concept arose out of Toyota Production System which was found by Taiichi Ohno, a Japanese businessman. He is considered to be the father of the Toyota Production System. Toyota Production System was developed to provide products at world class quality levels to meet the expectations of customers, to reduce cost through the elimination of waste and maximize profit, to create flexible production standards based on market demand. Toyota was inspired by Ford's mass production system and by quality gurus Edwards Deming(American engineer, statistician) and Joseph Juran(known as father of quality)who put importance on quality besides cost reduction. In 1970s the supplier manuals about Toyota's Production System (TPS) were produced and translated in English. Thereafter, the performance gap between Western and Japanese manufacturing drew attention.

Through the book entitled, "The Machine That Changed the World"by Womack, Jones and Roos (1990) the world manufacturing community discovered lean manufacturing. The book purposed to guide manufacturers to management of customer relations, production operations, the supply chain. Both the book and Toyota Company have paved the way for lean approach. The "lean thinking" has been interpreted by Womack and Jones and they have given Lean Enterprise importance rather than Lean Production. Today, it is the paradigm for processes, in a wide range of manufacturing and service industry.[2]

Definition of Lean and Production Principles

Lean is one of the terms for Toyota's way of speeding up thesupply chain by concentrating on eliminating wasteful steps in processes. Taiichi Ohno has identified the first seven type of muda (waste), which is any activity that does not change the product or assembly, does not directly affect in

production. The seven wastes are defined as transportation(moving products or materials that are non mandatory to perform the process), inventory, motion(employees or equipment moving more than it required to perform the process), waiting, overproduction(producing more than demand), unnecessary processing(caused by poor product design) and defects. Wastes are also known as non-value added activities. The value is defined as a thing which brings a product in the form desired by the customers who want to pay for it. Lean is a philosophy that aims at reduction and elimination of all waste from the every area which are customer relations, product design, supplier networks and factory management to create valuefor the customer. Its goal is adoption of less human effort, less inventory, less time to develop products, less space to become highly responsive to customer demand, while producing high-quality products in the most productive and economical manner.

The Lean Production has five basic principles: "precisely specify value by product, identify the value stream for each product, make value flow without interruptions, let the customer pull value from the manufacturer and pursue perfection. Firstly, the value should be specified from the point of view of customer. The value can only be determined by thecustomer and it has to be expressed in terms of specific product which meets the customer's needs at a specific price at a specific time. Lean thinking starts with a clear definition of value. Next is identifying the value stream: This isthe set of all the actions essential to bring a specific product from raw material to final customer. After this, making the value-creating steps for specific products flow continuously should be carried out to avoid or at least reduce batch and queue. Following step is letting customers pull value from the enterprise, which is the capability of scheduling, designing and making exactly what the customer wants just when the customer wants. Finally, pursuing perfection, it is delivering accurately what the customer wants, at a fair price and with minimum waste.[3]

Consequently, lean strategies focus on waste diminishment, contributes to eliminate non-value adding activities about slack time, equipment, space, labor and inventories across the supply chain). A matrix propounds that there might be four possible supply chain strategies according to three-dimensional classification(products, demand, replenishment lead-times): lean (plan and execute), leagile (postponement), lean (continuous replenishment), agile (quick response). Lean is a business model that eliminates waste while delivering quality products at the least cost. The competitiveness of lean production originates from physical savings (fewer parts, shorter production operation, less unproductive needed for set-ups, less material) on the technical side, psychological efficiency(commit, empowerment, communication etc.) is also stressed. Lean production system has been one of the competitive advantages for firms.

SUSTAINABILITY

History and Definition of Sustainability

Sustainability or sustainable development has emerged in the late 1980s by the Norwegian Prime Minister Brundtland as "Meeting the needs of the present without compromising the ability of future generations to meet their own needs. The principle of sustainability concept covers an not only environmental aspect, but also delivers social and economic benefits. The term triple-bottom-line is directly which is planet, people, and profit, is directly related to three dimensions of sustainability: ecological, social and economical [2].

According to these aspects, different performance measures have arosen in the supply chains. In economic aspect, the operational cost, environment cost, inventory cost; in social aspects, supplier screening, corruption risk, local suppliers. Finally, the ecological dimension, which is also referred as "Green Philosophy", targeting green is improvement of the quality of green compliant products, processes while decreasing cost, the carbon and the environmental footprint of all product design, manufacturing, raw material processing, remanufacturing, recycling, warehousing and logistics activities, considers business wastage, green image and carbondioxide as performance measures[4].

COMPARISON OF LEAN AND SUSTAINABILITY PHILOSOPHIES

There are both conflicts and similarities while comparing the two philosophies. An exploratory study was conducted by collecting data on different cases. The study is summarized by the Table 1.

Table 1. Lean and Sustainability

Attribution	Lean Philosophy	Sustainability Philosophy
FOCUS	Elimination of waste in every area, including customer relations, product design, supplier networks and factory management [1].	Minimizing environmental impact of manufacturing processes and products is ever more important to our sustainable future [5].
MAIN PURPOSE	Cost minimization and waste elimination[6].	Reduction of the ecological impact of the industrial activity without sacrificing quality, cost, reliability, performance or energy utilization efficiency; meeting environmental regulations, minimize ecological damage and leading to overall economic profit [7].
	Incorporate less human effort, less inventory, less time to develop products and less space to become highly responsive to customer demand, while producing top-quality products in the most efficient and economical manner possible [1].	To find out the sources of pollutants and eliminate them [7].
	Maximize profits through cost reduction[5].	Reducing environmental risks and impacts while improving ecological efficiency of organizations and their partners [5].
TOOLS, METHODS AND PRACTICES	Kaizen Rapid Improvement Process, 5S, Total Productive Maintenance (TPM), Cellular Manufacturing (One-piece Flow Production Systems), Just-in-time Production, Kanban, Six Sigma ,Pre-Production Planning (3P) [8].	Ensuring materials that are not in inventory past shelf life, modification of layout, equipment, seperation of hazardous and non hazardous waste, improvement of maintainance Schedule, substitution of raw materials, Life-Cycle Assessment:Analyzingthe potential environmental aspects and potential aspects associated with a product (or service), Sustainable VSM, waste minimization(energy, water, non product output), reduction of lead time for transportation and replenishment(reordering) frequency [8][9].
KPI	Leadership, cost, time, quality, people and organization[10].	Emission(Air emission,water emission, land emission), Resource utilization(Energy utilization,Water utilization,Fuel consumption, Land used), Waste(Solid waste, Hazardous waste,Waste water)[11].
EMPLOYEE EMPOWERMENT	The ability to participate in decision-making and Problem-solving(Kaizen), job satisfaction [12]	Employee training, development and job satisfaction [10].

MANUFACTURING IMPLEMENTATION	JIT, controlling the flow resources by replacing only consumed ones in production process, using customer order-driven production schedules based on actual demand and consumption [13].	Resource efficiency and waste elimination for environmental benefits lead to a development of remanufacturing capabilities to integrate recyclable/reusable parts [14].
WASTES	Overproduction Waiting Inventory Motion Defects Transportation Overprocessing [8].	Water: leaks, waste streams from processes. Air: evaporation of chemicals, dust, particulate. Solid Waste: filters, excess material scrap. Toxic & Hazardous Waste: solvents, process residuals. Energy: machinery on when not in use, heat loss, oversized motors [14].
TRANSPORTATION	To reduce motion, it aims at minimize material handling during manufacturing [5].	To reduce fuel consumption and carbondioxide emissions, it aims at reduction of replenishment frequency [5].
CUSTOMER SATISFACTION	Satisfying customers by diminishing costs and lead times [5].	Satisfying customers by helping them for environmental sustainability, producing products or providing services in green principles [14].
END OF LIFE	Lean does not consider end of life scenerios [14].	Environmental sustainability aims at less scrap through considering different scenarios by product life cycle planning procedure from the product design phase [14].
ENVIRONMENT	Lean considers environment as a valuable source [14].	Sustainability considers environment as limitation for product and services design and Production [14].
ISO STANDARDS	Implementation of ISO14001 standard is the continuation of Lean Manufacturing techniques improvement [14].	Implementation of ISO14001 is strong beginning for Environmental Sustainability Integration [14].
COST	Costs can be classified as operational cost, inventory cost and environmental cost. Supply chain management practices in lean like just in sequence, single sourcing, deliveries directly to the point of utilization reduce all these three types of costs [4].	Costs can be classified as operational cost, inventory cost and environmental cost. Supply chain management practices in environmental sustainability like using reusable packaging to deliver materials, using green purchasing guidelines and sourcing from environmentally responsible resources only reduce environmental cost, they have no influence on operational cost and inventory cost [4].

In the view of this information, it can be deducted that lean and sustainability have strong connections in waste management, they target waste elimination and this factor integrates them. Their main purpose and focus are similar. When ISO Standards are considered, both methodologies are parallel. Cost minimization is another common attribution, by reducing cost they both improve efficiency. The benefits of these two are are energy savings, productivity increase, and advantages from improved utilization of materials, they can also lead to innovations that involve creation of new products out of waste materials.

CONCLUSION

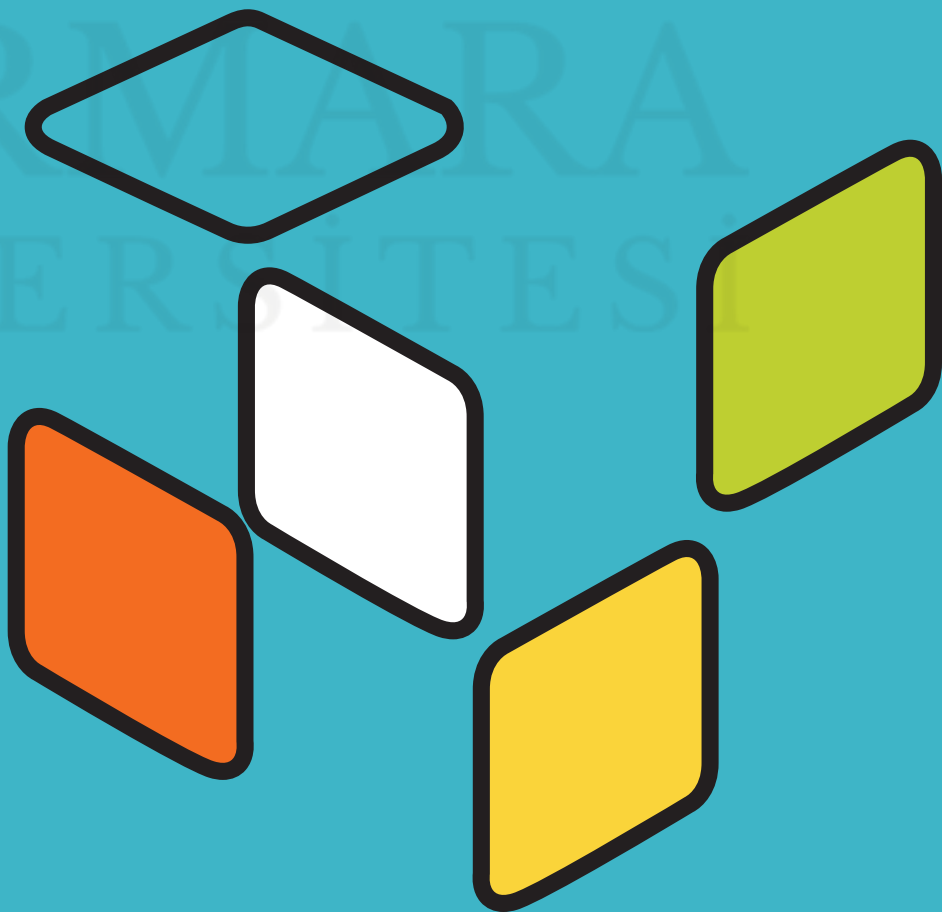
The research findings shows that a Lean environment supports sustainable supply chains. The integration of Lean and Sustainability practices will bring benefits to companies and introducing Sustainability as the new Lean is no longer a strong and unsupported statement. It is rather obvious that the ultimate Lean will be Sustainable.

References

[1] Ravet, D., 2011, Lean production: the link between supply chain and sustainable development in an international environment, Colloque Franco-Tcheque Trends in international business, 1-20.
[2] http://www.slideshare.net/rgort/lean-sustainabilitythesis20080909g (Access Date:28.10.2014)
[3] http://aut.researchgateway.ac.nz/bitstream/handle/10292/3451/StammM.pdf?sequence=3 (AccessDate: 30.10.2014)
[4] Azevedo, S. G., Carvalho, H., Duarte, S., Machado, V. C. Influence of Green and Lean Upstream Supply Chain Management Practices on Business Sustainability,2012, IEEE Transactıons On Engıneerıng Management, Vol. 59,753-765
[5] Dües, M. C., Tan, K.H., Lim, M., 2013, Green as the new Lean: how to use Lean practices as a catalyst to greening your supply chain, Journal of Cleaner Production Volume 40, 93-100.
[6] http://creativeclass.com/rfcgdb/articles/13%20Green%20Manufacturing.pdf(Access Date:02.11.2014)
[7] Cabral, I., Grilo, A., Leal, R. P., Machado, V. C., 2011, Modelling Lean, Agile, Resilient, and Green Supply Chain Management, Proceedings of the ITI 2011 33rd Int. Conf. on Information Technology Interfaces, 365-370.
[8] http://www.epa.gov/lean/environment/pdf/leanreport.pdf (Access Date:02.11.2014)
[9] http://www.gdrc.org/uem/lca/lca-define.html(Access Date:02.11.2014)
[10] Stamm, M. L., Neitzert, T. ,2008,Key Perfomance Indıcators (KPI) For The implementation of Lean Methodologies In A Manufacture To Order Small And Medıum Enterprıse, Manufacturing Fundamentals:Necessity and Sufficiency, 355-368
[11] Amrina, E.,Yusof, S. M., Key Performance Indicators for Sustainable Manufacturing Evaluation in Automotive Companies,2011, Industrial Engineering and Engineering Management (IEEM), 2011 IEEE International Conference,1093-1097
[12] Chan, C. S. C., Yu, K. M., Yung, K. L., 2010, Green Manufacturing Using Integrated Decision Tools, Proceedings of the 2010 IEEE IEEM, 2287-2291
[13] http://www.wvmep.com/kanban.html (Access Date:02.11.2014)
[14] Bashkıte, V., Karaulova, T., 2012,Integratıon Of Green Thınkıng Into Lean Fundamentals by Theory Of Inventıve Problems-Solvıng Tools, Annals of DAAAM for 2012 & Proceedings of the 23rd International DAAAM Symposium, Volume 23, No.1, ISSN 2304-1382, ISBN 978-3-901509-91-9, CDROM version, Ed. B. Katalinic, Published by DAAAM International, Vienna, Austria.

MARMARA ÜNİVERSİTESİ YAYINEVİ

SUSTAINABILITY I



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

A Descriptive Study on Sustainability Perception: Turkish Logistics Industry

Okan Tuna[1], Aysun Akpolat[2] Ezgi Uzel[3], Özlem Sanrı[4]

Abstract

Today customers are more conscious about sustainability thus companies have to take sustainability into consideration in order to meet the expectations of their customers. In this longitudinal and descriptive research the concept of sustainability in the logistics industry is emphasized. This study attempts to measure the sustainability perceptions of top managers in logistics industry with regard to two topics; performance and expectations. Survey method used for data collection and sample of this research is based on the members of UTIKAD (Association of International Forwarding and Logistics Service Providers) which is a non-governmental organization in the field of transportation in Turkey. In the first part, the study discusses the concept of sustainability and profitability as one of the performance measures. Then, last quarter of 2013's performance and expectations of industry is shown. With the results of this study the recognition of Turkish logistics industry is expected to be increased, and meanwhile managers can identify opportunities and provide recommendations in order to have sustainable operations in the industry.

Keywords: Logistics, Performance, Profit, Sustainability

Introduction

It was the traditional view that the main goal of all firms is only to maximize their profits by using their resources efficiently (Jensen and Meckling 1976). However, this view is challenged in last years by expanding the responsibilities of firms beyond profit maximization. The corporate responsibility is built on three basic principles: environmental responsibility, economics responsibility and social responsibility which also become the pillars of the concept of sustainability (Barbier 1987; Elliott 2005). Even it has been still discussing that sustainability increases the costs of firms, many research proposes a positive relationship between sustainability and profitability (Lo, 2010).

Sustainability in logistics industry is one of the hot topics in today's business world. The understanding of sustainable supply chains have become established, and stakeholders' preferences are formed around sustainability when generating profitability across the chain. Profitability bring expectations toward growth of the firm and investments. Also, competitiveness and cooperation levels of the firms increase the profitability so that supports the sustainability.

In order to discover the situation of logistics industry, this study aims to measure the perceptions of top logistics managers of Turkey regarding the performance and expectations about logistics industry in sustainability framework.

This longitudinal study is based on a research conducted in every three months. This part is based on a research conducted between the dates of 16 June – 30 June 2014 by Beykoz Vocational School of Logistics, Center of Logistics Applications and Research. The research samples of this study are taken from the

[1] Okan Tuna, Beykoz Vocational School of Logistics, Logistics Programme, Istanbul, Turkey okantuna@beykoz.edu.tr
[2] Aysun Akpolat, Beykoz Vocational School of Logistics, Business Administration Programme, Istanbul, Turkey, aysunakpolat@beykoz.edu.tr
[3] Ezgi Uzel, Beykoz Vocational School of Logistics, Logistics Programme, Istanbul, Turkey, ezgiuzel@beykoz.edu.tr
[4] Özlem Sanrı, Beykoz Vocational School of Logistics, Rail Systems Management Programme, Istanbul, Turkey, ozlemsanri@beykoz.edu.tr

members of UTIKAD (Association of International Forwarding and Logistics Service Providers). The sample size judgmentally derived from the total population surveyed consists of 400 firms. The survey is delivered to all of the 400 companies in the sample by mail and Internet until a representative response rate (16.5% in the Second Quarter of 2014) is reached.

In the first part of the study, the literature review is provided about the concept of sustainability and the relationship between sustainability and performance. In the second part, research methodology is explained. In the last part the findings are given and the dashboard of the logistics industry of Turkey is established.

Literature Review

Concept of Sustainability in Logistics Industry

In order to clarify what logistics companies do to be more sustainable, the definition of sustainability is needed. With the rise of today's "conscious consumer", sustainability is meeting the expectations of investors while taking into account the long-term impact that operations have on the community and environment (Prokesch, 2010).

One of the most frequently quoted definition is from Our Common Future, also known as the Brundtland Report (1987, 43): "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs". According to this definition the world is seem as a system. Thus, one event connects another and acts like a total link. Specifically, logistics is also a system and the components of a typical logistics system are: customer service, demand forecasting, distribution, inventory control, material handling, order processing, parts and service support, plant and warehouse site selection, purchasing, packaging, return handling, salvage and scrap disposal, traffic and transportation, and warehousing and storage. For logistics companies that imply sustainability in their processes have to make integration throughout the system surrounding the workforce, suppliers, shippers, distributors and retailers.

When all partners in the logistics system have different concerns about sustainability, there has to be a common ground in order to achieve an agreement on this issue. Thus, the concept of People, Planet and Profit (PPP) concept is used. PPP wants to consider all aspects which could influence a decision on sustainability. According to Stonebraker et. al. (2009), pre-calculations of both market costs and external costs (people, profit, and planet) in many cases are necessary as a support to new sustainable supply chains and networks that are started up by companies. Unsustainable practices hidden in the supply chain has the potential to become public information extremely quickly, leaving a company's brand value damaged and shareholders displeased (Dey, LaGuardia and Srinivasan, 2011). Though adding sustainability throughout the logistics company takes creativity, many firms have learned how to use it to differentiate themselves from their competitors, reduce costs, and improve services to their customers (Gold and Seuring, 2011; Pedersen, 2009).

Relationship Between Sustainability and Performance

In the past, the concept of sustainability was associated only with environmental issues, but later it is understood that it is also a base for good business management with the economics and social aspects as well as the environmental aspects (Funk, 2003). Lo (2010) defined the corporate sustainability as it is built on complementary issues of financial benefit, environmental protection and social responsibility. Linnanen and Panapanaan (2002) built a model for corporate sustainability with three dimensions attached to corporate social responsibility of a firm: economic responsibility – profit, social responsibility- people, and environmental responsibility – planet. Lo (2010) proposed a model which explains the performance of a firm

from profitability and marketing frameworks. According to Lo's (2010) findings, there is some evidence that corporate sustainability helps a firm for profit generation, and also he offered that sustainable firms generally perform better than other firms, and ensure competitiveness. Profitability also drives the growth of the industry, and call for more foreign investments from outside of the country. Besides profitability, the interest for cooperation between firms has increased in order to achieve and ensure the competitive advantage in logistics industry. So, expectations for growth and investments related with profitability, and cooperation and competitiveness levels are indicated as the performance tools for this study.

Performance Indicators For Sustainability

Growth and investment expectations related with profitability

The concept of sustainability of the firms are considered as one of the valuable intangibles that helps to generate profit by interacting with stakeholders' preferences. According to Bagozzi and Phillips (1982) and Chakravarthy (1986), performance of firms is a complex issue that requires multifactor performance measurement methods. Profitability is one of the performance methods which is desired by all firms in the business world (Rothschild, 2006). As it is known by everyone, a performance of a firm is highly related with its success of generating profit in its business sector. Nowadays, there is another issue about performance of firms. Even some of the studies found a negative impact of sustainability on profitability, still many empirical studies proposed a positive relationship between sustainability and profitability of the firms (King and Lenox, 2002; Schnietz and Epstein, 2005; Lo and Sheu, 2007).

Besides achieving profitability, firms also desire to sustain this profitability by growing. According to Jang and Park (2011) growth is highly related with profitability. In his study, Gupta (1969) tried to explain the effects of growth by using some profitability ratios. Geroski et al. (1997) found a positive relationship between growth and profitability. Growth of firms' is an important tool of economic development, especially for a country like Turkey which is one of the mid-level developed countries in the world (Sanghamitra, 1995). When the profitability of the firms has increased in a specific industry, the attractiveness for investments to this industry will also be increased. This is called as the sustainable development as one of the measurements of economic development.

Competitiveness and cooperation levels of firms

Sustainability has become one of the tool for improving the productivity of firms, and new way of achieving competitiveness (Keindorfer, Singhal, & van Wassenhove, 2005; Lee & Kim, 2011). In the past, business competitiveness focused on internal factors such as achieving economies of scale in the production. However, some other factors have started to be the sources of competitive advantage, such as cooperation and information sharing (Prezioso, 2007). Especially, the idea of working as partners instead of rivals improved the cooperation level between parties of a chain which drives the level of competitiveness as well.

In today's business world, instead of transactional relationships, there are more cooperative relationships between producers and their suppliers in supply chains in order to perform better (Dyer 1997; Bensaou 1999; Carr and Pearson, 1999). Especially, international trade and outsourcing of logistics activities push the firms to create more reliable relationships with their suppliers, distributers and logistics service providers. In order to achieve sustainable competitive advantage, firms should cooperate with the all the partners in their supply chain. Hollos, Blome and Foerstl (2012) also underlined the importance of cooperation between suppliers, and its positive effect on sustainable performance in their study.

Methodology Of The Research

General Description of the Research

This study is based on a research conducted between the dates of 16 June – 30 June 2014 by Beykoz Vocational School of Logistics, Center of Logistics Applications and Research. The research sample of this

study is derived from the members of UTIKAD (Association of International Forwarding and Logistics Service Providers). UTIKAD is also a partner and supporter of this longitudinal study. UTIKAD is an active member of the International Federation of Freight Forwarders Association (FIATA) which is the largest non-governmental organization in the field of transportation in the world. The sample size judgementally derived from the total population surveyed consists of 400 firms. These firms are primarily members of UTIKAD, and the response rate to the survey reaches the sample level at 16.5% by both mail and web-based inquiry forms. When compared with last year's 16 % sample rate, it can be said that the attention of the logistics industry to this research is slightly increased. However, there were important constraints during data collection. The theme of "Trends in the Turkish Logistics Industry," "performances" and "expectations," is derived from the evaluation of senior managers. All the senior managers of the surveyed companies/institutions were asked a control question in order to confirm that the survey is actually replied to by the intended person.

The Method of Data Collection and Description of Sample

Research is comprised of investigating performance and experience within the logistics industry. The research method is to prepare 15 different questions and present them for response to the senior managers of the logistics industry. The entire set of 15 questions is closed-ended.

The 400 companies, members of UTIKAD (Association of International Forwarding and Logistics Service Providers), which serve as the sample population for the continuing study, are given a survey in every three month (quarterly) period by Beykoz Vocational School of Logistics. The evaluation of survey responses is made in the last month and made public by publishing the results. The table below includes the published results for quarterly periods in 2014.

Table 1. Results Identification of Publishing Periods (2014)

Year of 2014 Results	Release Date	Reference Period: Performances	Reference Period: Expectations
Quarter 1	31 March 2014	(January-March 2014)	(April-June 2014)
Quarter 2	30 June 2014	(April-June 2014)	(July-September 2014)
Quarter 3	30 September 2014	(July-September 2014)	(October-December 2014)
Quarter 4	31 December 2014	(October-December 2014)	(January-March 2015)

The survey is delivered to all of the 400 companies in the sample by mail and Internet until a representative response rate (16.5% in the Second Quarter of 2014) is reached. The current and the previous survey response rates are listed in the table below.

Table 2. Survey Response Rates

Research Period	N	Population Representation Ratio
Quarter 4 (October-December, 2013)	40	10%
Quarter 1 (January-March, 2014)	64	16%
Quarter 2 (April-June, 2014)	66	16.50%

Results Of The Research

Performance of the logistics industry during the April-May-June period of 2014 are described below.

Competition Levels in the Logistics Industry

Of the managers surveyed in the research, 68.1% of them evaluated price competition as "high" in the logistics industry. Moreover, service quality (63.6%) and service speed (71.2%) competition were considered as "middle". When compared with the first quarter results for 2014, the level of price competition and service speed competition which is defined as "high" is decreased; however the level of "service quality" competition defined as "middle" is significantly increased, (see Table 3 and Figure 1).

Table 3: Competition Levels in Logistics Industry: Comparative Table

Evaluation	Price Competition (%)			Quality Competition (%)			Service Speed Competition (%)		
	2013: 4. Quarter	2014: 1. Quarter	2014: 2. Quarter	2013: 4. Quarter	2014: 1. Quarter	2014: 2. Quarter	2013: 4. Quarter	2014: 1. Quarter	2014: 2. Quarter
High	82,5	73,0	68,1	25,0	11,1	13,6	37,5	27,0	19,6
Middle	10,0	12,7	19,6	47,5	49,2	63,6	57,5	57,1	71,2
Low	7,5	14,3	12,1	27,5	31,7	22,7	5,0	15,9	9,0

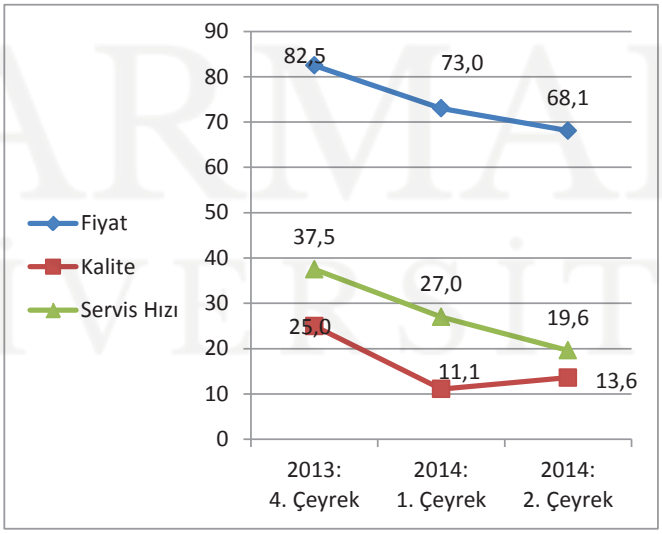


Figure 1. Competition Levels in Logistics Industry (%)

"high" responses were evaluated.

Cooperation Level In Logistics Industry

The 87,6 % of the managers who participated to the research mentioned that there is a high level of information sharing in logistics industry. Also, 77,2 % of the participants point out a high level cooperation between companies in the industry.

When the results are compared with the first quarter of year 2014, a significant increase can be observed both in information sharing and cooperation levels (See Table 4 and Figure 2).

Table 4. Cooperation Level in Logistics Industry: Comparative Table

Evaluation	Information sharing between companies (%)			Cooperation between companies (%)		
	2013: Quarter 4	2014: Quarter 1	2014: Quarter 2	2013: Quarter 4	2014: Quarter 1	2014: Quarter 2
Yes	82,5	82,5	87,6	87,5	69,8	77,2
No	17,5	17,5	12,4	12,5	30,2	22,8

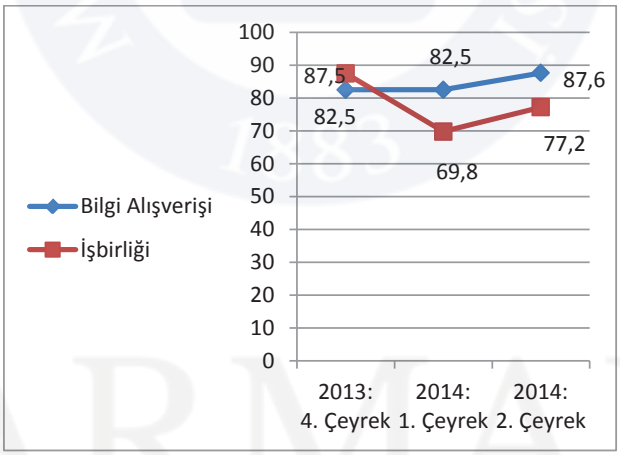


Figure 2. Cooperation Level in Logistics Industry (%)

Expectation of Foreign Capital Investment in Logistics Industry

The 1,5 % of the managers that participated to the research think that the foreign capital investments will increase significantly, while % 28,7 of them mentioned that there will be an increase. % 9 of the managers said foreign capital investments will decrease.

Table 5. Expectation For Foreign Capital Investment: Comparative Table

Evaluation	2013: Quarter 4 (%)	2014: Quarter 1 (%)	2014: Quarter 2 (%)
will increase significantly	22,5	3,2	1,5
will increase	65,0	19,0	28,7
will remain same	7,5	61,9	60,6
will decrease	5,0	15,9	9,2

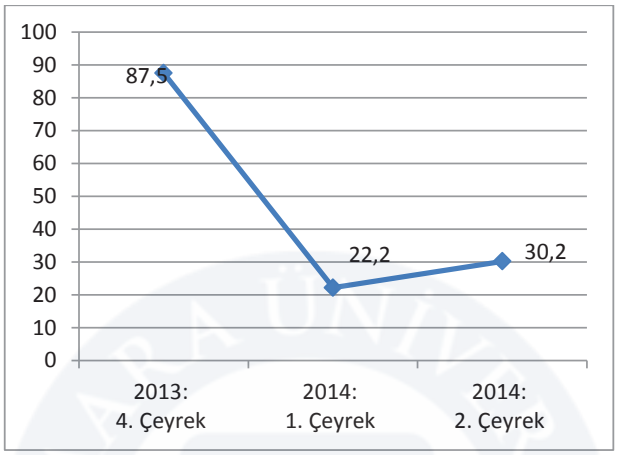


Figure 3. Expectation for Foreign Capital Investment

* The sum of responses of "increase significantly" and "will increase" were evaluated.

Growth Expectation in Logistics Industry

The % 16,6 of the managers that participated to the research express their opinions toward the growth expectation of the industry in three months, and they mention that logistics industry will shrink. On the other hand, % 54,5 of the participants mention that the industry will remain same, and the rest express their opinions as the industry will grow.

When these results are compared with the first quarter of the year 2014, a decrease is observed in growth expectation of the logistics industry (See Table 6). The rate of those who expressed their opinions toward a increase in logistics industry decreased from % 39,7 to % 28,7. This continuous decrease since fourth quarter of year 2013 should be followed up seriously.

Table 6. Growth Expectation in Logistics Industry: Comparative Table

Evaluation	2013: Quarter 4 (%)	2014: Quarter 1 (%)	2014: Quarter 2 (%)
will grow	57,5	39,7	28,7
stay same	35,0	44,4	54,5
Will shrink	2,5	12,7	16,8

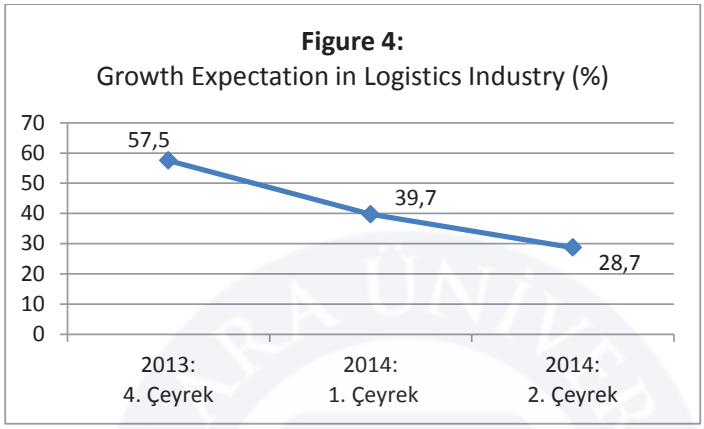


Figure 4. Growth Expectation in Logistics Industry

Sustainability Dashboard Of Turkish Logistics Industry

As a summary, findings of the study are braught together in Table 9 under two main titles of "performances" and "expectations". A comparison can be seen between the last quarter of the year 2013 and first two quarters of the year 2014.

Table 7. Sustainability Dashboard Of Turkish Logistics Industry

PERFORMANCES					EXPECTATIONS				
HİGH		2013 4.Quarter	2014 1.Quarter	2014 2.Quarter	FOREIGN CAPITAL INVESTMENT		2013 4.Quarter	2014 1.Quarter	2014 2.Quarter
	Price Competition	—	↓	↓		Will increase significantly	—	↓	↓
	Quality Competition	—	↓	↑		Will increase	—	↓	↑
	Service Speed Competition	—	↓	↓		Will remail same	—	↑	↓
MIDDLE	Price Competition	—	↑	↑		Will Decrease	—	↑	↓
	Quality Competition	—	↑	↑			2013 4.Quarter	2014 1.Quarter	2014 2.Quarter
	Service Speed Competition	—	↓	↑	GROWTH	Will Grow	—	↓	↓
LOW	Price Competition	—	↑	↓		Stay Same	—	↑	↑
	Quality Competition	—	↑	↓		Will Shrink	—	↑	↑
	Service Speed Competition	—	↑	↓				2014 1.Quarter	2014 2.Quarter
COOPERATION/ INFORMATION SHARING		2013 4.Quarter	2014 1.Quarter	2014 2.Quarter	INVESTMENT PLANNING	Yes		—	↓
	YES	—	—	↑		No		—	↑
	NO	—	—	↓					
COOPERATION BETWEEN COMPANIES	YES	—	↓	↑					
	NO	—	↑	↓					

As it is observed in the findings and seen in the dashboard, price competition is found to be high in Turkey, but decreased in the last quarter. Also, an increase is observed in service quality. Besides competition level, in the cooperation level there is a significant positive trend.

For expectations of the foreigh investment, participants expect an increase in the last quarter, but they think there will be no growth, and the sector will stay same.

Conclusion

"Trends in Turkish Logistics Industry" is a longitudinal study reported quarterly since the last quarter of 2013. This study attempts to measure the perceptions of top managers in logistics industry with regard to two topics; performance and expectations. It is a unique study in terms of its scope in the Turkish logistics market and well regarded among the parties in the industry.

Sustainability has become one of the emerging concepts in logistics industry. It is complementing the aim of profit maximization by increasing the cooperation between parties in the supply chain, ensuring the competitive advantage, and increasing the expectations toward growth of the logistics industry and foreign capital investment. Hence, according to findings it is better to say that logistics companies have to take into consideration not only environmental sustainability but also economical sustainability.

This study tried to summarize the major trends by using dashboard in logistics sector of Turkey in order to contribute to sustainable operations in the industry. By using this economical indicators the logistics managers can turn their operations into more sustainable processes.

References

[1] Bagozzi RP, Phillips LW. (1982), "Representing and testing organizational theories: A holistic construal", *Administrative Science Quarterly* 17, 459–489.
[2] Bensaou, M., (1999), "Portfolios of buyer–supplier relationships", *Sloan Management Review*, 40 (4), 35–44.
[3] Carr, A.S. and Pearson, J.N., (1999), "Strategically managed buyer–supplier relationships and performance outcomes", *Journal of Operations Management*, 17 (5), 497–519.
[4] Chakravarthy BS. (1986), "Measuring strategic performance", *Strategic Management Journal* 7, 437–458.
[5] Dey, A, LaGuardia P., Srinivasan, M. (2011), "Building Sustainability İn Logistics Operations: A Research Agenda", *Management Research Review*. 34 (11), 1237-1259.
[6] Dyer, J.H., (1997), "Effective interfirm collaboration: how firms minimize transaction costs and maximize transaction value", *Strategic Management Journal*, 18 (7), 535–556.
[7] Funk K. (2003), "Sustainability and performance", *Sloan Management Review* 44(2): 65–70.
[8] Geroski, P. A., Machin, S. J., & Walters, C. F. (1997). Corporate growth and profitability. *The Journal of Industrial Economics*, 45(2), 171-189
[9] Gold, S. and Seuring, S. (2011), "Supply chain and logistics issues of bio-energy production", *Journal of Cleaner Production*, 19 (1), 32-42.
[10] Gupta, M. C. (1969). The effect of size, growth, and industry on the financial structure of manufacturing companies. *The Journal of Finance*, 24(3), 517-529.
[11] Hollos, Daniel, Blome, Constantin, Foerstl, Kai (2012), "Does sustainable supplier co-operation affect performance? Examining implications for the triple bottom line", *International Journal of Production Research*, 50 (11) 2968-2986.
[12] Jang, S., & Park, K. (2011). Inter-relationship between firm growth and profitability. *International Journal of Hospitality Management*, 30(4), 1027-1035.
[13] Keindorfer, P., Singhal, K., & van Wassenhove, L. (2005). Sustainable operations management. *Production and Operations Management*, 14(4), 482e492.
[14] King A, Lenox M. (2002), "Exploring the locus of profi table pollution reduction", *Management Science* 48, 289–299.
[15] Lee, K.-H., & Kim, J. (2011), "Integrating suppliers into green product innovation development: an empirical case study in the semiconductor industry", *Business Strategy and the Environment*, 20(8), 527-538.
[16] Linnanen L, Panapanaan V. (2002), Roadmappng Corporate Social Responsibility in Finnish companies, Helsinki University of Technology:Helsinki, Finland.

[17] Lo SF, Sheu HJ. (2007), "Is corporate sustainability a value-increasing strategy for business?", *Corporate Governance – An International Review* 15(2), 345–358.
[18] Lo, Shih-Fang, (2010), "Performance Evaluation for Sustainable Business:A Profitability and Marketability Framework", *Corporate Social Responsibility and Environmental Management*, 17, 311–319.
[19] Pedersen, A.K. (2009), "A more sustainable global supply chain", *Supply Chain Management Review*, 13 (7), 6-7.
[20] Prokesch, S. (2010), "The sustainable supply chain", *Harvard Business Review*, 88 (10), 70-2.
[21] Sanghamitra, D. (1995). Size, age and firm growth in an infant industry: The computer hardware industry in India. *International Journal of Industrial Organization*, 13(1), 111-126.
[22] Schnietz K, Epstein M. (2005), "Exploring the fi nancial value of reputation for corporate social responsibility during a crisis", *Corporate Reputation Review* 7: 327–345.
[23] Stonebraker, P., Goldhar, J., Nassos, G., (2009), "Weak links in the supply chain: measuring fragility and sustainability", *J. Manuf. Technol. Manag.* 20 (2), 161-177.
[24] World Commission on Environment and Development (WCED). Our common future. Oxford: Oxford University Press, 1987 p. 43.

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Renewable Energy for a Sustainable Future

Koray Altıntaş[1], Tuğba Türk[2], Özalp Vayvay[3]

Abstract

Sustainable development becomes more and more important in recent years, since bold actions are necessary to ensure the needs of future generations. Using renewable sources for producing energy plays an important role to achieve sustainable development. Major global issues like depletion of sources and environmental concerns triggers the rapid development of these clean energy production systems. This paper focuses on the current status and future potentials of different renewable energy sources by considering various quantitative and qualitative factors that may affect the capabilities and significance of renewable energy systems such as the potential for power generation, availability issues, carbon dioxide emissions, capital costs, land requirements and social impacts. Furthermore, some of those factors are used for making comparisons between different technologies and systems, which are also discussed in the paper. The results and discussions reveal that these systems provide promising opportunities for people to access cheap, reliable and clean energy in the future, which is one of the key elements to sustain healthy ecosystems and human life. The recommendations and conclusions presented here will be beneficial to engineers, researchers, city planners and energy policy makers.

Keywords: Renewable Energy, Sustainability

Introduction

The terms "sustainability and sustainable development" becomes more and more popular due to the serious problems faced by human kind such as the risk of depletion of sources and increasing human impact on environment. Sustainability is described as maintaining welfare over a long-term according to Kuhlman and Farrington [1] and the report of United Nations [2] defines sustainable development as "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Therefore, human activities which have negative effects on the worlds' delicate balance can be determined as unsustainable activities. It is also an important point that considering not only environmental but also economic and social aspects must be taken into account together in order to achieve sustainability. Solving problems just considering one of these aspects is not enough to find sustainable solutions [3].

Pesonen [4] states that increasing public awareness towards sustainability issues especially environmentally problems as well as the pressure from stakeholders and society to go green triggered companies to evaluate their entire value chain and set sustainability objectives. Many firms have performed major changes in their activities such as changes in distribution strategies and packaging methods in order to achieve those objectives.

Reducing the impacts related with energy consumption is one of the most effective efforts to achieve sustainability targets. This can be achieved either by using energy saving measures or using the power generated from renewable energy technologies. Since energy plays the major role in terms of sustainability, investing in renewable energy technologies have become attractive among investors, which is also an important step to provide cheap, reliable, ecological and accessible energy all around the world [5].

This paper focuses on introducing the main sustainability indicators for renewable energy technologies including potential power generation, availability of renewable sources, capital costs, land requirements,

[1] Koray Altintas, Marmara University, Engineering Faculty, Department of Engineering Management, Istanbul, Turkey, korayaltintas@marun.edu.tr
[2] Tugba Turk, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, tugba.turk@marun.edu.tr
[3] Ozalp Vayvay, Marmara University, Engineering Faculty, Department of Engineering Management, Istanbul, Turkey, ozalp@marmara.edu.tr

carbon-dioxide emissions, social acceptance and social impacts. It is mainly concentrated on hydro, wind, photovoltaic, geothermal, marine (wave & tidal) and bioenergy technologies, which are used to generate power.

Sustainability Indicators

Potential Power Generation

The importance of renewable energy will definitely continue to grow in a world, where the demand for energy will be 56% more than today in 2040 [6]. Although renewable energy sector has already attracted many investors, the global energy status report of Renewable Energy Policy Network for the 21st Century [7] shows that renewable energy sector still has a long way to go. According to this report only 19% of global energy demand is provided by renewables in 2013. However, the report of U.S. Energy Information Administration [8] indicates that renewables is the fastest growing sector from now until 2035 projections. This clearly shows that this sector provides promising opportunities to meet the future energy demands.

Potential power generation is linked with the installed capacity of that specific technology, which indicates the amount of power that can be delivered under specific conditions. The amount of total installed capacity of renewable technologies that is used for worldwide power generation is 1560 GW. 1000 GW of this amount corresponds to the hydro-power capacity. Therefore, hydro-power can be identified as the locomotive renewable energy source for power production. However, it is also very important to consider annual growth rates in terms of installed capacity for each renewable source in order to evaluate the future of that technology. For example, although photovoltaic systems correspond to 8.9% of the total installed capacity for power generation among renewable technologies; photovoltaic market has the record in terms of annual installed capacity growing rates with 39% in 2013. Approximately 39 GW of installed capacity became operational in that year, which was about 100 GW in the end of 2012 [7]. Figure 1 demonstrates the annual growth rates of renewable energy capacities from the end of 2012 to the end of 2013.

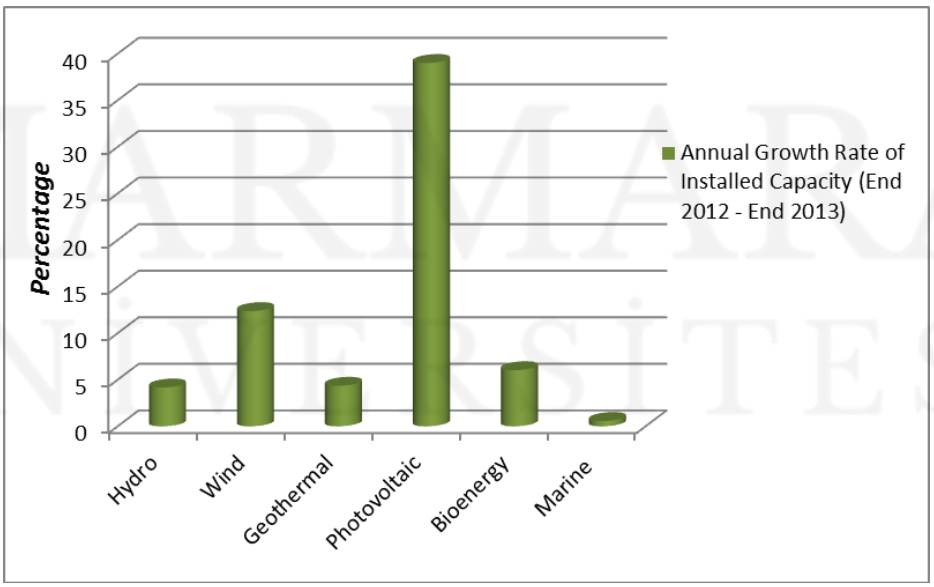


Figure 1. Annual growth rate of different renewable energy technologies

Availability Issues

Renewable energy systems may be the key for sustainable energy production, but it is important to assess the availability of renewable sources for the specific area, on which a renewable system is planned to be installed. The availability of renewable sources can be challenging to be evaluated, which requires

many different factors to consider such as the weather conditions and the potential amount of specific sources. One of the most comprehensive researches related with this issue is undertaken by Dimakis et al [9]. This research introduces new strategies and tools for determining the availability of different renewable sources that may be useful for investors.

There is a difference between the installed capacity of any power plant and the actual output provided by this plant. This difference is defined as the capacity factor and plays a major role for power plant assessments. Although different factors may affect the capacity factor, the main determinants for renewable energy systems are availability issues. For instance, it is only possible for solar panels to operate, if the sun shines. As stated by Wilson [10], the capacity factors of solar systems are approximately 10% in Germany and 20% in the state of Arizona depending on the amount of received solar radiation. This clearly demonstrates the importance of the location of the area for renewable systems.

Energy Costs

Renewable energy systems are generally considered to have high initial costs, which is the main constraint for large-scale development of these systems. Thus, estimating the costs of such systems is a must for assessing technologies in terms of sustainability. In order to achieve this objective, comparing the capital costs and when possible levelized energy costs of different technologies gives the most appropriate results [11].

The power obtained by renewable energy technologies is highly dependent on factors such as the location of the site and the weather conditions, which lead to wide range of costs among different technologies. It is a fact that the maturity of the technology also plays a role in terms of the levelized energy costs. It is expected that the money spent for research and development of a technology is proportional with the maturity level of that technology. This means an increase of efficiency and a decrease of capital and/or operating costs comparing to the early phase of that technology. Another advantage of mature technologies is being more reliable. Proven technologies are generally preferred among investors in order to avoid the risks of unexpected results. It is also an important point that providing financial support as a government policy for research and development costs as well as providing incentives for investors accelerates the development of different technologies [12].

Land Requirements

Land use requirement for renewable energy production is an important factor, since the land available can be used for any other purpose that may be more profitable for the investor. Thus, considering area requirements is necessary to assess the sustainability indicators for renewable energy technologies. An efficient way to show the efficiency of land requirements for different systems is to indicate the area that is needed to generate 1 kW of power, which can be expressed as m^2/kW.

Troldborg, Heslop and Hough [13] state that area requirements of specific technologies can vary from site to site due to various factors including land topography, weather conditions and the size of the system to be installed. There are also opportunities for dual land use. For example, using roof-integrated solar systems or installing wind turbines in agricultural lands reduces the need for extra space. The capacity of the system also plays a role by determining land requirements, since substations, access roads and any other relevant infrastructure necessary for power generation requires extra land. Therefore, small capacity power stations are generally less land efficient compared to high capacity ones. An example for this claim is provided by the research of Ong et al [14]. This research takes 192 different photovoltaic projects located in US into consideration. It is observed that photovoltaic power plants, which have a capacity between 1 MW and 20 MW requires 5 to 18% more land compared to the ones, which have a capacity more than 20 MW.

The laws of nature are also important while considering land requirements for different technologies. Although solar panels become more and more efficient to capture the solar energy, sun's rays are highly dispersed which increases the need for land in the case of solar technologies. On the other hand,

geothermal technologies generally require less land, since large volumes of hot water or rock required is located underground. Therefore, they are generally indicated as one of the most efficient renewable energy technologies in terms of land occupation [15].

Carbon-dioxide Emissions

Carbon-dioxide (CO_2) is the most significant greenhouse gas, which is claimed to be the main determinant responsible for global warming. According to ASME [16], 65% of greenhouse gas emissions are linked with energy related activities. Thus, reducing CO_2 emissions must be a priority for investors, who are planning to finance new power plant projects. Negligible amounts of CO_2 are released into the environment during operation of most of the renewable energy technologies. However, it doesn't mean that they don't play a role in CO_2 emissions. Life-cycle analysis, which is the main tool for determining the carbon-footprint of any system, can be used to evaluate the role of renewable technologies [17].

Life-cycle analyses show that renewable energy technologies are responsible for a far smaller amount of CO_2 emissions compared to other conventional methods except nuclear energy. Based on a recent research [18], nuclear energy is a competitive alternative to renewable technologies in terms of CO_2 emissions. This research also shows that nuclear, wind and solar technologies together are responsible for 20 times less greenhouse gas emissions per kWh than coal fired power plants.

CO_2 emissions of different technologies are quantitative factors that can be compared. By considering major quantitative sustainability indicators of renewable energy technologies, comparisons have been performed. These comparisons are indicated in table 1, which are based on a number of studies [13, 17, 19, 20]. For the comparisons of CO_2 emissions, land requirements and capital costs, maximum and minimum values, which are observed in different projects, are used. Data for the year 2011 is used for the total power generated from different renewable technologies.

Table 1. Major quantitative sustainability indicators for renewable energy technologies

Renewable technology	Total electricity generation (TWh)	CO_2 emissions (g CO_2 / kWh)	Land requirements (m^2 / kW)	Capital costs ($/ kW)
Hydro	3490	2 - 74.9	10 - 6500	750 - 6000
Wind	434	5.3 - 123.7	10 - 1200	925 - 6040
Geothermal	424	11 - 78	20 - 1000	1900 - 5500
Photovoltaic	69	9.4 - 300	10 - 500	1200 - 3800
Bioenergy	61	14.4 - 650	1000 - 6000	500 - 6500
Marine	2	10 - 50	10 - 300	5290 - 5870

It is observed that hydro-power is the main locomotive for power generation and marine technologies are still in an early stage of their development. However, maximum observed land requirement for marine technologies is less compared to the one for hydro-power.

Social Impacts & Acceptance

It is a fact that assessing social impacts of renewable energy technologies is as important as assessing the environmental and economic effects [21-23]. In order to assess social impacts, social acceptance of different technologies must be identified [24]. Thus, a comprehensive research on social acceptance is a must.

As stated by D'Souza and Yiridoe [25] "To be socially acceptable requires positive attitudes and feelings towards an object or issue under consideration". Therefore, positive attitude towards renewable energy technologies is definitely necessary. Cohen, Reichl and Schmidthaler [26] underline the observation of local opposition to some of renewable energy projects despite the fact that people are willing to use power generated by this kind of technologies. On the other hand, it is also stated that there are researches which show high levels of public support towards those projects. Based on these facts, assessing social acceptance of renewable energy technologies is not a simple task [13]. In table 2, studies by different

researchers about various reasons of why people accept or don't accept renewable energy technologies are demonstrated.

Table 2. Positive and negative outcomes of renewable energy technologies from different studies

Study	Negative outcomes	Positive outcomes
[26]	- Diminished viewsheds - Landscape intrusion - Ecosystem disturbance - Technical issues such as repair work - Decreased recreational opportunity and safety concerns (especially for wind farms) - Watershed damage - Noise and pollution during construction	- Greenhouse gas reduction - Decreased fossil fuel dependence - Place distinctiveness - Possible economic benefits - Energy supply security
[25]	- Concerns about potential changes in land scape - Visual aesthetics problems - Excess noise - Lack of transparency about future projects - Bias against some renewable technologies	- Economic development and growth - Contribution for creating employment opportunities - Population growth in some rural areas
[27]	- Maturity issues for some technologies - Environmental degradation - Damages suffered by the maritime storms	- Growth in local tourism - Use of a local generated energy - Economic benefits for locally-established installations,
[28]	- Economic risks (uncertainty of feasibility) - Unproven technology	- Decreasing electricity costs - Improvement on human health
[29]	- Problems about (public or private) ownership - Lack of financial incentives - High investment costs compared to installations relying on the combustion of conventional fuels - Inefficiencies in the existing legal framework and bureaucratic problems or complex licensing - Technical complexities such as local geography - Problems for the selection of an appropriate application site - Lack of impartiality and suspicion towards investors	- Monetary benefits for nearby communities, - Economic boost to the entire region - Reliable energy supply
[30]	- Additional cost for raising the level of consumption of green electricity	- The impression of being clean, green and having low negative environmental impacts
[31]	- Sleep disruption and psychological distress	
[32]		- Have little or no negative impacts on residential property values

NIBMY (not in my backyard) is a popular term which is used to refer the resistance to a project that is unwanted by the local community due to potential economic losses and social conflict issues. On the contrary, the term PIMBY (please in my backyard) is used for neighboring communities, which consider the projects as opportunities for gaining economic, environmental and social benefits. These phenomena must be evaluated for assessing social acceptance [29].

Before starting to a renewable project, it is useful for investors to take studies performed on the issues of social acceptance into account. Table 3 demonstrates different researches, which are carried out to assess social acceptance. This table is created mostly based on the study of Heras-Saizarbitoria, Zamanillo and Laskurain [27].

Table 3. Different researches on social acceptance

Study	Country	Methodology	Aim of the research	Main results
[27]	Australia	Participatory action research	Investigating the social acceptance of geothermal technologies	Despite the limited understanding of geothermal technologies, they receive general support due to increasing popularity of renewable energy systems
[27]	Spain	Various participatory techniques	Assessing social acceptance of wind farm location	Main factors for local conflicts and opposition to wind farms are about the extensive land use and negative visual impacts
[33]	Australia	Face-to-face interviews	Studying the reasons of resistance to wind power and wind farms	Four common themes emerged that restrain the social acceptance of wind farms: Trust, distributional justice, procedural justice and place attachment
[27]	China	Survey questionnaire	Investigating social acceptance of solar energy technologies	High level of social acceptance for solar thermal technologies and low level of social acceptance for solar photovoltaic technologies are observed
[27]	Turkey	Survey questionnaire	Analyzing the level of understanding what clean energy means	The concept of clean energy is understood to a certain degree but more knowledge is required to foster social acceptance
[25]	Australia	Survey questionnaire	Evaluating predictor importance of key constructs in terms of social acceptance	Investing in consumer confidence is beneficial for social acceptance and a must for the widespread adoption of new renewable technologies
[27]	China	Survey questionnaire	Examining social acceptance of renewable energy installations in rural areas	Rural residents generally support renewable energy developments
[21]	Finland	Survey questionnaire	Investigating social acceptance towards renewable energy technology deployments in Finland	62% of all participants are willing to pay extra for using green energy and about 52.4% of all participants think that most of the investments in renewable energy must be carried out by public sector
[27]	Ethiopia	Face-to-face interviews	Assessing social acceptance of small photovoltaic systems for rural electrification	People think that photovoltaic systems have positive effects on family life and public security

Conclusions & Recommendations

Renewable energy systems are considered to be one of the most important technologies for achieving sustainable development goals. Many governments, companies and individual investors from all over the

world are interested in investing renewable technologies not just for gaining long term economic advantages but also contributing to worldwide sustainability efforts. The popularity of renewable energy technologies will definitely continue, if potential investors are encouraged to invest in renewable energy technologies. Therefore, studies for determining sustainability indicators play a significant role.

Increasing carbon-footprint is an emerging issue, which is seriously dealt in developed countries by taking different measures such as increasing taxes for energy consumption generated from fossil fuel plants or providing incentives for consumers who have invested in renewable technologies for providing some or all of their energy needs. Furthermore, development and research efforts for these technologies cause a decrease of initial costs. These are important factors, which make renewable energy systems an attractive investment tool.

In terms of social acceptance and impacts, every technology has its own problems and benefits, which must be seriously considered. It is necessary to propose solutions, in which perceived advantages of renewable technologies to local people are increased and negative impacts caused by those systems to local people are decreased. It is vital to improve the knowledge of general public about the potential advantages of renewable energy technologies and why brave steps must be taken in order to solve worlds' urgent problems such as CO_2 emissions. These actions can definitely change the opinion towards these technologies in a positive way.

For further research, multi-criteria analyses can be carried out in order to assess and compare the sustainability of different renewable energy technologies. This can provide the optimum solutions for deciding on the technology to be used on a specific area. It may be also useful to include concentrated solar power technology, which is considered to be a new and promising renewable technology for generating power.

To conclude, renewable energy technologies are becoming progressively popular each day. However, its share among the global energy production is still very small. Therefore, supporting worldwide efforts for increasing the share of renewable energy technologies in the global energy mix is very important. Renewable energy is a reliable key source for energy generation, which is capable of meeting the world's total energy demand and an excellent opportunity to provide innovative solutions to unsustainable problems.

References

[1] Kuhlman, T., Farrington, J., 2010, What is sustainability?, *Sustainability*, 2(11), 3436-3448.
[2] United Nations, 1987, *Report of the World Commission on Environment and Development: Our Common Future*. [online] Available at: http://www.un-documents.net/our-common-future.pdf [Accessed 18 November 2014].
[3] Strange, T., Bayley, A., 2008, *Sustainable Development: Linking Economy, Society, Environment, OECD Insights*, OECD, Paris.
[4] Pesonen, H.L., 2001, Environment management of value chains: Promoting life-cycle thinking in industrial networks, *Greaner Management International*, 33, 45-58.
[5] Siemens, 2014, *Sustainable Energy in the U.S.* [online] Available at: http://www.usa.siemens.com/sustainable-energy/ [Accessed: 18 November 2014].
[6] Zhou, M., 2013, *World Energy Consumption to Increase 56% by 2040 Led by Asia*. [online] Available at: http://www.bloomberg.com/news/2013-07-25/world-to-use-56-more-energy-by-2040-led-by-asia-eia-predicts.html [Accessed: 20 November 2014].
[7] Renewable Energy Policy Network for the 21st Century (2014) *Renewables 2014 Global Status Report*. [online] Available at: http://www.ren21.net/Portals/0/documents/e-paper/GSR2014KF/index.html#/22 [Accessed: 20 November 2014].
[8] U.S. Energy Information Administration, 2011, *World Energy Outlook*. [online] Available at: http://www.iea.org/publications/freepublications/publication/weo2011_web.pdf [Accessed: 20 November 2014].
[9] Dimakis, A.A., Biberacher, B., Dominguez, J., Fiorese, G., Gadocha, S., Gnansounou, E., Guariso, G., Kartalidis, A., Panichelli, L., Pinedo, I., Robba, M., 2011, Methods and tools to evaluate the availability of renewable energy sources, *Renewable and Sustainable Energy Reviews*, 15(2), 1182-1200.
[10] Wilson, R., 2013, *Low Capacity Factors: challenges for a low carbon energy transition*. [online] Available at: http://theenergycollective.com/robertwilson190/288846/low-capacity-factors-challenge-low-carbon-energy-transition [Accessed: 21 November 2014].

[11] Ouyang, X., Lin, B., 2014, Levelized cost of electricity (LCOE) of renewable energies and required subsidies in China, *Energy Policy*, 70, 64-73.
[12] Salvatore, J., 2013, "World Energy Perspective" in Turner, G., Nekhaev, E., Clerici, A., Ulreich, S. (Eds.), *Cost of Energy Technologies*, World Energy Council, London.
[13] Troldborg, M., Heslop, S., Hough, R., 2014, Assessing the sustainability of renewable energy technologies using multi-criteria analysis: Sustainability of approach for national-scale assessments and associated uncertainties, *Renewable and Sustainable Energy Reviews*, 39, 1173-1184.
[14] Ong, S., Campbell, C., Denholm, P., Margolis, R., Heath, G., 2013, *Land-Use Requirements for Solar Power Plants in the United States*, NREL, Denver.
[15] Tabak, J., 2009, *Energy and the Environment: Solar and Geothermal Energy*, Infobase, New York.
[16] ASME, 2009, *Technology and Policy Recommendations and Goals for Reducing Carbondioxide Emissions in the Energy Sector*. [online] Available at: http://files.asme.org/asmeorg/NewsPublicPolicy/GovRelations/PositionStatements/17971.pdf [Accessed: 22 November 2014].
[17] Amponsah N., Y., Troldborg, M., Kington, B., Aalders, I., Hough R.L., 2014, Greenhouse gas emissions from renewable energy sources: A review of lifecycle considerations, *Renewable and Sustainable Energy Reviews*, 39, 461-475.
[18] NREL, 2013, *Life Cycle Greenhouse Gas Emissions from Electricity Generation*. [online] Available at: http://www.nrel.gov/docs/fy13osti/57187.pdf [Accessed: 26 November 2014].
[19] U.S. Energy Information Administration, 2013, *World Energy Outlook*. [online] Available at: http://www.worldenergyoutlook.org/media/weowebsite/2013/WEO2013_Ch06_Renewables.pdf [Accessed: 20 November 2014].
[20] Evans, A., Strezov, V., Evans, T.J., 2009, Assessment of sustainability indicators for renewable energy technologies, *Renewable and Sustainable Energy Reviews*, 13, 1082-1088.
[21] Moula, M., Moula, J., Hamdy, M., Fang, T., Jung, N., Lahdelma, R., 2013, Researching social acceptability of renewable energy technologies in Finland, *International Journal of Sustainable Built Environment*, 2, 89-98.
[22] Sauter, R., Watson, J., 2007, Strategies for the deployment of micro-generation: Implications for social acceptance, *Energy Policy* 35(5), 2770-2779.
[23] Wüstenhagen, R., Wolsink, M., Bürer, M.J., 2007, Social acceptance of renewable energy innovation: An introduction to the concept, *Energy Policy*, 35(5), 2683-2691.
[24] Batel, S., Devine-Wright, P., Tangeland, T., 2013, Social acceptance of low carbon energy and associated infrastructures: A critical discussion, *Energy Policy*, 58, 1-5.
[25] D'Souza, C., Yiridoe, E.K., 2014, Social acceptance of wind energy development and planning in rural communities of australia: A consumer analysis, *Energy Policy*, 74, 262-270.
[26] Cohen, J.J., Reichl, J., Schmidthaler, M., 2013, Re-focussing research efforts on the public acceptance of energy infrastructure: A critical review, *Energy*, 76, 4-9.
[27] Heras-Saizarbitoria, I., Zamanillo, I., Laskurain, I., 2013, Social acceptance of ocean wave energy: A case Study of an OWC shoreline plant, *Renewable and Sustainable Energy Reviews*, 27, 515-524.
[28] Romanach, L., Carr-Cornish, S., Muriuki, G., 2014, Societal acceptance of an emerging energy technology: How is geothermal Energy portrayed in Australian media?, *Renewable and Sustainable Energy Reviews*, 42, 1143-1150.
[29] Stigka, E.K., Paravantis, J.A., Mihalakakou, G.K., 2014, Social acceptance of renewable energy sources: A review of contingent valuation applications, *Renewable and Sustainable Energy Reviews*, 32, 100-106.
[30] Lim, X., Lam, W., 2013, Public acceptance of marine renewable energy in Malaysia, *Energy Policy*, 65, 16-26.
[31] Bakker, R.H., Pedersen, E., Van Den Berg, G.P., Stewart, R.E., Lok, W., Bouma, J., 2012, Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress, *Science of The Total Environment*, 425, 42-51.
[32] Sterzinger, G., Beck, F., Kostiuk, D., 2003, *The Effect of Wind Development on Local Property Values*, Renewable Energy Policy Project, Washington, D.C.
[33] Hall, N., Ashworth, P., Devin-Wright, P., 2013, Social acceptance of wind farms: Analysis of four common themes across Australian case studies, *Energy Policy*, 58, 200-208.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Green Marketing and Advertising: A Path to Sustainability

Koray Altıntaş [1], *Emine Çobanoğlu* [2]

Abstract

In a world where sustainability becomes more and more important, the significance of purchasing environmentally friendly products is increasing rapidly. Green marketing and advertising may be a key tool in order to achieve sustainable development. This paper focuses on the effectiveness of marketing and selling green products by targeting environmentally sensitive target market. Different factors, which may have an influence on the effectiveness of this strategy, are discussed in the paper. Various examples and applications, potential challenges, current status and future prospects of green advertising and some other segments of green marketing are also presented. The discussions reveal various aspects that may be helpful for determining green advertising strategies for companies which can provide environmentally friendly and socially responsible products and services. It is concluded that green marketing is an effective strategy when applied correctly, which can be a major factor for encouraging companies to boost their sustainability efforts. Based on this paper, further research can be done on examining deceptive green advertising in terms of ethical issues as well as long-term negative impacts on company's image and public perception of green products.

Keywords: Environmental Consciousness, Green Advertising, Green Marketing, Green Product

[1] Koray Altintas, Marmara University, Engineering Faculty, Department of Engineering Management, Istanbul, Turkey, korayaltintas@marun.edu.tr
[2] Emine Cobanoglu, Marmara University, Business Administration Faculty, Department of Business Administration (English), Istanbul, Turkey, ecobanoglu@marmara.edu.tr

Introduction

Since the late 1960s, public awareness towards the environment has increased significantly due to major environmental issues such as the global warming, pollution, loss of biodiversity, deforestation and overpopulation. Increased concerns for the environment have caused a demand for environmentally friendly products all around the World. Moreover, companies face pressure from society and stakeholders to decrease their environmental impacts. As indicated by Pesonen [1], this is one of the impelling factors for firms to determine sustainability targets in order to reach not only environmental but also economic and social targets for staying competitive in the market as well as contributing to sustainable development efforts globally performed. Therefore, brave steps across the entire value chain must be taken in order to reach this target, which can be challenging especially due to high initial costs.

In order to achieve the environmental sustainability targets, green marketing provides promising opportunities for business firms and organizations to reduce their environmental impacts and to supply eco-friendly products for their customers. The increase in the number of consumers, who believe that human kind may experience a major ecological catastrophe in a very close future, can incite green market revolution. If this trend continues, it is a high possibility that most of the products available in the market will be replaced by green products, which have less negative effects on environment. It is also important that environmentally conscious people must be willing to pay more for a green product compared to the non-green equivalent assuming all other features of two products are the same [2].

The main objective of this study is to identify environmental consciousness market segments, environmentally friendly consumer behavior and attitude towards green products in order to determine useful strategies for green marketing and advertising. This is done by analyzing the data collected from the available literature and the survey, which is conducted online.

Literature Review

Green Marketing

According to American Marketing Association [3], green marketing is defined as “The efforts by organizations to produce, promote, package, and reclaim products in a manner that is sensitive or responsive to ecological concerns”. This definition indicates that green marketing is not just about providing green products but also making modifications on processes, pricing, packaging and other related activities of the organization.

Green marketing is an opportunity for firms and organizations to achieve business growth. Although making alterations in the activities of an organization may cause high capital costs, high profits can be achieved in long-term. Furthermore, consumers may also save money by using green products. For example installing building-integrated renewable energy systems may have a high initial cost, but it is an important investment for future cost savings. It is a fact that companies, which are focused on providing environmentally friendly products or services, may increase their shares in green market. This can provide them a competitive advantage over their competitors besides increasing their profits [4].

Green Advertising

With respect to Omidnateghkho [5], green advertising is defined as “social marketing efforts by companies to promote a product or service from a medium green lifestyle and enhance the image of his company uses environmental activities”. Green advertising can be considered as one of the green marketing tools which aim to increase the environmental awareness and the attractiveness of green products. The increase of public awareness towards environmental issues is also an opportunity for business firms to use advertisement strategies targeting environmentally conscious people.

Green advertisements generally consist of three main parts. The first step is introducing the environmental issue, which must be considered seriously. The second step is demonstrating the actions that the company performed in order to compete with this issue and the last step is about representing the results of those actions [6].

Environmental Consciousness

Environmental consciousness is a vital factor for target market in order to apply successful green marketing and advertising strategies. Many studies and researches from all over the world indicate that people are generally concerned about the environmental issues and think that precautions must be taken as soon as possible in order to avoid from their possible consequences. According to Purohit [7], 80% of adults are concerned about the negative impacts of consuming societies on environment and think that radical changes in current-lifestyles are definitely required for protecting the environment.

The increase and decrease of the ratio of people, who are concerned about the environmental problems, is also an important factor for business firms in order to evaluate the future of green marketing. The survey undertaken by National Geographic [8] indicates that in 2012, 56% of participants from different countries around the world were very concerned about the environmental issues, which is 61% in 2014.

Although researches indicate that consumers are aware of the environmental problems, it doesn't mean that all of them behave environmentally friendly. This can be supported with the findings of the survey by World Wide Fund for Nature [9]. The results show that 69% of total participants have been separating their waste for recycling, despite the fact that 92% of them are aware of environmental problems and paying attention to environmental activities. This leads to the result that environmental consciousness is proportional with environmentally friendly behavior, but the ratio of environmentally friendly behavior is less compared to environmental consciousness [10].

Challenges

There are several challenges faced by businesses, which use green marketing strategies. One of the issues is about the high manufacturing costs for green products. For instance, the manufacturing products consisting of recycled materials or products that use less energy or water compared to traditional ones generally require huge investment in new technologies [11]. Changing the activities of a firm such as using environmental management systems or minimizing waste production may also increase costs dramatically [12].

Dhar and Das [13] underline the importance of trust by consumers towards green products, since the issue of lack of credibility by consumers is another problem faced by companies. This is mainly a result of deceptive environmentally marketing claims used by some of them. With respect to Cone [14], 71% of consumers would stop buying the product, if they find out that announced environmental claims of that product not to be true. This can start skepticism among consumers towards any other green product.

Although it is generally agreed that green products are more expensive than traditional ones, there is no consensus among researchers on the willingness of consumers to pay extra for environmentally friendly products. Dhar and Das [13], Steht and Steht [11] and Unruh [15] state that most of the consumers are willing to pay the same price for environmentally friendly products compared to regular ones. The research conducted by IPSOS [16] supports those claims. According to this research only 38% of the participants would pay a premium for environmentally friendly products. On the other hand, the research conducted by Rao [17] indicates that consumers tend to pay more for green products. It is stated that 34% of the participants strongly agree and 31% of the participants agree to the claim "I am ready to bear extra cost for green products". There are also researches, which demonstrate that people would definitely pay more, but not so much. This can be supported with the research of McKinsey & Company [18] that demonstrates 70% of 2000 participants are willing to pay up to 5% for green products. It is also indicated that less than 10% of those customers would pay more than 25%.

Current Status and Future Prospects

Many companies have already begun to use green marketing policy for achieving their sustainability objectives as well as their profit objectives. With respect to Steht and Steht [11], many international high-valued companies from different sectors have already made investments to recycling programs, waste management systems and technologies to go green for their activities and produce environmentally

friendly products and services. This plays an important role to provide the stimulus for other companies to make necessary investments for using green marketing strategies. Lampe and Gazda [19] indicates that in a world where sustainability and going green gains popularity within the media, an increase of public awareness is expected.

Research Methodology

In this paper, an online survey has been conducted in November 2014 for determining the level of environmental consciousness, environmentally friendly behavior and the attitude towards green products. It is also aimed to measure the importance of green marketing and green products for evaluating their current status. Three different kind of five point Likert scales are used ranging from 5 (strongly agree / always / concerned) to 1 (strongly disagree / never / unconcerned). In addition to that, there are also questions for determining what people understand from "green products" and how much they would pay extra for them compared to traditional ones. The sample consists of 75 different respondents from different countries and nationalities (convenience sampling technique has been adopted by the researcher). It is observed that the participants are mostly well educated young people. Only descriptive statistics have been used in this study.

Results & Discussions

Environmental Issues & Environmental Friendly Behavior

As mentioned before, peoples' concern for environmental issues is one of the main factors which accelerate the demand for green products. Thus, participants are asked to indicate the level of concern for some of the major environmental issues. The results are shown in table 1. It has been found out that the pollution is determined as the major environmental problem faced by human kind. It is also indicated that participants are highly concerned for deforestation. Moreover, observed low standard deviation demonstrates that the data points tend to be close to the mean.

Table 1. The level of concern for some of the major environmental issues based on Likert scale ranging from 5 (concerned) to 1 (unconcerned)

Please rate your level of concern on each of the following environmental issues:	Mean score	Standard deviation
Overpopulation	4.24	0.95
Global warming	4.43	0.82
Deforestation	4.51	0.77
Loss of biodiversity	4.07	0.90
Bio-engineered food	3.79	0.94
Waste disposal	4.23	0.84
Pollution	4.56	0.73

It has been agreed that the success of green marketing strategies is related with the environmentally friendly behavior; therefore asking questions to reveal the level of green behavior among participants are necessary. In order to achieve this objective, different questions have been asked regarding with the contribution of various kinds of efforts which aim to reduce environmental impacts. With respect to table 2, it is observed that the mean scores of activities 1 and 2 are the highest among others. Activity 1 is also an indicator for conservation behavior and activity 2 is an indicator for pollution avoidance behavior. It was provided that major environmental concerns are pollution and deforestation by the previous table. This supports the claim that the type of environmentally behavior is related with the concern level of the environmental issue.

Table 2. Environmentally friendly activities based on Likert scale ranging from 5 (always) to 1 (never)

How frequently do you do following activities?	Mean score	Standard deviation
1. I separate bottles, cans, paper or plastic for recycling instead of throwing them away.	3.89	1.10
2. I use my own personal bag or reusable bags instead of plastic bags for shopping.	3.36	1.34
3. I use cooler, air conditioners, fans, lights, etc., as little as possible.	3.45	1.11
4. I refrain littering even if no trashcan/dustbin available.	3.89	1.11
5. I take steps to be informed about environmental issues.	3.47	1.05
6. I influence others behave in environmentally friendly manner.	3.61	1.02
7. I receive e-bills instead of printed version of consumer bills a major ecological catastrophe.	3.16	1.40

Green Products & Green Marketing

Providing green products is an important segment of green marketing strategies. Therefore, participants are asked to type, what they understand by the term "green product". Unlike the other questions, this is not a mandatory question, which is responded by 67 participants out of 75. It is observed that the words "environmentally friendly or eco-friendly" have been used in 21 out of 67 answers for describing what green products are. Based on the responses of participants, it is widely accepted that green products have less environmental impacts. Only one of the respondents defined the green product as a marketing scam.

The results of the question about determining the characteristics of green products are provided in table 3. It is observed that the mean scores of different answers are close to each other and the perception to be green is mostly related with consisting of recycled materials. The results represented in table 4, clearly demonstrates that green products are accepted as environmentally friendly products among participants. Moreover, it is mainly agreed that investing in green strategies is beneficial for firms and companies. However, the majority think that green products are overpriced, which is an important point that must be taken into account seriously.

Table 3. The characteristics that make products green based on Likert scale ranging from 5 (strongly agree) to 1 (strongly disagree)

What are the characteristics that make products green?	Mean score	Standard deviation
1. Contain recycled materials	4.28	0.83
2. Contain organic materials	4.05	0.89
3. Use less energy to produce	4.15	0.96
4. Require less energy to operate	4.09	0.95
5. Use less water to produce	3.89	0.97
6. Require less water to operate	3.88	0.35

Table 4. The statements for green marketing based on Likert scale ranging from 5 (strongly agree) to 1 (strongly disagree)

Listed below are statements about the green products. Please indicate the degree to which you agree with each item.	Mean score	Standard deviation
1. Green products are overpriced	3.63	0.95
2. Going green is a beneficial investment in long-run	4.23	0.69
3. Green products are real ecological need	4.20	0.77
4. Lack of availability/unease of access is a major reason for low popularity and demand of green products	3.64	0.90

Paying a Premium for Green Products

The question whether green consumers are willing to pay extra for green products, couldn't be answered according to the data collected from available literature. Therefore, the question of "How much extra would you be willing to pay for a green product assuming all other features of two products same?" has

been provided to participants in order to clarify this issue. Figure 1 shows the answers given by participants. More than 60% of the consumers are willing to pay up to 10% and only approximately 20% of them would pay more than 25%. The results obtained from this question are similar to the findings of the research undertaken by McKinsey & Company [18]. It is concluded that consumers generally would like to pay slightly more for environmentally friendly products (the average is 8.33%), which is more or less the same price. Therefore, the claims provided by Dhar and Das [13], Steht and Steht [11] and Unruh [15] are proven to be true to a certain degree.

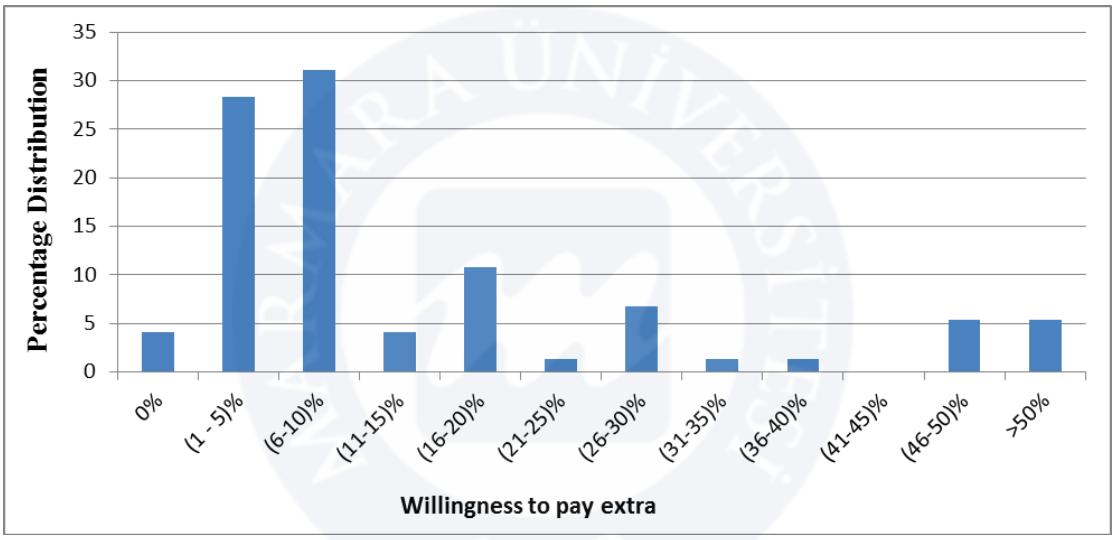


Figure 1. Willingness to pay extra

Environmental Consciousness

New Ecological Paradigm (NEP) is a popular tool among researchers that is used to determine the level of awareness towards environment and nature. It consists of fifteen statements, which is demonstrated in table 5 [20]. Agreement to odd number statements and disagreement to even number statements are determined as pro-NEP answers. The scores obtained from even numbers are revised in table 5. Therefore, higher scores for all of the questions indicate pro-NEP behavior.

Table 5. Pro-NEP response level for each question ranging from 5 (high NEP response) to 1 (poor NEP response)

Listed below are statements about the relationship between humans and the environment. Please indicate the degree to which you agree with each item.	Mean score	Standard deviation
1. We are approaching the limit of the number of people the Earth can support.	3.67	0.94
2. Humans have the right to modify the natural environment to suit their needs.	3.25	1.23
3. When humans interfere with nature it often produces disastrous consequences.	3.97	0.85
4. Human ingenuity will insure that we do not make the Earth unlivable.	2.79	1.06
5. Humans are seriously abusing the environment.	4.11	0.90
6. The Earth has plenty of natural resources if we just learn how to develop them.	1.96	0.93
7. Plants and animals have as much right as humans to exist.	4.48	0.74
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.	3.44	1.20
9. Despite our special abilities, humans are still subject to the laws of nature.	4.11	0.84
10. The so-called “ecological crisis” facing humankind has been greatly exaggerated.	3.43	1.13
11. The Earth is like a spaceship with very limited room and resources.	3.45	1.11
12. Humans were meant to rule over the rest of nature.	3.40	1.31
13. The balance of nature is very delicate and easily upset.	3.64	0.99
14. Humans will eventually learn enough about how nature works to be able to control it.	2.91	1.10
15. If things continue on their present course, we will soon experience a major ecological catastrophe.	4.16	0.91

Conclusions & Recommendations

Green marketing can be a very effective tool for achieving long term profit due to increasing demand for green products. Moreover, making changes in the activities of a company to achieve desired sustainability targets also contribute to this objective. Therefore, it is important to use correct strategies for green marketing in order to reach the target market.

Determining the target market is the most important step for performing correct strategies. Consumers, who are environmentally conscious, are the potential customers of green products. Therefore, companies must use green advertising strategies for increasing the level of consciousness towards environment and encourage people to take actions for protecting it. The advertising policy of being informative rather than deceptive must be used in order to be successful. Otherwise, the company image can be damaged, which possibly leads to a decrease on the demand of any product that company provides.

The opinion towards green products plays a major role for green marketing. According to the collected data, consumers think that green products are overpriced. This seems to be one of the factors, which discourage potential customers to buy green products. The perception of being unfairly priced must be changed by determining the right price policy and persuading customers that the prices are fair. However, there may be examples, in which even the fair price policy doesn't work. The results achieved in this study show that people only are interested paying slightly more (which is found out to be about 8%) for green products and most of the data collected from available literature also supports that claim. It is a possibility that the fair price of a green product is higher than its alternative due to high manufacturing costs. In that case, it is important to find ways for reducing the price to a certain degree, which can be economically competitive against non-green alternatives.

For further research, different analyzing methods such the factor analysis can be used for reducing the data provided by New Ecological Paradigm scale to determine similar patterns for responses. This can be only achieved with a greater sample size. It may be also useful to make detailed studies why customers are willing to pay slightly more, although they think that green products are overpriced. In addition to these, examining and assessing deceptive green advertising in terms of ethical issues as well as long-term negative impacts on company's image and public perception of green products is also a useful research topic for future.

To conclude, the level of being environmental conscious and behaving environmentally friendly is high among societies. However, this doesn't assure the success of green marketing. The relationship between environmental awareness and green behavior must be assessed and analyzed seriously. Furthermore, avoiding higher price policy as well as deceptive marketing and using the correct method for communicating with potential customers plays a major role to be successful.

References

[1] Pesonen, H.L., 2001, Environment management of value chains: Promoting life-cycle thinking in industrial networks, *Greaner Management International*, 33, 45-58.
[2] Awan, U., 2011, Green marketing: Marketing strategies for the Swedish energy companies, *International Journal of Industrial Marketing*, 1(2), 1-19.
[3] American Marketing Association, 2014, *Dictionary*. [online] Available at: https://www.ama.org/resources/Pages/Dictionary.aspx?dLetter=G [Accessed: 13th November 2014].
[4] Mohanasundaram, V., 2012, Green marketing - Challanges and opportunities, *International Journal of Multidisciplinary Research*, 2(4), 66-73.
[5] Omidnateghkho, S., 2012, Green advertising, a new approach to generate wealth, *Interdisciplinary Journal of Contemporary Research in Business*, 4(7), 223-229.
[6] Delafrooz, N., Taleghani, M., Nouri, B., 2014, Effect of green marketing on consumer purchase behavior, *QScience Connect*, 1(5) [e-journal] Available at: http://www.qscience.com/doi/abs/10.5339/connect.2014.5201 4(1) [Accessed: 16th November 2014].
[7] Purohit, H.C., 2011, Consumer perception, attitudes and awareness of green products: A study of consumer goods, *International Journal of Economic and Political Integration*, 1(1), 45-53.

[8] National Geographic, 2014, *Increased Fears About Environment, but Little Change in Consumer Behavior According to New National Geographic/GlobeScan Study*. [online] Available at: http://press.nationalgeographic.com/2014/09/26/greendex/ [Accessed: 14 November 2014].
[9] World Wide Fund for Nature, 2011, *WWF survey reveals major reasons for non-green behaviour among big city Chinese netizens*. [online] Available at: http://en.wwfchina.org/?3800/WWF-survey-reveals-major-reasons-for-non-green-behaviour-among-big-city-Chinese-netizens [Accessed: 17 November 2014].
[10] Honabarger, D., 2011, *Bridging the Gap: The Connection Between Environmental Awareness, Past Environmental Behavior, and Green Purchasing*, M.A. American University. Available at: https://www.american.edu/soc/communication/upload/Darcie-Honabarger.pdf [Accessed: 17 November 2014]
[11] Sheth, K. and Sheth, P., 2012, Role of green marketing in current scenario, *Arth Prabandh: A Journal of Economics and Management*, 1(3). [e-journal] Available at: http://prj.co.in/setup/business/paper18.pdf [Accessed: 15 November 2014].
[12] Li, H., Cai, V., 2008, Green marketing and sustainable development of garment – A game between cost and profit, *International Journal of Business and Management*, 3(12), 81-85.
[13] Dhar, P., Das, S., 2012, Green marketing: Challanges & opportunities for innovation and sustainable development, *International Journal of Marketing, Financial Services & Management Research*, 1(5). [e-journal] Available at: http://indianresearchjournals.com/pdf/IJMFSMR/2012/May/6_IJM_MAY12.pdf [Accessed: 15 November 2014].
[14] Cone (2011) "Nearly three-quarters of consumers (71%) will stop buying a product if they feel misled by environmental claims". [online] Available at: http://www.conecomm.com/stuff/contentmgr/files/0/2b06eda8bc17be5d656bfda12c153dd7/files/2011_cone_green_gap_trend_tracker_press_release_and_fact_sheet_final.pdf [Accessed: 16 November 2014].
[15] Unruh, G., 2011, *No, Consumers will not pay more for green*. [online] Available at: http://www.forbes.com/sites/csr /2011/07/28/no-consumers-will-not-pay-more-for-green/ [Accessed: 15 November 2014].
[16] IPSOS, 2013, *Half (52%) Globally Care About Brands' Environmental Efforts but Only Four in Ten (38%) Willing to Pay More*. [online] Available at: http://ipsosna.com/newspolls/pressrelease.aspx?id=6310&utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+IpsosNewsAndPollsAll+%28Ipsos+News+and+Polls++All%29&utm_content=Netvibes [Accessed: 15 November 2014].
[17] Rao, S., 2014, Green marketing and its impact on sustainable development, *International Journal of Innovative Technology & Adaptive Management*, 1(5). [e-journal] Available at: http://www.ijitam.org/doc/6.pdf [Accessed: 15 November 2014].
[18] McKinsey & Company, 2012, *How much will consumers pay to go green?*. [online] Available at: http://www.mckinsey.com/insights/manufacturing/how_much_will_consumers_pay_to_go_green [Accessed: 15 November 2014].
[19] Lampe, M., Gazda, G., 1995, Green marketing in Europe and the United States: An evolving business and society interface, *International Business Review*, 1(5), 292-315.
[20] Dunlap, R.E., Liere, K.D.V., Mertig, A.G., Jones, R. E., 2000, Measuring endorsement of the New Ecological Paradigm: A revised NEP scale, *Journal of Social Issues*, 56(3), 425-442.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

High Durable Polymer Electrolyte Membrane for Fuel-Cell Applications

Asuman C. Küçük [1], Jun Matsui [2], Takuji Miyashita [3]

Abstract

Phosphonic-acid-containing double-decker-shaped polyhedral silsesquioxanes (2-PHOS-DDSQ and PHOS-DDSQ) were synthesized and the proton conductivity of the PHOS-DDSQ cast film was studied under humid and non-humid conditions. Two-armed and four-armed DDSQ functionalized with di(ethylene glycol) (DEG) (2DEG-DDSQ, 4DEG-DDSQ) were used as initial materials. Esterification reaction of phosphate was carried out using $POCl_3$ through the hydroxyl-terminated groups attached to 2DEG-DDSQ, 4DEG-DDSQ to synthesize 2PHOS-DDSQ and PHOS-DDSQ. However, it has been found that 2PHOS-DDSQ is not sustainable against to the water, thus proton conductivity measurements carried out with PHOS-DDSQ. A uniform film of PHOS-DDSQ was fabricated by drop casting. The cast film showed high proton conductivity (0.12 S cm^{-1}) under humid conditions. Moreover, the cast film offered good proton conductivity under non-humid conditions (3.6 10^{-4} S cm^{-1} at 170 °C). The conductivity and thermal stability indicate that PHOS-DDSQ is a good candidate for use as a proton-conductive membrane in hydrated type fuel cells as well as fuel cells operated at intermediate temperatures (100–200 °C) under non-humid conditions.

Keywords: Silsesquioxane, Proton Conducting Electrolyte, Intermediate Temperature, Fuel-Cell

Introduction

Polymer electrolyte fuel cells (PEMFC) have clearly become an important research area. Mass productions on vehicles equipped with fuel cells have been already started. Perfluorosulfonic acid, which is known as Nafion, is widely used as polymer electrolyte membrane (PEM) in fuel cells [1]. It is chemically stable and its proton conductivity is very high up to 100 °C at high humidity level [2]. At low temperatures, the cell performance decreases with time due to the catalyst poisoning. Conversely, up to 120 °C, the catalyst poisoning remarkably decreases and there is no need to use highly pure hydrogen fuel. Thus, gas consumption of fuel cell greatly reduces. In addition to that, higher temperatures lead to faster electrode reactions and H_2/O_2 diffusion that increase the fuel cell performance [3]. However, the large scale-up of polymer fuel cells are still limited by their incompatibility with operating conditions of the automotive applications and required high cost [4].
Polyhedral silsesquioxanes (POSS) are organic–inorganic hybrid materials composed of an inorganic $SiO_{1.5}$ core with organic coronae [5]. The $SiO_{1.5}$ core provides good thermal and mechanical stability, whereas organic coronae provide compatibility with polymer materials [6]. Up to now, silsesquioxanes have been used as a nanofiller to improve the thermal and structural stability of polymer electrolytes. It has been reported that incorporation of sulfonated POSS into Nafion not only improves thermal and mechanical properties, but also increases the proton conductivity under non-humid conditions [7]. This new generation materials may be used in PEMFC as electrolytes and may have potential to increase the range of the operation region of electrolytes.

[1] Department of Metallurgical and Materials Engineering, Marmara University, Goztepe Campus, 34722, Kadikoy, Istanbul, Turkey, asuman.celik@marmara.edu.tr
[2] Department of Material and Biological Chemistry, Faculty of Science, Yamagata University, 1-4-12 Kojirakawamachi, Yamagata 990-8560, Japan, jun_m@sci.kj.yamagata-u.ac.jp
[3] Institute of Multidisciplinary Research for Advanced Materials (IMRAM), Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan, miya@tagen.tohoku.ac.jp

Results and Discussion

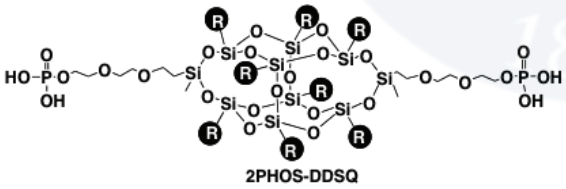
We earlier reported synthesizing process of core–coronae" type hybrid amphiphiles consist of double-decker-shaped polyhedral silsesquioxanes (DDSQ) as a hydrophobic core and DEG units as a hydrophilic coronae [8]. We used two kinds of hydrophobic cores, which are two-armed, and four-armed DDSQ. These hydrophobic cores were functionalized with DEG and 2DEG-DDSQ, 4DEG-DDSQ were obtained respectively. Furthermore, we studied the assembly ability of these structures at the air-water interface using Langmuir-Blodgett technique [9-11]. It is concluded that the self-assembled structure of "core-coronae" type amphiphile can be controlled by the chemical structure of the hydrophilic end groups as well as the number of hydrophilic chains [11].

In the following study, phosphoric acid groups were bonded covalently to 2DEG-DDSQ, 4DEG-DDSQ through DEG units. 2PHOS-DDSQ and PHOS-DDSQ were respectively obtained [12]. Then the proton-conductive abilities of 2PHOS-DDSQ and PHOS-DDSQ were investigated. Obtained hybrid materials (2PHOS-DDSQ and PHOS-DDSQ) **(Scheme 1)** were characterized using ^{1}H, ^{31}P-NMR, FT–IR, XPS and MALDI–TOF MS spectrometry. In the FT-IR spectrum of 2PHOS-DDSQ suggested that DDSQ core remained unchanged during the synthesis. Moreover, in the ^{1}H NMR spectrum of 2PHOS-DDSQ showed just shifting of methyl protons to a higher magnetic filed.

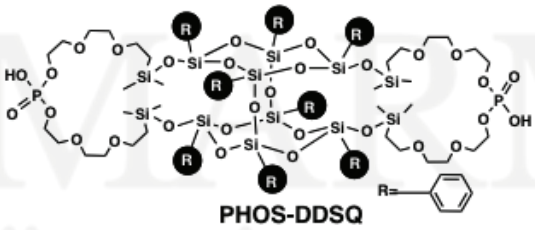
Fig. 1 shows the ^{31}P NMR spectra of 2PHOS-DDSQ taken in CDC_3. After 2nd time washing of 2PHOS-DDSQ with water for purification, phosphor atom peak at 5.6 ppm disappeared **(Fig. 1).**

This result shows that ester bond in 2PHOS-DDSQ was hydrolyzed by several treatments with water and 2PHOS-DDSQ cannot be durable against to the water.

a)



b)



Scheme 1: Structure of 2PHOS-DDSQ (a), PHOS-DDSQ (b).

On the other hand, FT-IR and also ^{1}H NMR spectra show similar result with 2PHOS-DDSQ, Si-O-Si stretching of DDSQ core appears, suggesting that DDSQ core remained unchanged during the synthesis and just shifting of methyl protons to a higher magnetic filed in ^{1}H NMR respectively. Conversely to 2PHOS-DDSQ, according to the ^{31}P NMR spectra of PHOS-DDSQ taken in CDC3, even for 2nd time washing with water, one phosphor atom peak at -21.4 ppm, and its position or intensity did not change **(Fig. 2).** This result can be concluded that the phosphor atom is stable against to the water. Therefore, proton-conducting measurement carried out just for PHOS-DDSQ.

The amount of acid in one PHOS-DDSQ molecule was determined by titration measurement and found to be 1.82. Further characterization made by MALDI-TOF mass spectrum, which shows molecular ions at 2058.50 g mol^{-1} for [M+Ag^{+}, calculated value 2060.27, that strongly supports successfully functionalization of 4DEG-DDSQ with phosphonic acid [MALDI-TOF MS =2058.50 (M + Ag^{+}, calculated value 2060.27)]. The results obtained from the spectra and titration measurements have proven that PHOS-DDSQ has crown-ether like structure.

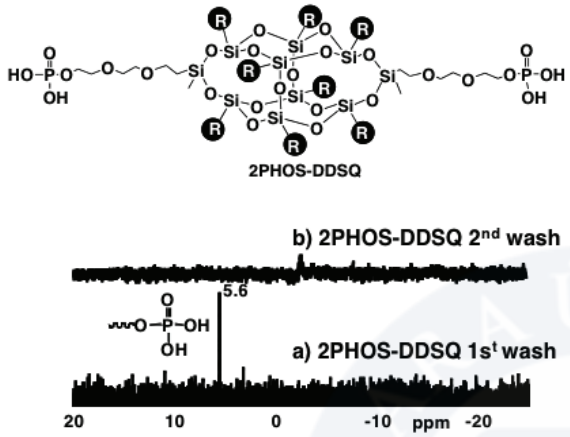


Fig. 1: ^{31}P NMR of 2PHOS-DDSQ in $CDCl_3$ after (a) 1st washing, (b) 2nd washing with water.

The temperature stability of PHOS-DDSQ was found to be 222 °C that is beneficial for use as an intermediate proton-conductive polyelectrolyte application. Furthermore, amorphous phase transition belong to PHOS-DDSQ was also determined from DSC measurement (The glass transition temperatures is -24 °C).

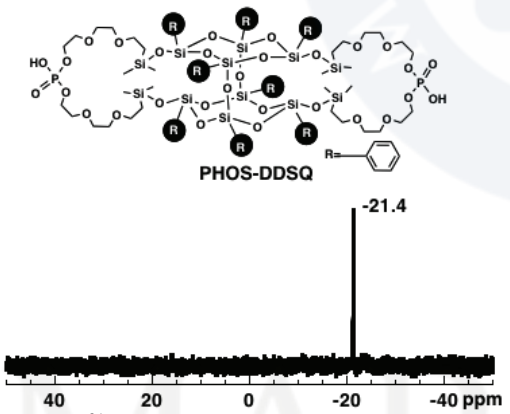


Fig. 2: ^{31}P NMR spectrum of PHOS-DDSQ.

PHOS-DDSQ formed an amorphous film by drop casting. Then the proton conductivities of the cast film under humid and non-humid conditions were studied using impedance spectra measurements. The conductivity of PHOS-DDSQ are reasonable at 75 °C in the present measurement relative humidity conditions: 1.2×10^{-3} S cm^{-1} at 55% RH, 1.3×10^{-2} S cm^{-1} at 75% RH, and 1.2×10^{-1} S cm^{-1} at 95% RH respectively **(Fig. 3).**

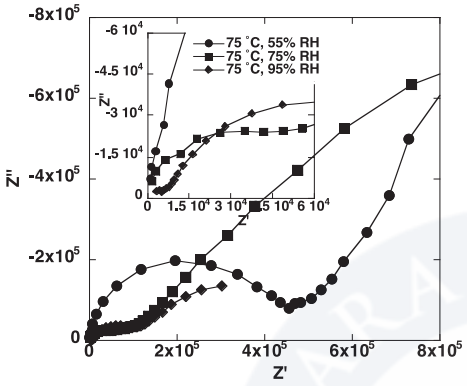


Fig. 3: Impedance response of the PHOS-DDSQ cast film at different RH at 75 °C.

In the humid condition, the proton transport mechanism of the film occurs via both "forming–breaking–forming" hydrogen bonding process and diffusion of water. The activation energy of PHOS-DDSQ was calculated to be 40 kJ mol^{-1} at 95% RH (**Fig. 4**).

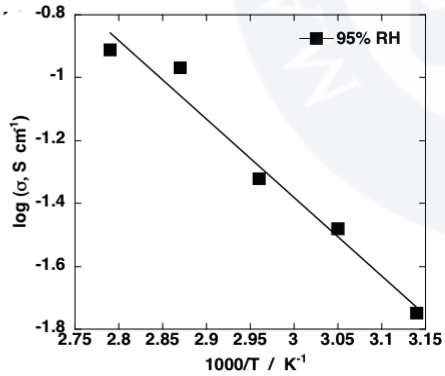


Fig. 4: Arrhenius plots of proton-conductivities of the PHOS-DDSQ cast film measured at 95% RH condition.

The non-humid proton conductivity of PHOS-DDSQ film was measured by increasing the temperature in the chamber. The highest conductivity value has been reached the value of 3.6×10^{-4} S cm^{-1} at 170 °C with the increasing temperature, then it drops to a low conductive value **(Fig. 5).** Up to 170 °C, the conductivity started to decrease due to the self-condensation of phosphonic acid units.

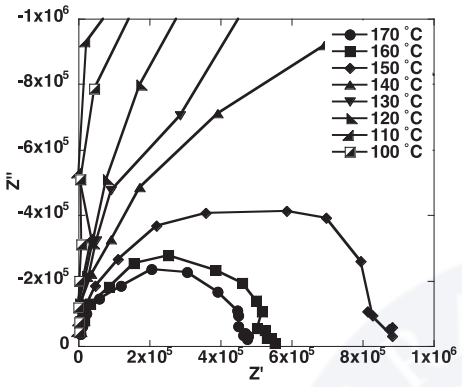


Fig. 5: Arrhenius plot of proton-conductivities of the PHOS-DDSQ cast film measured in non-humid conditions.

Proton transportation mechanism occurred via hydrogen-bond breaking and forming processes among phosphonic acids and between phosphonic acid and ether oxygen of DEG groups. The conductivity followed the Arrhenius relation in the range of 100–165 °C. The activation energy was calculated as 70 kJ mol^{-1} **(Fig. 6).**

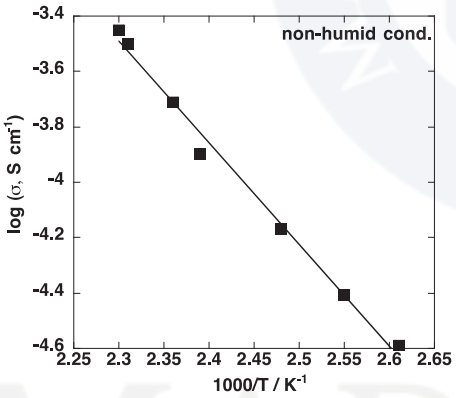


Fig. 6: Arrhenius plot of proton-conductivities of the PHOS-DDSQ cast film measured in non-humid conditions.

Conclusions

Phosphonic acid groups were attached to the DDSQ through DEG units. The spectra and titration measurements prove that PHOS-DDSQ has a crown-ether-like structure. Additionally, PHOS-DDSQ is stable against to the water and reaches proton conductivity of 0.12 S cm^{-1} in humid conditions, as well as maximum conductivity of 3.6×10^{-4} S cm^{-1} in non-humid conditions. The prepared material exhibits high proton conductivity in humid conditions and moderate proton conductivity in non-humid conditions. Considering acceptable proton conductivity either humid or non-humid conditions as well as the high thermal stability, this material, PHOS-DDSQ, may be powerful candidate for fuel cell applications.

References

[1] H. Steininger, M. Schuster, K. D. Kreuer, A. Kaltbeitzel, B. Bingol, W. H. Meyer, S. Schauff, G. Brunklaus, J. Maier and H. W. Spiess, Intermediate temperature proton conductors for PEM fuel cells based on phosphonic acid as protogenic group: A progress report, *Phys. Chem. Chem. Phys.*, 2007, 9, 1764

[2] Eliana Quartaronw and Piercarlo Mustarelli, Polymer fuel cell based on polybenzimidazole/H3PO4, *Energy&Environmental Science*, 2012, 5,6436;

[3] B. Bae, T. Hoshi, K. Miyatake and M. Watanabe, Sulfonated Block Poly(arylene ether sulfone) Membranes for Fuel Cell Applications via Oligomeric Sulfonation, *Macromolecules*, 2011, 44, 3884.

[4] M. Amjad, S. Rowshanzamir, S.J. Peighambardoust, S, Sedghi, Preparation, characterization and cell performance of durable nafion/SiO2 hybrid membrane for high-temperature polymeric fuel cells, *Journal of Power Source*, 210 (2012) 350-357)

[5] Decker, B.; Hartmann-Thompson, C.; Carver, P. I.; Keinath, S. E.; Santurri, P. R., *Chemistry of Materials*, 2009, 22, 942-948.

[6] Chhabra, P.; Choudhary, V., *Journal of Applied Polymer Science*, 2010, 118, 3013-3023.

[7] Phillips, S. H.; Haddad, T. S.; Tomczak, S. J., Developments in nanoscience: polyhedral oligomeric silsesquioxane (POSS)-polymers, *Current Opinion in Solid State and Materials Science*, 2004, 8, 21-29.

[8] Kucuk, A. C.; Matsui, J.; Miyashita, T. Journal of Colloid and Interface Science 2011, 355, 106-114.

[9] Asuman Celik Kucuk, Jun Matsui, and Tokuji Miyashita. Effects of Hydrogen Bonding on the Monolayer Properties of Amphiphilic Double-decker Shaped Polyhedral Silsesquioxanes. *Langmuir*, 2011, 27 (10), Pages 6381–6388

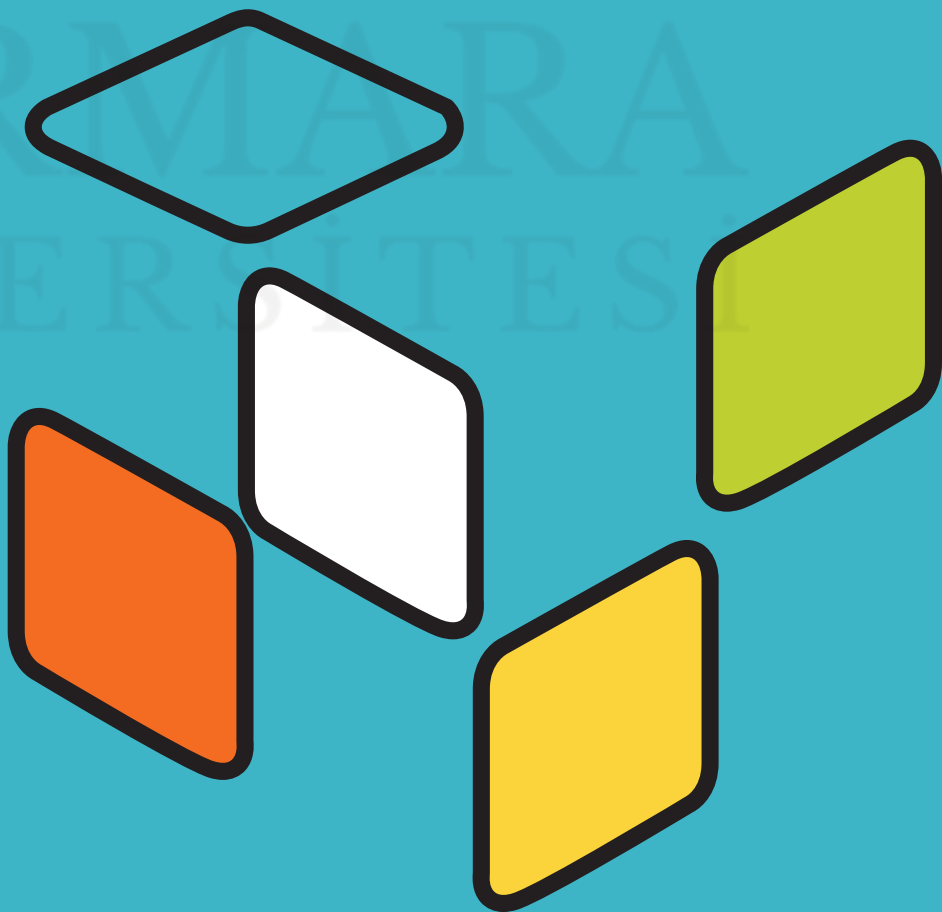
[10] Matsui, J., Kucuk, A.C., Miyashita, T., Monolayer property of "CoreCoronae" type hybrid amphiphile with four hydrogen-bonding groups at airwater interface, *Chemistry Letters*, 2012, 41 (10), pp. 1204-1206.

[11] Asuman Celik Kucuk, Jun Matsui, and Tokuji Miyashita. Effects of Subphase Composition on the Monolayer Properties of “Core-coronae” Type Hybrid Amphiphiles Thin Solid Films, Volume 534, 1 May 2013, Pages 577-583

[12] A. C. Kucuk, J. Matsui and T. Miyashita, Proton-conducting electrolyte film of double-decker-shaped polyhedral silsesquioxane containing covalently bonded phosphonic acid groups, *Journal of Material Chemistry*, 2012, 22, 3853-3858.

MARMARA ÜNİVERSİTESİ YAYINEVİ

SUPPLY CHAIN MANAGEMENT I



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Change in Organizational Paradigms in Complex Supply Networks

Göknur Arzu Akyüz[1], *Güner Gürsoy*[2]

Abstract

Today's global, IT-based, multi-enterprise, complex and networked business relationships require organizational structures and paradigms which are radically different from what they were at the birth of the supply chain (SC) concept. Collaboration across partners stands out as a key theme at all organizational levels for the benefit of the entire network. This study provides a broad coverage of the change experienced in the organizational aspects and discusses the characteristics of the new era from organizational perspective. A clear shift is observed towards collaborative, lean and extended organizational structures with cross-enterprise teams being the most recent managerial units. Organizational structures which are dynamic, tightly coupled, process-centric, strategy-oriented, and trust-based appear as key for competitiveness in today's SC era. In this context, the unit of analysis and focus has shifted from the enterprise to network in organizational and managerial perspectives. A new organizational understanding, which is based on negotiation, consensus, openness and trust among SC partners, is required and a coaching-style leadership for the cross-enterprise, cross-country teams stand out among the main managerial skills.

Keywords: Organizations, Supply Networks

Introduction

Today, under changing business conditions and advances in IT, supply chains have turned into increasingly global, IT-intensive and highly interdependent, complex supply networks [1,2,3]. Supply Chain Management (SCM) practices, initially possessing a local, logistics-oriented and functionally-focused character, are reshaped after the new dynamics created by ever-demanding business pressures and advancements in the IT domain in order to meet the requirements of price-driven competitive markets. The outcome of this transformation is customer-driven, process-oriented, global, strategically coupled, complex, dynamic, multi-agent, web-based and value-creating collaborative networks [4]. Under such circumstances, increasing value creation, strategic orientation, web-based information exchange and collaboration at different SCM processes are well-supported to be the key themes that characterize the new way of doing business in the literature [5,6,7]. Consequently, we witness a transformation from a firm-centric understanding to a chain-centric one, representing a radical change from technological, organizational and managerial aspects in the SCM domain and resulting in new paradigms and understandings [4]. In this paper, we will focus on the organizational dimension of this change, and analyze the paradigm change from the organizational perspective.

Consistent with these transforming business practices in SCM throughout decades, the role and mission of the firm itself has also changed. Throughout the evolution of managerial theories, it has been established that the main goal of the management team of a company is to maximize the wealth of the shareholders. However, today the definition of shareholders seems to be changing with these new practices. As managers, are we concerned with the wealth of only the shareholders of the leader company, or of all the shareholders of all firms operating within the same supply chain? Is this concern limited to only the shareholder, or should we also include all stakeholders into the picture as well? In today's highly global and tightly-coupled business understanding, the answer to this question lies in considering the overall well-being of the SC, which involves all stakeholders of all of the chain partners.

[1] Goknur Arzu Akyuz, Atilim University, Engineering Faculty, Department of Industrial Engineering, Ankara, Turkey, arzu.akyuz@atilim.edu.tr
[2] Guner Gursoy,Yeditepe University, Faculty of Economics and Administrative Sciences, Department of Business Administration, Istanbul, Turkey, guner.gursoy@yeditepe.edu.tr

Therefore, the shift from a firm-level understanding to a chain-level one demands that instead of keeping the firm at the core of the management and organization theories, we should be concentrating on the common needs and interests of all the parties in a given SC, and on keeping the overall well-being of the chain ahead of the individual interests. Given that SCM is a well-supported strategic management tool which drastically affects both the performance and risk of the company [8,9], the context, focus, goal and the organizational structure all need to be redefined for the firm.

With this understanding, this paper analyzes the paradigm change experienced from an organizational perspective. Section 2 describes the transformation experienced in the domain, covering increasingly strategic and collaborative orientation, new organizational forms that have evolved, the new organizational culture and understanding of leadership. Section 3 provides the discussion, and Section 4 concludes.

Transformation in Organizational Aspects

A literature review on the organizational aspects of today's SCs reveals the following characteristics to describe the transformation experienced in the field:

Strategically Dependent and Collaborating Organizations

Managing a business in global and networked business conditions requires the resolution of the dilemma concerning valuing the network over individual enterprises [7,9]. It is necessary to give directions to the overall SC in alignment with the partner strategies, necessitating a holistic, integrative, multi-agent perspective with a process-oriented systems approach. Organizational dependencies and couplings are created at not only the operational-level, but also the strategic level. Naturally, planning and control of operations become paramount in moving an organization or a SC in the desired direction [10]. However, the degree of collaboration across organizations is extended far beyond basic operational and logistics activities enabled by the current IT availabilities. Collaborative planning, forecasting and replenishment (CPFR) integrates the main processes across enterprises, bringing in the ability to jointly handle the planning and control activities [11]. After this level of integrity, joint performance and risk management, as well as collaborative financial and budgetary planning are further included in today's broadened understanding of collaboration [7,12]. Information sharing, interactions and dependencies way beyond operational activities are created across organizational structures, and collaboration stands out as the main theme shaping the success in the domain. In this context, formal and informal mechanisms enabling communication and collaboration become essential, with cross-functional teams, category teams, supply councils, executive supply committees etc. turning into 'required attendance' for team members. Establishing and maintaining a governing SC Council that can provide constant and consistent validation of the strategy assumes an especially critical role for a systemic perspective and a strategic orientation [13].

Consequently, we are faced with highly dependent and cross-border organizational structures interacting beyond functional as well as individual enterprise boundaries to manage cross-enterprise processes. In the literature, we frequently witness the concept of 'blurred boundaries', and some scholars even speak of 'boundariless organizations' [14,15]. This concept of blurring boundaries eliminates the restrictions in the flow of information and knowledge, breaks down the functional barriers, enables cross-border process integrity, and helps organizations to build relationships with a set of partners that constantly change. It also represents an increasing ability for cross-border collaboration. As a result, it seems that boundaries no longer represent an essential element for organizations.

Birth of New Organizational Forms

The network-centric paradigm requires players to have dynamic adaptation capabilities, and forces enterprises to become organizationally lean and agile [4]. The capabilities of adaptability, agility, flexibility, resilience, responsiveness, robustness, innovativeness and sustainability are vital for the competitiveness and survival of any enterprise. However, tight dependencies across the organizations demand that these terms be considered for not only the individual enterprises, but also the overall SC. A 'leagile' philosophy is needed for the entire network, representing a strategic balance between agility and lean capabilities [16,17]. Eliminating the non-value added processes and waste across the SC while

improving adaptiveness, responsiveness and innovation are at the core of the overall success.

In such an environment, traditional, function-based and hierarchical organizational structures are naturally doomed to fail. Any partner containing over-hierarchy, functional barriers and inefficiencies is a node which blocks the network-level flows and negatively affects the overall network-level performance [18]. To ensure success in SC operations, the degree of decentralization also appears as a core issue. Both centralized versus decentralized organizational models have their own advantages and disadvantages, while center-led organization represents the trade-off between these two models [13,19]. In this context, a center-led SC organization focuses on corporate SC strategies, strategic commodities, best practice, and knowledge sharing while leaving the tactical execution to the individual units. A center-led structure relies on cross-functional and divisional teams, flexible processes and policy standards that can be tailored at the local level, coordinated metrics and incentives, and an integrated procurement information systems infrastructure that automates and aligns source-to-settle processes across the enterprise. The consequence is that traditional, multi-layered, hierarchical and centralized structures are being replaced by relatively independent and process-oriented units that are coordinated via cross-functional teams [15].

We further observe that a new stream of thought called 'organizational fluidity' has emerged in recent years, stressing the need for highly flexible and fluid organizational forms with quick improvisation and ad-hoc response capabilities [14]. In this new understanding, one can witness a transition:

- from hierarchies to networks,
- from formal programs and coordination rules to spontaneous action,
- from departmentalization to improvised, cross-border processes and temporary project teams, and
- from vertical lines of command to lateral, organization-wide lateral communication [14].

This stream of thought also reiterates that high-performing organizations be seen as constantly redesigning and reinventing themselves with increasingly fuzzy and eventually dissipating boundaries [14]. This is fully in line with the 'blurring boundaries' concept in the literature, with the focus shifting from rigid organizational structures to behavioral features of flexibility, dynamic capabilities, competencies, adaptation and cooperative networking. Consequently, what become essential are the organizational structures which are flat, flexible and utilizing cross-departmental as well as cross-enterprise teams which can collaborate. Among the partners, long-term strategic dependencies, agreements and alliances are formed and we witness the creation of new organizational forms and structures along with a multitude of recent terminology referring to these new organizational forms [20,21,22]. These terminologies can be summarized as given below:

- Extended enterprise
- Boundariless organization
- Strategic networks
- Dynamic networks
- Value-added networks
- Ad-hoc networks
- Project-based enterprise/network
- Virtual enterprise/organization/corporation/ network
- Coalescence

In the recent literature, one can observe a significant degree of overlapping and interchangeable use of such terms. To start with, the term 'extended' emphasizes the beyond-ERP (Enterprise Requirements Planning) integrity across multiple enterprise systems [20,23]. 'Boundariless' focuses on the idea of 'blurring boundaries' and disappearing functional barriers. The 'dynamic' character emphasizes the fast-reconfiguration and adaptation ability of the network to changing conditions. Both the terms 'ad-hoc' and 'project-based' highlight the transient and 'as-required-basis' character of the organization structure, and the limited duration for collaborative relationships. Naturally, this contains the dynamic ability to gather together and dissolve the partnerships triggered by a specific collaboration opportunity. 'Virtual' forms again represent temporary and rather volatile structures established on an ad-hoc basis with rapid reconfiguration abilities. However, they differ from the others by containing minimal/no physical resources, and having utmost reliance on IT infrastructure [21,22, 24,25]. In the study by Binder and Clegg [20], a clear comparison is put forward between extended enterprises and virtual ones. They

highlight that extended enterprises are characterized by: being quasi-permanent, having a lean and agile resource base, medium degree of transaction costs, and asset specificity and integration. Whereas, virtual enterprises are mentioned to have the characteristics of: being temporary, having a fragmented resource base with high level of transaction costs and asset specificity, and low degree of integration.

Among the above-mentioned terminologies, 'coalescence' refers to the ultimate unification, total integration and 'sharing a common faith' among partners, representing an extreme stage in the evolution of collaboration.

Despite this multitude of terminologies, it is obvious that these new organizational forms share the common characteristics of being dynamic, collaborative, IT-intensive and reconfigurable. This is perfectly in line with the 'fluidity' school of thought. Inarguably, these recently emerging forms are in sharp contrast to the hierarchical and rigid traditional organizational forms.

In this transformation, there exists obvious trade-offs between: (a) fluidity and stability, (b) formal, rigid structures and minimal structures, and (c) formal rules/procedures and few robust routines [20]. Consequently, there is a balance between flexibility (which is associated with organic structures, loose coupling and improvisation), and maintaining efficient routines (which are in conjunction with mechanistic structures, tight coupling, control and bureaucracy). Undoubtedly, successful organizational models are those that fit in both corporate-level as well as chain-level strategies.

New Organizational Culture

The aspects described earlier require an entirely new organizational culture, characterized by openness to communicate, negotiation, consensus and collaboration. Managing tight dependencies at all temporal levels (operational, tactical and strategic), and valuing the overall network over the individual enterprise interests necessitate: (a) establishment of dynamic, cross-functional and cross-enterprise teams for all these levels, and (b) managing these teams with continuous negotiation and consensus. In this organizational culture, joint evaluations, negotiations and collaborative decision-making, not only within the organization but also across the enterprises, become the new way of doing business. In addition, respect for the well-being of other partners and valuing long-term, win-win relationships become the key issues in this new collaborative environment.

Power, commitment and trust among SC partners appear as other key determinants of the new organizational culture. Together with the increasing length of relationships, we witness trust development, increasing commitment and decreasing opportunistic behavior among partners at all temporal levels [26,27]. This definitely contributes to further collaboration beyond material management. As a result, sharing of more strategic-level, almost confidential information becomes possible along with the development of trust, while collaboration on critical matters such as performance management and risk management are enabled across partners. The power of a channel partner, defined as the ability of a partner to affect key decision variables and to control critical assets, is also fully supported to affect collaboration among partners and SC integrity [28]. Hence, these three concepts become key notions determining the resultant scope of collaboration and the working culture across the network. Still, successful SC organizations are those that ensure the best fit between the organizational model and actual corporate culture, and not the desired corporate culture. Therefore, creation of a collaborative, trust-based organizational culture depends on managing the transformation in the prevailing organizational culture and mindsets.

New Approach to Leadership

Undoubtedly, new organizational forms and cultures demand new approaches and skills from the leadership perspective. Managing multi-enterprise human resources and talents in a multi-enterprise, cross-borders context is required with a broad understanding of complex, networked relationships. Leadership opportunities matter for not only a specific enterprise but also the overall chain because of all the extended and intensely coupled relationships [4]. In this context, the basic requirements for a leader are: (a) openness to communication, collaboration and consensus; (b) ability to lead multi-cultural, cross-border teams, and (c) openness to change. Without question, this demands a coaching-style approach to leadership rather than an authoritative one. Today's supply chain leaders have also been shown to possess the following characteristics: (a) the ability to understand and experience all aspects of an end-to-end SC,

not being limited to operational aspects, material management and logistics, (b) the experience for living and working in multiple regions and cultures in both developed and emerging markets, (c) the ability to foresee future market changes, (d) the ability to adapt quickly to new business models, and (e) the capability to understand where value is being created and re-created [29]. Thus, a broad vision, a strategic perspective, foresight with a proactive mode of behavior, and the ability to respond to new conditions define modern-day leadership. In the literature, the concept of 'transformational leadership' is specifically emphasized as a dynamic capability, referring to the ability of the leader to lead the organizational change, and having both a direct and indirect positive relationship with organizational performance [30,31,32,33]. In short, leadership in today's supply networks context requires those who can create and manage a collaborative, dynamic, consensus- and trust-based working environment, and who can manage the transformation of the organizations towards these ends. Still, the presence of one strong channel leader, or very small number of dominant leaders, will drive the direction of the chain in the governing council. Therefore, power asymmetries and the exercise or lack of power among the representative leaders in the governing board will affect the level of commitment of other channel members and the success of the overall chain.

Discussion

The transformation experienced in the SC domain due to changing business conditions and IT developments has resulted in dramatic changes from an organizational perspective. We have seen that the shift from a firm-level understanding to a network-level one is the main driver of all these changes.

It was revealed that the new era outlines an environment in which organizational and functional boundaries become increasingly blurred, relationships become more and more dependent, and collaboration appears as the dominant theme. It is apparent that process-centric, shared goal-oriented, trust-based, tightly coupled, and dynamic organizational structures are essential to meet the requirements of the new business environment. Having said so, the ability to engage in dynamic and long-term partnerships in which partners can collaborate beyond the operational relationships characterizes today's complex supply networks. Hence, we are witnessing new organizational designs, the birth of various flexible organizational forms and recent terminologies for extended, strategically-dependent and IT-intensive organizational structures. The multiplicity and immaturity of these terms is obvious in the literature. However, it has become apparent that they all point out to flexibility, liquidity, dynamic adaptation capability and web-intensive nature as key features. What's more, it has become evident that surviving organizational forms are, in fact, the ones that ensure a good fit with strategy and culture, while assimilating and utilizing IT towards cross-border collaboration.

It is also revealed that a whole new organizational culture is created, which values open communication, negotiation, consensus, collaboration and trust among partners, along with a new approach to leadership. Undoubtedly, all the opportunities and challenges related with working in a multi-partner and multi-cultural environment prevail, and negotiation and consensus-seeking stand out as crucial aspects of this new working environment.

Conclusion

Since its emergence, SCM has become a management tool with an increasingly strategic character, and context, focus, goal and organizational structure have been redefined for organizations. Within the global and extended context of business, a network-centric focus with network-level goals and objectives has become essential. As a result, a transformation is witnessed in the organizational structures of the partners, and less rigid, less centralized and boundariless organizational forms have now evolved.

Consequently, the collaborative network-centric paradigm of today's SCM creates strategically dependent and extended organizational structures that can engage into dynamic, long-term and collaborative partnerships. This trend is in contrast with the traditional, hierarchical, function-based and isolated understanding of organizations, and requires an entirely new, collaborative and 'leagile' mindset. The focus has shifted from operations, functional barriers, command-and-control and hierarchical organizational forms to integrated processes, cross-border integration, negotiation and consensus, and leagile organizational structures. Trust-based collaboration models appeared, and a giant step is taken beyond operational-level coordination, enabling strategic-level collaboration. We even speak of

'coalescence' as the ultimate unification, instead of the old versions of operational-level coordination. Therefore, it is obvious that organization and management theories of today should consider the network rather than the enterprise as their focus and unit of analysis with a global and holistic perspective, in which leader partners assume responsibility for not only wealth maximization for their own shareholders, but also for those of all the parties within the same chain.

With these in mind, the organizational and managerial aspects of collaborative networks and newly emerging organizational structures appear to be fruitful areas for future research.

References

[1] Akyuz, G.A., Rehan, M., 2009, Requirements of forming an 'e-supply chain', *International Journal of Production Research*, 47(12), 3265-3287.
[2] Zsidisin, G., Ritchie, B., 2009, *A Handbook of Assessment, Management and Performance*, Springer Science and Business Media, NY, USA.
[3] Heaney, B., 2013,Supply chain visibility: A critical strategy to optimize cost and services, An Aberdeen Group White Paper, May 2013.
Retrieved from:http://www.gs1.org/docs/visibility/Supply_Chain_Visibility_Aberdeen_Report.pdf
[4] Akyuz, G.A., Gursoy, G., 2013, Paradigm shift in supply chain management, *American Society for Engineering Management (ASEM) 2013, International Annual Conference*, Article No:56, 2-5 Oct. 2013, Minneapolis-Minnesota.
[5] Simatupang, T.M., Sridharan, R., 2002, The collaborative supply chain: A scheme for information sharing and incentive alignment, *The International Journal of Logistics Management*, 13(1),15-30.
[6] Derrouiche, R., Neubert, G., Bouras, A., 2008, Supply chain management: A framework to characterize the collaborative strategies, *International Journal of Computer Integrated Manufacturing*, 21(4), 426-439.
[7] Akyuz, G.A., Gursoy, G., 2010, Taxonomy of collaboration in supply chain management, *VIII. International Logistics and Supply Chain Congress*, pp.31-44, 4-5 November 2010, Istanbul, Turkey.
[8] Cohen, S., Roussel, J., 2005, *Strategic Supply Chain Management*, McGraw-Hill, USA.
[9] Hult, G.T., Ketchen, D.J., Arffet, M., 2007, Strategic Supply Chain Management: Improving performance through culture of competitiveness and knowledge development, *Strategic Management Journal*, 28(10),1035-1052.
[10] Lambert, D., Cooper, M., 2000, Issues in Supply Chain Management, *Industrial Marketing Management*, 29(1), 65-83.
[11] Germain, R., Claycomb, C., Dröge, C., 2008, Supply chain variability, organizational structure and performance: Moderating effect of demand unpredictability, *Journal of Operations Management*, 26(5), 557-570.
[12] Harland, C., Brenchley, R., Walker, H., 2003, Risk in supply networks, *Journal of Purchasing and Supply Management*, 9(2), 51-62.
[13] Engel, R.G., Wesoky, J., 2010, 10 Best Practices for Supply Management Organizations, *Proceedings from 95nd Annual International Supply Management Conference*, April 2010. San Diego, CA.
[14] Schreyögg, G., Sydow, J., 2010, *Organization Science*, 21(6),1251-1262.
[15] Picot, A., Reichwald, R.,Wigand, R.T., 2008, *Information, Organization and Management*, Springer-Verlag, Berlin.
[16] Jafarnejad, A., Shahaie, B., 2008, Evaluating and improving organisational agility, *Delhi Business Review*, 9(1), 1-18.
[17] Wang, L., Koh, S.C.L., 2010,*Enterprise Networks and Logistics for Agile Manufacturing*, Springer-Verlag, London.
[18] Kim, C.S., Tannock, J., Bryne, M., Farr, R., Cao, B., Er, M., 2007, *State-of-the-art review:Techniques to model the supply chain in an extended enterprise*, VIVACE Consortium.
Retrieved from:
http://pdf.aminer.org/000/352/141/robust_supply_chain_design_a_strategic_approach_for_exception_handling.pdf
[19] Enperior.com, 2009, *Analysis of successful supply chain organization models*.
Retrieved from:
http://www.enporion.com/media/whitepapers/Enporion_Supply_Chain_Org_Whitepaper_03032009.pdf
[20] Binder, M., Clegg, B., 2007, Enterprise management: A new frontier for organizations,*International Journal of Production Economics*, 106(2), 409-430.
[21] Camarinha-Matos, L.M., Afsarmanesh, H., 2008, "Classes of Collaborative Networks" InPutnik, G.D. , Cunha, M.M. (Eds.) *Encyclopedia of Networked and Virtual Organizations*, IGI Global, PA, pp.193-198.
[22] Camarinha-Matos, L.M., Afsharmanesh, H., Galeano, N., Molina, A., 2009, Collaborative Networked organizations: Concepts and practice in manufacturing enterprises, *Computers and Industrial Engineering*

Journal, 57(1), 46-60.
[23] Bendoly, E., Jacobs, F.R., 2005, *Strategic ERP Extensions and Use*, Stanford Business Press, Stanford, CA.
[24] Poirier, C.C, Queen, F.J., 2003, A survey of supply chain progress, *Supply Chain Management Review*, Sept.-Oct.
[25] Noran, O., 2009, A decision support framework for collaborative networks, *International Journal of Production Research*, 47(17), 4813-4832.
[26] Lander, M.C., Purvis, R.L., McCray, G., Leigh, V., 2004, Trust-building mechanisms utilized in outsourced IS development projects: A case study, *Information and Management*, 41(4), 509-528.
[27] Mayer, R.C., 2005, An integrative model of organizational trust, *The Academy of Management Review*, 20(3), 709-734.
[28] Belaya, V., Hampf, J.E., 2011. *Power and Supply Chain Management: Insights from Russia*, Retrieved from: http://ageconsearch.umn.edu/bitstream/114483/2/belaya_hanf.pdf
[29] O'Brian, P.L., 2013,*Supply chain leaders of the future*, Retrieved from: http://www.russellreynolds.com/content/supply-chain-leaders-future
[30] Overstreet, R.E., Hanna, J.B., Byrd, T.A., Cegielski, C.G., Hazen, B.T., 2013, Leadership style and organizational innovativeness drives motor carriers to sustained performance, *International Journal of Logistics Management*, 24(2), 247-270.
[31] Day, D.V., Antonakis, J., 2012, *Leadership:Past, Present and Future*, SAGE, Los Angeles, CA.
[32] Crossan,M., Gandz, J., Seijts, G.H., 2010, *Cross-Enterprise Leadership: Business Leadership for the Twenty-First Century*, JOSSEY BOSS, Gebunden.
[33] Nightingale, D.J., Srinivasan, J., 2011, *Beyond the Lean Revolution: Achieving Successful and Sustainable Enterprise Transformation*, American Management Association, New York.

MARMARA ÜNİVERSİTESİ

Responsive Supply Chain and an Analysis on Manufacturing Industry

Murat Bilsel [1], *Semih Özel* [2], *Özalp Vayvay* [3]

Abstract

Supply chains can be considered one of the most popular operations strategies for improving organisational competitiveness. Since the 1990's, rapid development of supply chains has played a significant role in the manufacturing sector. Supply chains are all about effectively integrating the information and material flows within the demand and supply process. Supply Chain Management (SCM) sets up a relationship between the suppliers and the customers through the supply chain participants, using information flow and logistics activities to gain competitive advantage and customer satisfaction.

This study presents a brief outline of different approaches to SCM before discussing Agile Manufacturing (AM) and its relationship with Responsive Supply Chain (RSC). Considering the significance of both AM and SCM for organisations to improve their performance, an attempt has been made in this paper to analyse both AM and SCM with the objective of developing a framework for RSC. Finally an assessment model has been proposed to evaluate an organization's RCS competency. The proposed model has four dimensions: logistics, knowledge, strategy and customer.

Keywords: Supply Chain, Responsive Supply Chain, Agile Manufacturing, Supply Chain Management

MARMARA ÜNİVERSİTESİ

[1] Murat Bilsel, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, murat.bilsel@marmara.edu.tr

[2] Semih Özel, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, semih.ozel@marmara.edu.tr

[3] Özalp Vayvay, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, ozalp@marmara.edu.tr

Introduction

Due to the increase in competition these days, companies are constantly working to decrease their costs and increase their market share. Therefore they need to get products in demand to customers at the right time in the right way whilst at the same time working with suppliers effectively to get raw materials or stock as fast as possible at the lowest possible cost. This collective effort is called the Supply Chain and is the basis for the carrying out of a series of related processes in a compatible manner. These processes are concentrated mainly on the supplier, manufacturer, and customers. When considered from the view of business processes, supply chains cover many areas including sales processes, manufacture, stock management, material procurement, distribution, supply, sales forecasts, and customer services.

Supply chains, which have a seemingly increasing importance, are the subject of much research and have been defined by many researchers. For example, Simchi and Kaminsky [13] defined supply chain management as "a set of approaches utilised to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements." Furthermore, a supply chain also encapsulates all the facilities of the supplier, manufacturing equipment, storage, retailers, stores and distribution centres considering all units that have an impact on costs and play a role in the manufacture of products that meet customers' wants and needs.
Similarly, Lee and Billington [9] defined a supply chain as "*a network of manufacturers and distributors who procure raw materials, turn them into intermediate goods, and distribute the final goods to customers*". Similarly according to Kopczak [8], a supply chain is "*the set of elements including suppliers, logistics providers, manufacturers, distributors, and retailers through which materials, products, and information flow*".
The developments in information and communications technology and new management methods nowadays have increased the importance of the management of supply chain processes. The main aim of supply chain management is the provision of the effectiveness of output and costs in all businesses. For this reason, it is necessary to adopt supply chain management with a system approach rather than just simply minimising transport costs or reducing stock costs. Supply chain management aims to run the system in the best possible manner by coordinating all the functions of the supply chain from the planning of the product to product forecasts, from logistics costs to the procurement of raw materials, from sales marketing to customer satisfaction, taking into account the whole system. Responsive Supply Chain (RSC) is one important strategy of many developed to this purpose.
The aim of RSC is to enable a business to stay on its feet in the face of changes in critical factors in the market such as quality, price, response time, and service. Furthermore, it connects supply and manufacturing operations to the market and market distribution channels in order to provide competitive advantage. In this way, better levels of service and higher profits can be obtained with the benefits achieved from lower costs and sales [3].

This study introduces supply chain management in particular and evaluates strategies in use. In this scope, responsive supply chain strategy is evaluated as a new SCM strategy and a conceptual model is proposed to measure it. The relationship between SCM and Agile Manufacturing is explained and it is proposed that it needs to be used as a new strategy for the supply chain.

Supply Chain Management

Supply chain management sees the supply chain and organisation as one entity. It is a system approach for the management and understanding of different activities needed for the coordination of the flow of products and services to serve the final customer in the best possible way. This system approach creates a framework that will respond to business needs in the best way, otherwise the components will stay in discrepancy of each other. An effective supply chain requires instant developments in both customer service levels and the productivity of a business's internal operations within the supply chain. Put simply, customer service is a high rate of fulfilling orders, delivering right on time, and whatever the reason may be, a low rate of customer product returns. Productivity of an organisation's internal operations in a supply chain means to have an attractive rate of investment returns from stock and assets, and to find ways to reduce sales spending.

According to Hugos [6], any company within a supply chain must make an individual or collective decision about activities in five foundational fields. As will be explained in more detail below, these five main areas are production, inventory, location, transportation, and information.

Production: Production covers the creation of the original production plan considering factory capacity, workload balance, quality control, and maintenance of equipment. Furthermore, it is the field that identifies what products the market needs, and how many and at what time these products need to be manufactured.

Inventory: The method of storage and amount of stock throughout the supply chain process is important. How much stock is needed to be held as raw materials, semi-finished products or finished products is decided here. The main purpose behind holding stock is to provide a buffer against uncertainty in the supply chain. It is important to identify the optimum level of stock and the point at which to reorder without increasing the costs of holding stock.

Location: Where the production and storage facilities will be located is important for keeping costs to a minimum. Answers to questions such as whether new facilities need to be built or whether existing facilities can be used, and the identification of the most appropriate route for the product flow will be provided.

Transportation: This is an important action for getting stock from one supply chain location to another. Although air and land transportation is generally faster and more trustworthy, it is also more expensive. Although sea and rail transportation is cheaper, it takes longer and carries more uncertainty. Considering this uncertainty, a logistics network must be formed to decide on the most appropriate form of shipping whilst keeping costs at a minimum.

Information: When used at the right time in the right place, information allows for more effective desired results to be obtained. Obtaining the right information and when necessary and sharing it in the right manner is important from the view of making better decisions and providing better coordination. In a supply chain, the gathering and use of information plays a big role in the fulfilment of other actions such as production, inventory, location, and transportation. Therefore, it is the most important process in the supply chain that affects the process from start to finish.

The decisions made in these five areas will define a company's supply chain capacity and effectiveness. A company's capacity and competitive strength in the market are linked to its supply chain. If a firm's strategy is to compete in a market where products are concentrated and costs are a main element, it needs the type of supply chain that will optimise low costs. If a firm's strategy is to serve in a more niche market where customer service is more important, it needs a supply chain based on responsive product optimisation.

Supply Chain Management Approaches

When it comes to supply chain management approaches, different companies and even managers within the same company have different points of view and paradigms. As there is no single approach to supply chain management, it cannot be said that any one is right or wrong. In reality, one company's view can be different from that of another. Just as there are many reasons for this, these views are not constant and as time goes on and as pressure from competitors' increases, these views can change. Ayers [1] considered these approaches generally, and summarised them as follows, stating with the connections between them. These approaches have been ordered below from the most narrow-scoped to the broadest approach.

Functional Approach: The functional approach is the most fundamental approach concept used in the majority of businesses today. In this perspective companies are made up of individual departments. An example of such an organization is supply, operation, engineering and distribution departments in a manufacturing business. Each department has its own agenda. Auditing of connections between the departments is weak. This sort of audit isn't even considered between companies in a supply chain. Performance evaluation for this kind of company is cost heavy.

Supply Approach: In general, differences from the functional approach start with working on reducing costs. From this perspective, the 'supply' of a supply chain is given predominance. These days, the cost of materials is the most important element for most manufacturing companies. When these kind of firms refer to supply chains, their first thoughts are of suppliers and supplying. They buy a lot of products and services from service organisations. Most of these organisations are connected to other suppliers. For example, car insurance companies have a wide network of vehicle repair stores and insurance experts. The healthcare sector on the other hand relies on a supply network made up of doctors, hospitals, and insurers. The cost of materials and services make the supply approach appealing in terms of reducing costs. At the same time, this understanding has brought various programmes such as supplier number reduction programmes and vendor-managed inventory to the table. In this approach supply is completely under the responsibility of the supply chain. This effort is reflected outside the company and affects the suppliers, too.

Generally partnership meetings tend to be concentrated on price discounts, particularly in situations where there is pressure on sellers from buyers. Under such circumstances, without any improvement, the topic turns to profit within the supply chain, or a change in location.

Logistics and Shipping Approach: The physical movement of products in the supply chain is an important part of the national economy. Logistics is defined as a part of the supply chain comprising the productive and effective planning, implementation and control of the product, service flow, information from the point of origin to the consumer, and storage operations in order to meet the needs of the consumer [4]. With the logistics and shipping approach, companies that want to employ a supply chain manager usually hire someone with a career in distribution management. Within the scope of the term supply chain, these kind of businesses can turn it into an alternative demand chain. This is turn is the reason for extra attention to be paid to the supply chain or externally rather than internally. At the same time this is a cost reducing effort that will increase profit. Here, typical cost reducing activities such as creating a storage model or a network of distribution centres and shipping are considered.

Information Approach: The information approach is an approach that focuses on the development of connections both within the company and in the supply chain. New approaches and implementations for the transfer of information have made this approach more active. Electronic Data Interchange (EDI) is one of the first applications of developing communication between businesses. One of the biggest hurdles here is the lack of integrated programs in businesses both internally and externally. Organisations such as the Supply Chain Council are still working to form a standard description for the data and processes they sponsor. These efforts will ease the sharing of information within supply chains. Using information can produce good results in improving the performance of the supply chain.

Business Process Reengineering Approach (BPR): This process is called process reengineering and here the main aim is to stop anything from going to waste and to improve quality. This can be achieved in a number of ways. For example, the Six Sigma concept is closely related to BPR. System and technology plans should follow the process plan, and this is the underlying principle of BPR. Therefore the driving force behind changes is not technology, but process requirements. Technology is just a tool. BPR efforts no longer stop at company boundaries, but have been spread among members of supply chains.

Strategic Approach: From one point of view, supply chain planning is integrated with competitive strategy. For those who defend this view, competition should not be concentrated on just the product but also on operations that realise the concept of the 'extended product'. These operations take the product to the consumers' hands. From these view supplier relations, logistics and information systems support customer satisfaction. The conversion of this is an increased market share and profit. Costs are a secondary factor in this approach.

Process Model Approach: In order for a supply chain to create value it must also be thought of as a process model. For the successful creation of an integrated value system, a process model represents a series of actions and strategies necessary for its implementation. The first step enables optimum coordination among a business's functions. Sales, operations and distribution business strategies, performance matrix, and understanding of where the organisation is heading must be brought into order. The main processes (ordering, source strategies, logistics flows) need to be analysed and developed. All business should be documented with an established goods strategy taking into account all the important sales places in line with global units. In addition, a foundational supplier and consumer network must be implemented (in many cases this supplier/consumer base needs to be reduced). This requires managers to closely monitor who they work with, and in some cases know the supply chain from the very beginning.

Agile Manufacturing and Responsive Supply Chain

One of the most important problems that businesses come across today is the changes, uncertainties and unexpected developments that occur in the environment they operate in. In order to be successful among these changes and uncertainties businesses must look for new methods and approaches. Global competition, developing technology, changing and developing business and industry environments, and the difficulty of keeping consumers satisfied put companies under more pressure. Current production practices increase a business's productivity and effectiveness, but they don't help a business adapt to changing market circumstances. The concept of agile manufacturing is defined as the process that needs to be followed for a company to be successful in an ever changing and uncertain competitive environment.

Goldman et al [2] state that responsive manufacturing gains competitive advantage in operations realised in an environment where the competition is ever changing and in unexpected ways, and argue that agile manufacturing has four fundamental components. They make the value of the product apparent to the customer. Every department and every employee must be ready for change at any moment. Employees are a company's most important resource and employees' skills must be fully utilized.
A virtual cooperation must be set up between businesses. By sharing information with key customers and key suppliers, agile manufacturers should create a virtual network, and through the effective sharing of information due to this network supported online they will be able to identify both changes and customers' needs more quickly and accurately [12]. Of the components above, the first three are found in lean production, and the importance given to them is less than that given to the prevention of waste.

Hormozi [5] defines an agile business as one that can adapt quickly and easily to changes. Agility means being successful in an ever changing environment whilst at the same time reordering inter-company relations, operations and processes in an effective way in response to change. This new approach comes from long-term strategic plans and covers the business from top to bottom [5]. Nagel and Bhargave argue that product variety, awareness of customer desires, and product development duration are determinants of competitive strength and that their success will lead to a more agile organisation structure. Responsive production is defined as the manufacturing structure that is can answer to demands and problems at the highest degree and create virtual cooperation's. According to researchers, future leading businesses will have structures that are continuously developing and able to incorporate agile manufacturing without overlooking the importance of quality. Therefore, being able to respond to changes in both production and supply chain processes will be a critical point for companies. Fluctuations caused by a country's economic or political changes make it harder for companies to make long term plans. High and changing inflation rates, changing exchange rates, government policies that can change in an instant, increasing interest rates, political chaos that can erupt in some countries from time to time, globalisation, barriers to trade, technological advances and the behaviour of online businesses, and business relationships with customers and other businesses can be shown as some of the reasons for these kinds of fluctuations [10].

A Model Proposal for a Responsive Supply Chain

Nowadays, constant change and uncertainty dominates many industries. For businesses change has become a necessity, not an exception. As consumer demands change, consumers expect personalised products of high quality at a reasonable price. In order to gain a competitive advantage it is necessary to meet the demand of high quality and personalised products immediately. As in manufacturing, acquiring the characteristic of responsiveness in the supply chain too requires being ready for the causes of change, and integrating motivated and reinforced quality personal with flexible technology. In this way companies will attain the fundamental characteristics for the Responsive Supply Chain (RSC) approach.

Kidd [7] argues that the three core components of people, organisation and technology need to be integrated in order to achieve agility that will deliver a business to success in a new competitive environment.
RSC address new ways of running companies to meet challenges such as consumer demand or logistics. In a changing and competitive environment there is a need to develop cost effective solutions for organisations and facilities that are highly flexible and responsive to the changing market and customer requirements. Youssef et. al. [14] describes the RSC as necessary for manufacturers to be flexible and compatible to changing market conditions. According to their research, the manufacturing approach most similar to supply chain manufacturing is agile manufacturing. A strategic responsive supply chain requires a strong partnership between suppliers and customers, and information systems for effective supply chain management. It also requires the ability to survive and prosper in a competitive environment of continuous and unpredictable changes by reacting quickly and effectively to changing market, driven by customers [3].
Measuring how well supply chain strategies are carried out is just as important as managing them in an effective manner. There is a need for evaluation approaches that get feedback by analysing results, and then uses this feedback with the aim of improving supply chain processes. With the view that it is difficult to manage a process that can't be measured, great importance is given to the development of an evaluation model for RSC. The biggest problem encountered in this kind of RSC evaluation approach is the acquisition of numerical data from RSC processes. However, these days it is possible to analyse a firm's position by

measuring intangible assets other than financial data such as intellectual capital. Özel and Öztemel [11] carried out a study into the measurement of intangible assets in businesses, looked at the evaluation systems already used in literature, and proposed an evaluation model. According to this model proposal a framework model has been created and an evaluation proposed that covers fields such as strategic competency, intellectual competency, and R&D and innovation competency where it is hard to obtain numerical data together with areas where it is easy to collect numerical data such as financial values.

Considering the approaches explained in detail in earlier sections, four important dimensions in the evaluation of RSC processes have been determined. The four dimensions of importance for RSC are:

- logistics dimension
- knowledge dimension
- strategy and business process dimension
- customer dimension

In the figure below a schematic diagram of the proposed RSC evaluation model has been given.

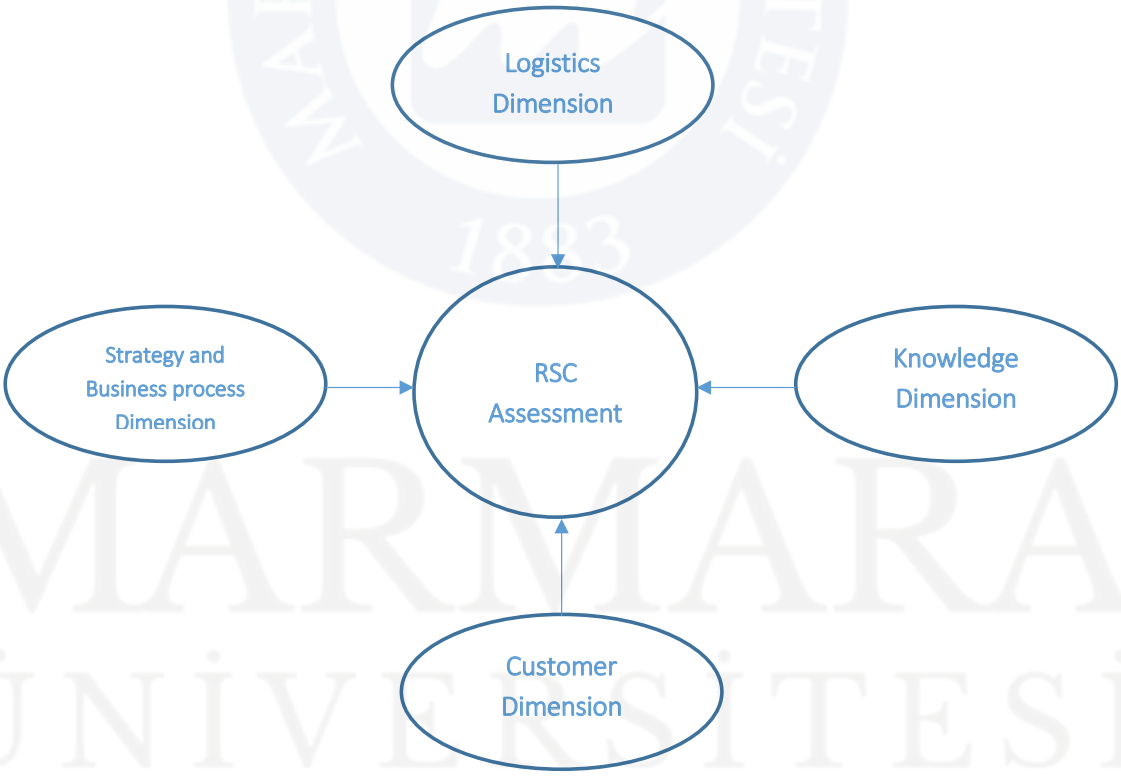


Figure 1. Responsive Supply Chain Assessment

Consequences

Nowadays, instead of businesses having individual competitors, there is a competitive environment created from the whole supply chain that the business is a part of. In this environment, enterprises need to forward their cooperation's with the suppliers and customers they work with in order to stay ahead of their competitors and ensure sustainability of the company. It is important for business to work according to collective principles, create a trustful environment and share working processes with each other.

The increasing competition between businesses makes the subject of supply chains even more important. In particular, by using new approaches and strategies in this field, it is possible to both cut costs and corporately reach new successes in the race for market leadership. With this goal in mind, responsive supply chains are an important driving power for companies in this race as an addition to classic SCM strategies. Furthermore, it is possible to take the continuation of the success provided by using RSC even further with the assessment approach proposed under the scope of this work. It is considered that developing the proposed model will make a contribution to business and researchers studying in this field.

References

[1] Ayers J. B., 2002, Making Supply Chain Management Work : Design, Implementation, Partnerships, Technology, and Profits, Auerbach Publications: A CRC Press Company: New York, s.8-11

[2] Goldman, S.L., Nagel, R.N., Preiss, K., 1995, Agile Compeitors and Virtual Organizations-Strategies for Enriching the Customer, Van Nostrand Reinhold, New York

[3] Gunasekaran A., Lai KH, 2008, Cheng E., "Responsive supply chain: A competitive strategy in a networked economy, Omega, Volume 36, Issue 4, Pages 549-564

[4] Handfield R. B., Ernest L. Nichols, Jr., 2002, Supply Chain Redesign Transforming Supply Chains Into Integrated Value Systems, Prentice Hall PTR Upper Saddle River, NJ, s:25

[5] Hormozi M. A., 2001, Agile Manufacturing: the next logical step, *Benchmarking: An İnternational Journal*, Vol.8 No.2

[6] Hugos M., 2003, Essentials Of Supply Chain Management, New Jersey: John Wiley & Sons, Inc, s:2-10

[7] Kidd, P. T.,1994, Agile Manufacturing: Forgoing New Frontiers, Addison-Wisley, Reading, MA

[8] Kopczak, L.R., 1997, Logistics partnership and supply chain restructuring. survey results from the US computer industry, Production and Operations Management,Vol.6 No.3, pp.226-247

[9] Lee, H.L. and Billington C., 1992, Managing supply chain inventory: pitfalls and opportunities, Sloan eManagement Review, Vol.33 No.3, pp.65-73

[10] Nagel, R.N. ve Bhargave, P., 1994, Agility: The ultimate requirement for world-class manufacturing performance, National Productivity Review, Summer, pp.331-340

[11] Özel S., Öztemel E., 2013, "Kobi Destek Değerlendirme Sistemlerinin İncelenmesi ve Temel Kriterlerin Belirlenmesi", UAS2013 Üretim Araştırmaları Sempozyumu, Sakarya

[12] Parkinson, S., 1999, Agile Manufacturing, *Work Study*, Vol 48, Is. 4

[13] David S-L, Kaminsky P., 2004, Managing The Supply Chain The Definitive Guide for the Business Professional New York :McGraw-Hill, s.2-3

[14] Youssef MA., 1994, Agile manufacturing; the battle ground for competition in the 1990s and beyond, International Journal of Operations Production Management, 14(11), s4–6.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Lean, Agile and Leagile Supply Chain Managements: A Review Study

Eyüp Anıl Duman [1], *Mete Han Topgül* [2], *Hüseyin Avni ES* [3]

Abstract

Companies should continuously pay attention in responding to the customer demand and improving the efficiency of their business processes in order to take part and survive in the marketplace. Profitability is another challenge for companies to stay in the market, reducing the cost of their product the best method for competitive price. Lean management is quite good method where demand is stable, predictable and low variety of customer requirement for reducing the cost. In volatile and high variety type of demand exist situations; agility management is required for profitable opportunities to compete in the market. Combining lean and agile management in the supply chain management area via the strategic use of a de-coupling point has been termed "Legile Supply Chain Management". Therefore, companies have realized that leagility, the combination of the leanness and agility paradigms, is essential for their survival and competitiveness. For this reason, the studies related leagile supply chain management have been realized. The leagile strategy is a comparatively new strategy for the supply chain management. In this paper, lean and agile supply chain managements were examined with respect to time while leagile supply chain was presenting according to research methods.

Keywords: Leagile Supply Chain, Lean Supply Chain, Agile Supply Chain, Review

Introduction

Companies should continuously pay attention in responding to the customer demand and improving the efficiency of their business processes in order to take part and survive in the marketplace. The concept of leagility has drawn attention in recent years to gain competitive advantages. Leagility is the combination of the leanness and agility paradigms. Leanness means developing a value stream to eliminate all waste, including time, and to ensure a level schedule [1]. Lean is about doing more with less. Lean concepts work well where demand is relatively stable and predictable and where the customer requirement for variety is low. On the contrary, a much higher level of agility is required in those situations where demand is volatile and variety is high. Although leanness may be an element of agility in certain circumstances, it is not be able to meet the precise needs of the customers rapidly [2].

Agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile marketplace [1]. Agility is being defined as the ability of an organization to respond rapidly to changes in demand, both in terms of volume and variety [3]. The lean and agile paradigms have been combined within successfully designed and operated total supply chains. The companies in the supply chain must deal with and exploit this volatility to their strategic advantage. In addition cost is another important market qualifier, and this is usually reduced by leanness. Combining leanness and agility in one supply chain via the strategic use of a de-coupling point has been termed ''le-agility''. Leagility is the combination of the lean and agile paradigm within a total supply chain by positioning the decoupling point so as to best suit the need for responding to a volatile demand downstream yet providing level scheduling upstream from the decoupling point [1].

The purpose of this paper is to introduce the concept of leagility integrating leanless and agile paradigms and present reviews of lean, agile and leagile supply chain managements.

[1] Eyup Anil DUMAN, Marmara University, Engineering Faculty, Department of Metallurgical and Materials Engineering , Istanbul, Turkey, anil.duman@marmara.edu.tr
[2] Mete Han TOPGUL, Pesico, Department of BIS-DMO, Istanbul, Turkey, metehan.topgul@pepsico.com
[3] Huseyin Avni Es, Karadeniz Technical University, Engineering Faculty, Department of Industrial Engineering, Trabzon, Turkey, avnies@ktu.edu.tr

Review of Lean Supply Chain Management

The discussion of lean supply was started by Lamming (1993). Then he expended his research with a new paper in 1996. Lamming mentioned that the lean paradigm can be applicable in many other areas and he listed characteristics of lean supply which will be followed by other researchers [4]-[5]. New and Ramsay (1997) made a comprehensive research about lean supply chain concept and they made suggestions for the future research [6]. Erridge and Murray (1998) researched within Belfast City Council to the feasibility of lean supply in local government purchasing [7]. Taylor (1999) described the Parallel Incremental Transformation Strategy (PITS) for an approach of the transformation of supply chain from traditional to lean [8].

In 2000s lean supply chain had more attention. McIvor (2001) determined the principles of lean supply model between an original equipment manufacturer and its key suppliers according to the dimension of design and joint cost reduction [9]. Fearne and Fowler (2006) mentioned the lean thinking in supply chain impacts on the industry effectiveness [10]. Part of Taylor (2006) researched was focused the developing an integrated lean supply chain in UK pork sector [11]. Another research in UK red meat sector was made by Cox et. al. (2007). They investigated the scope for lean strategies to be adopted in three red meat supply chains which are beef, lamp and pig [12]. Adamides et. al. (2008) developed the software tools for the design and management of lean supply network. They also discussed the knowledge and information management requirements of lean supply networks in their paper [13]. Wee and Wu (2009) studied a case from the Ford Motor Company to describe a lean supply chain (LSC) through value stream mapping (VSM). They also demonstrated lean supply chain affects product cost and quality [14].

After a decade, in 2010s, lean supply chain still has a important role between the others supply chain methods. Perez et. al. (2010) tested lean approaches in the Catalan pork supply chain [15]. Mollenkopf et al. (2010) made a literature review to examine the relationship among green, lean, and global supply chain strategies [16]. Zarei et al. (2011) integrated Analytic Hierarchy Process and Quality Function Deployment to enhance the leanness of the food supply chain [17]. Arlbjørn et. al. (2011) investigated the lean paradigm in a service supply chain management in the Danish municipal sector [18]. Martinez-Jurado and Moyano-Fuentes (2013) discussed the relationship between lean supply chain management and sustainability in a part of their review paper [19]. Chen et al. (2013) tried to find a solution for insufficient supply chain operations. They applied lean production and radio frequency identification (RFID) technologies to improve supply chain efficiency and effectiveness [20].

Review of Agile Supply Chain Management

Agile supply chain has emerged towards the end of the 1990s. Mason-Jones and Towill (1999) presented a route-map indicating the steps to be taken in achieving supply chain agility in real world [21]. Christopher (2000) proposed the conceptual framework of agile supply chain and discussed some applications [3]. Tolone (2000) studied on virtual situation room technology to provide agile supply chain [22]. Christopher and Towill (2002) proposed an integrated model for the design of agile supply chains [23]. Yusuf et al. (2004) discussed the nature of an agile supply chains and explored some of its attributes and capabilities [24]. White et al. (2005) investigated the role of emergent information technologies and systems in enabling supply chain agility [25]. Swafford et al. (2006) presented a framework of an organization's supply chain process flexibilities as an important antecedent of its supply chain agility [26]. Agarwal et al. (2007) proposed interpretive structural modeling to explore interrelationships of the variables in strategic planning for improving supply chain agility [27]. Song et al. (2007) studied on the agile supply chain management based on agent technology [28].

The papers related agile supply chains have increased year after year. Swafford et al. (2008) provided additional insights by testing hypotheses within a proposed conceptual framework of supply chain agility [29]. Jain et al. (2008) developed an approach based on fuzzy association rule mining for evaluating agility with both tangibles and intangibles characteristics in supply chain [30]. Baker (2008) studied on design and operation of distribution centres within agile supply chains [31]. Huang et al. (2009) developed a rough set-based generic label correcting algorithm which has agile approach in order to reduce the data/feature space in a

supply chain. Moreover, the four cases of the supply chain modeling are illustrated [32]. Luo et al. (2009) develop an information-processing model based on radial basis function artificial neural network for supplier selection in agile supply chains [33]. Riberio et al. (2009) presented an architecture supporting agile supply chains via service-oriented shop floor [34]. Braunscheidel and Suresh (2009) investigated the organizational antecedents of a firm's supply chain agility for risk mitigation and response [35].

Agile supply chain management has kept on its importance since 2010. Pearson et al. (2010) studied on process control in an agile supply chain network [36]. Wu and Barnes (2010) developed a model for the formulation of supply partner selection criteria in agile supply chain by applying both the Dempster–Shafer and optimisation theory [37]. Ji-peng et al. (2011) developed a prototype of the steel industry agile supply chain system with web service technology to achieve the supply chain agility and reconfigurability [38]. Ngai et al. (2011) developed a conceptual model based on the resource-based view to explore impact of the relationship between supply chain competence and supply chain agility [39]. Wang (2011) studied on dynamic coordination of framework and supporting platform design of the agile supply chain [40]. Costantino et al. (2012) proposed a technique for the strategic management of the chain addressing supply planning and allowing the improvement of the manufacturing supply chain agility in terms of ability in reconfiguration to meet performance [41]. Azevedo et al. (2012) proposed an index to assess the agility and leanness of individual companies and the corresponding supply chain. A case study in automotive industry was presented [42]. Ahn et al. (2012) discussed the use of extensible markup language for agile supply chains and proposed practical guidelines and future research directions for the field [43]. Vinodh et al. (2013) designed agile supply chain assessment model in order to assess the effectiveness of agile manufacturing. The computation was performed using fuzzy logic approach [44]. Liu et al. (2013) proposed a model to examine how information technology capabilities affect firm performance through absorptive capacity and supply chain agility [45]. Yusuf et al. (2014) assessed the link between dimensions of agile supply chain, competitive objectives and business performance in the UK North Sea upstream oil and gas industry via statistical techniques [46]. Yang (2014) developed a conceptual framework to investigate the antecedents of manufacturers' supply chain agility [47].

Review of Leagile Supply Chain Management

The term of legaility firstly used by Naylor et al. in 1999. Both lean and agile paradigm combined with a total supply chain strategy. Naylor et al. explain each paradigm's definition and they also provided their comparison according to key characteristics. They put information by considering to manufacturing paradigms as supply chain strategies [1].

After the first published paper researchers had huge interest on the legile supply chain strategy and paper in 1999 was still in the top 15 most downloaded articles during July-September 2007 [48]. For investigate legaility in supply chain; some researcher use comparative approach between three paradigms. Mason-Jones et al. (2000) classified supply chain design and operation depends on the actual needs of marketplace. The paper also gave a case study for each paradigm [49]. Agarwal et al. (2006) firstly specified performance determinant (lead time, cost, quality, service level) and made comparison between three strategies. Then they used the Analytic Network Process (ANP) approach to give the best supply chain type for the decision-makers [2]. Zhang et al. (2012) compared the traditional and leagile supply chain by using the system engineering concept. The paper chose the leagile strategy rather than traditional strategy by listing it's advantages [50]. Goldsbay et al. (2006) firstly described and reviewed all the three supply chain strategies. Then they examined supply chain performance according to three main aspects which are the expected level of customer service attainability, inventory and total cost [51]. Kisperska-Moron et al. (2011) picked a Polish distributor for a case study to compare mostly lean and agile supply chain strategy. Their paper also mentioned the leagility is an example of transformation the lean/agile strategies according to market needs [52].

Picking a case study or special subject another approaches style for the researchers. Couple of them focuses on the food industry. van der Vorst et al. (2001) analyzed the poultry supply chain in Netherland with the customer order decoupling point (CODP). After their research they mentioned that leagility and decoupling

point very useful for analyzing supply chain but characteristic of food supply chain cause some restriction to applicability of them [53]. Rahimnia et al. (2009) investigated the fast food restaurant chains which are located in Iran. Their study has also shown that leagility concept is useful in supply chain but the application of it is restricted in fast food supply chain due to the health regulations in Iran [54]. Rahimnia et al. also continued their research in different area but still with a case in Iran. They picked up the second case in professional services. Their research analyzed the concept of leagility in healthcare services, especially hospitals in Iran [55].

The other specific sector is textile industry. Bruce et al. (2004) looked at three supply chain management approaches (lean, agile, leagile) used in the textiles and apparel sector. They used different type of companies for the cases and then they specified companies in textile and apparel need capability of quick respond to changing market demands [56]. Bruce and Daly also mentioned leagile supply chain management specifically on fast fashion in another research [57].

Many other researches mentioned leagility concept in supply chain management with different perspective. Soni et al. (2012) mentioned that lack of standard is a issue to create a structure of any supply chain paradigm. They reached that result by evaluating reliability and validity of lean, agile and leagile supply chain construct in Indian manufacturing industry. For the evaluation, they used two methods; first the literature of supply chain management is researched and second survey research is applied to the pillars of supply chain management network in Indian manufacturing industry [58]. Purvis et al. (2014) recently focused meaning of flexibility in the context of all three supply chain paradigms. Then integrated leagility concept to the supply network flexibility and analyzed it [59]. Mason-Jones et al. (2000) tried to answer the question "How can we integrated lean and agile paradigms to create leagilie paradigm?". Their paper includes many comparisons between the lean and agile paradigms [60]. Herer et. al. (2002) offered different solution to achieve leagility in supply chain. They introduced transshipment with several examples as a fast and inexpensive approach in supply chain [61]. Chan et al. (2009) also offered solution but specifically scheduling problem in leagile environment. Their paper presented a leagile supply chain model for manufacturing industries and proposed Hybrid Chaos-based Fast Genetic Tabu Simulated Annealing (CFGTSA) algorithm to solve the problem [62]. Lastly, Ramana et al. (2013) noticed that there is a less attention on performance measurement and metrics pertaining to leagile supply chains and they developed a generic hierarchical model for performance measurement [63].

Conclusion

In the literature is seen that lean and agile strategies firstly used for manufacturing and production areas. After the 1990s, researchers found these strategies are applicable to many other area. This research identified the leagile paradigm which is combination of leanness and agility paradigms and reviewed other researches about all three strategies in the supply chain area. In this paper, lean and agile supply chain managements were examined with respect to time while leagile supply chain was presenting according to research methods.

The analyzed articles are divided according to their SCM methods and they are given as tables in appendix. The journals they appear in and the containing subject of each of them also given in appendix. Distribution of three supply chain strategies among the 63 articles which are analyzed in this research shown in Figure 1. The researchers' focus moving from the lean strategy (17 articles) to the agile strategy (28 articles) in time. Combining both strategies makes a new focus which is called leagile strategy (18 articles).

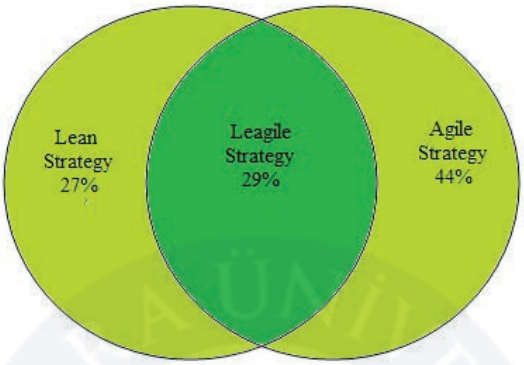


Figure 1. Distribution of Lean, Agile and Leagile strategies among the analyzed articles

The leagile strategy is a comparatively new strategy for the supply chain management. New attributes of leagility, applications of leagility in new sectors, new models for legile supply chain are outstanding issues for the future research. Especially, transformation of supply chain from traditional, lean or agile to leagile should be addressed.

Besides that quality is important point to satisfy the customer demand, for this reason quality become a significant element in the supply chain management also. Therefore to remain in the competitive market, company's should care about the quality. In the Lean Supply Chain Management, quality is one of the main part, so it should not be think that quality is apart from the Leagile Supply Chain Management. But the companies how produced a good qualified supply chain management. In order to measure the quality in Leagile Supply Chain Management, metrics should be found, addressed and measured. If we call the "Qualeagile Metrics", some implementations should be done for these metrics in the market and published by the researchers.

Appendix

List of the analyzed articles subject to Lean SCM with a time order

Paper Name	Journal Title	Year	Subject
Beyond Partnership: Strategies for Innovation and Lean Supply	Prentice-Hall, Hemel Hemstead	1993	Lean
Squaring lean supply with supply chain management	Journal of Operations & Production Management	1996	Lean
A critical appraisal of aspects of the lean chain approach	European Journal of Purchasing & Supply Management	1997	Lean
The application of lean supply in local government: the Belfast experiments	European Journal of Purchasing & Supply Management	1998	Lean
Parallel Incremental Transformation Strategy: An Approach to the Development of Lean Supply Chains	International Journal of Logistics Research and Applications	1999	Lean
Lean supply: the design and cost reduction dimensions	European Journal of Purchasing & Supply Management	2001	Lean
Efficiency versus effectiveness in construction supply chains: the dangers of "lean" thinking in isolation	Supply Chain Management: An International Journal	2006	Lean
Strategic considerations in the development of lean agri-food supply chains: a case study of the UK pork sector	Supply Chain Management: An International Journal	2006	Lean
Stairways to heaven or treadmills to oblivion?: Creating sustainable strategies in red meat supply chains	British Food Journal	2007	Lean
Supporting collaboration in the development and management of lean supply networks	Production Planning & Control	2008	Lean

Lean supply chain and its effect on product cost and quality: a case study on Ford Motor Company	Supply Chain Management: An International Journal	2009	Lean
Development of lean supply chains: a case study of the Catalan pork sector	Supply Chain Management: An International Journal	2010	Lean
Green, lean, and global supply chains	International Journal of Physical Distribution & Logistics Management	2010	Lean
Food supply chain leanness using a developed QFD model	Journal of Food Engineering	2011	Lean
Service supply chain management: A survey of lean application in the municipal sector	International Journal of Physical Distribution & Logistics Management	2011	Lean
Lean Management, Supply Chain Management and Sustainability: A Literature Review	Journal of Cleaner Production	2013	Lean
Supply chain management with lean production and RFID application: A case study	Expert Systems with Applications	2013	Lean

List of the analyzed articles subject to Agile SCM with a time order

Paper Name	Journal Title	Year	Subject
Total cycle time compression and the agile supply chain	International Journal of Production Economics	1999	Agile
The agile supply chain	Industrial Marketing Management	2000	Agile
Virtual situation rooms: connecting people across enterprises for supply-chain agility	Computer-Aided Design	2000	Agile
An integrated model for the design of agile supplychains	International Journal of Physical Distribution and Logistics Management	2002	Agile

Agile supply chain capabilities: determinants of competitive objectives	European Journal of Operational Research	2004	Agile
The role of emergent information technologies and systems in enabling supply chain agility	International Journal of Information Management	2005	Agile
A framework for assessing value chain agility	International Journal of Operations and Production Management	2006	Agile
Modeling agility of supply chain	Ind. Mark. Manage	2007	Agile
Study on the agile supply chain management based on agent	The Journal of China Universities of Posts and Telecommunications	2007	Agile
Achieving supply chain agility through IT integration and flexibility	International Journal of Production Economics	2008	Agile
A new approach for evaluating agility in supply chains using fuzzy association rules mining	Engineering Applica-tions of Artificial Intelligence	2008	Agile
The design and operation of distribution centres within agile supply chains	International Journal of Production Economics	2008	Agile
An agile approach for supply chain modeling	Transportation Research Part E	2009	Agile
Supplier selection in agile supply chains: An information-processing model and an illustration	Journal of Purchasing & Supply Management	2009	Agile
Supporting agile supply chains using a service-oriented shop floor	Engineering Applications of Artificial Intelligence	2009	Agile
The organizational antecedents of a firm's supply chain agility for risk mitigation and response	Journal of Operations Management	2009	Agile

Process control in an agile supply chain network	International Journal of Production Economics	2010	Agile
Formulating partner selection criteria for agile supply chains: A Dempster–Shafer belief acceptability optimisation approach	International Journal of Production Economics	2010	Agile
Interface Implementation of Manufacturing Industry Agile Supply Chain Nodes Based on Service Agent	Procedia Environmental Sciences	2011	Agile
Information technology, operational, and management competencies for supply chain agility: Findings from case studies	Journal of Strategic Information Systems	2011	Agile
The design of dynamic coordination architecture and supporting platform for agile supply chain	Procedia Engineering	2011	Agile
A model for supply management of agile manufacturing supply chains	International Journal of Production Economics	2012	Agile
An integrated model to assess the leanness and agility of the automotive industry	Resources, Conservation and Recycling	2012	Agile
Rethinking XML-enabled agile supply chains	International Journal of Information Management	2012	Agile
Design of agile supply chain assessment model and its case study in an Indian automotive components manufacturing organization	Journal of Manufacturing Systems	2013	Agile
The impact of IT capabilities on firm performance: The mediating roles of absorptive capacity and supply chain agility	Decision Support Systems	2013	Agile

A relational study of supply chain agility, competitiveness and business performance in the oil and gas industry	International Journal of Production Economics	2014	Agile
Supply chain agility: Securing performance for Chinese manufacturers	International Journal of Production Economics	2014	Agile

List of the analyzed articles subject to Leagile SCM with a time order

Paper Name	Journal Title	Year	Subject
Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain	International Journal of Production Economics	1999	Lean + Agile + Leagile
Engineering the leagile supply chain	Production Management	2000	Lean + Agile + Leagile
Lean, agile or leagile? Matching your supply chain to the marketplace	International Journal of Production Research	2000	Lean + Agile + Leagile
Supply Chain Design in the Food Industry	International Journal of Logistics Management	2001	Leagile
Transshipments: An emerging inventory recourse to achieve supply chain leagility	International Journal of Production Economics	2002	Leagile
Lean or agile A solution for supply chain management in the textiles and clothing industry?	International Journal of Operations & Production Management	2004	Lean + Agile + Leagile
Modeling the metrics of lean, agile and leagile supply chain: An ANP-based approach	European Journal of Operational Research	2006	Lean + Agile + Leagile
Buyer behaviour for fast fashion	Journal of Fashion Marketing and Management	2006	Leagile

Modeling lean, agile, and leagile supply chain strategies	Journal of Business Logistics	2006	Lean + Agile + Leagile
Benchmarking leagility in mass services The case of a fast food restaurant chains in Iran	Benchmarking: An International Journal	2009	Leagile
Performance Optimization of a Leagility Inspired Supply Chain Model: A CFGTSA Algorithm based Approach	International Journal of Production Research	2009	Leagile
Supply chain leagility in professional services: how to apply decoupling point concept in healthcare delivery system	Supply Chain Management: An International Journal	2010	Leagile
On leanness, agility and leagile supply chains	International Journal of Production Economics	2011	Lean + Agile + Leagile
Improving supply chain performance to satisfy final customers: "Leagile" experiences of a polish distributor	International Journal of Production Economics	2011	Lean + Agile + Leagile
Research on Demand-driven Leagile Supply Chain Operation Model: a Simulation Based on AnyLogic in System Engineering	Systems Engineering Procedia	2012	Traditional + Leagile
Evaluating reliability and validity of lean, agile and leagile supply chain constructs in Indian manufacturing industry	Production Planning & Control	2012	Lean + Agile + Leagile
The development of a lean, agile and leagile supply network taxonomy based on differing types of flexibility	International Journal of Production Economics	2014	Lean + Agile + Leagile

References

[1] Naylor, J.B., Naim, M.N., Berry, D., 1999. Leagility: Integrating the lean and agile manufacturing paradigms in the total supplychain. International Journal of Production Economics 63, 107–118.
[2] Agarwal, A., Shankar, R., Tiwari, M.K., 2006. Modelling the metrics of lean, agile and leagile supply chain: an ANP-based approach. European Journal of Operational Research 173, 221–225.
[3] Christopher, M., 2000. The agile supply chain. Industrial Marketing Management 29, 37–44.
[4] Lamming, R., 1993. Beyond Partnership: Strategies for Innovation and Lean Supply. Prentice-Hall, Hemel Hemstead, UK.
[5] Lamming, R., 1996. Squaring lean supply with supply chain management. International Journal of Operations & Production Management 16 (2), 183-196.
[6] New, S., Ramsey, J., 1997. A critical appraisal of aspects of the lean chain approach. European Journal of Purchasing & Supply Management 3(2), 93-102.
[7] Erridge, A., Murray, J.G., 1998. The application of lean supply in local government: the Belfast experiments. European Journal of Purchasing & Supply Management 4(4), 207-221.
[8] Taylor, D., 1999. Parallel Incremental Transformation Strategy: An Approach to the Development of Lean Supply Chains. International Journal of Logistics Research and Applications 2(3), 305-323.
[9] McIvor, R., 2001. Lean supply: the design and cost reduction dimensions. European Journal of Purchasing & Supply Management 7 (4), 272-242.
[10] Fearne, A., Fowler, N., 2006. Efficiency versus effectiveness in construction supply chains: the dangers of "lean" thinking in isolation. Supply Chain Management: An International Journal 11 (4) , 283-287.
[11] Taylor, D.H., 2006. Strategic considerations in the development of lean agri-food supply chains: a case study of the UK pork sector. Supply Chain Management: An International Journal 11 (3) , 271-280.
[12] Cox, A., Chicksand, D., Palmer, M., 2007. Stairways to heaven or treadmills to oblivion?: Creating sustainable strategies in red meat supply chains. British Food Journal 109 (9), 689-720.
[13] Adamides, E.D., Karacapilidis, N., Pylarinou H., Koumanakos D., 2008. Supporting collaboration in the development and management of lean supply networks. Production Planning & Control 19 (1), 35-52.
[14] Wee, H.M., Wu, S., 2009. Lean supply chain and its effect on product cost and quality: a case study on Ford Motor Company. Supply Chain Management: An International Journal 14 (5), 335-341.
[15] Perez, C., de Castro, R., Simons, D., Gimenez, G., 2010. Development of lean supply chains: a case study of the Catalan pork sector. Supply Chain Management: An International Journal 15 (1), 55-68
[16] Mollenkopf, D., Stolze, H., Tate, W.L., Ueltschy, M., 2010. Green, lean, and global supply chains. International Journal of Physical Distribution & Logistics Management 40, 14-41.
[17] Zareia, M., Fakhrzad, M.B., Paghaleh, M.J., 2011. Food supply chain leanness using a developed QFD model. Journal of Food Engineering 102, 25-33.
[18] Arlbjørn, J.S., Freytag, P.V, de Haas, H., 2011. Service supply chain management: A survey of lean application in the municipal sector. International Journal of Physical Distribution & Logistics Management 41, 277-295.
[19] Martínez-Jurado, P.J., Moyano-Fuentes, J., 2013. Lean Management, Supply Chain Management and Sustainability: A Literature Review. Journal of Cleaner Production, 1-17.
[20] Chen, J.C., Cheng, C.H., Huang, P.B., 2013. Supply chain management with lean production and RFID application: A case study. Expert Systems with Applications 40, 3389-3397.
[21] Mason-Jones, R., Towill, D.R., 1999. Total cycle time compression and the agile supply chain. International Journal of Production Economics 62 (1), 61–73.
[22] Tolone, W.J., 2000. Virtual situation rooms: connecting people across enterprises for supply-chain agility. Computer-Aided Design 32, 109–117.
[23] Christopher, M., Towill, D. R., 2002. An integrated model for the design of agile supplychains. International Journal of Physical Distribution and Logistics Management 31(4), 235–246.
[24] Yusuf, Y.Y., Gunasekaran, A., Adeleye, E.O., Sivayoganathan, K., 2004. Agile supply chain capabilities: determinants of competitive objectives. European Journal of Operational Research 159 (2), 379–392.
[25] White, A., Daniel, E.M., Mohdzain, M., 2005. The role of emergent information technologies and systems in enabling supply chain agility. International Journal of Information Management 24, 396–410.
[26] Swafford, P.M., Ghosh, S., Murthy, N.N., 2006. A framework for assessing value chain agility. International Journal of Operations and Production Management 26 (2), 118–140.
[27] Agarwal, A., Shankar, R., Tiwari, M.K., 2007. Modeling agility of supply chain. Ind. Mark. Manage. 36, 443–457.
[28] Song, M., Fu, R., Zhu, C., Xın, Z., 2007. Study on the agile supply chain management based on agent. The Journal of China Unıversities of Posts and Telecommunications 14, 115-118.
[29] Swafford, P.M., Ghosh, S., Murthy, N., 2008. Achieving supply chain agility through IT integration and flexibility. International Journal of Production Economics 116 (2), 288–297.

[30] Jain, V., Benyoucef, L., Deshmukh, S.G., 2008. A new approach for evaluating agility in supply chains using fuzzy association rules mining. Engineering Applica- tions of Artificial Intelligence 21 (3), 367–385.
[31] Baker, P., 2008. The design and operation of distribution centres within agile supply chains. Int. J. Production Economics 111, 27–41.
[32] Huang, C.C., Liang, W.Y., Lin, S.H., 2009. An agile approach for supply chain modeling. Transportation Research Part E 45, 380–397.
[33] Luo, X., Wu, C., Rosenberg, D., Barnes, D., 2009. Supplier selection in agile supply chains: An information-processing model and an illustration. Journal of Purchasing & Supply Management 15, 249–262.
[34] Riberio, L., Barata, J., Colombo, A., 2009. Supporting agile supply chains using a service-oriented shop floor. Engineering Applications of Artificial Intelligence 22, 950–960.
[35] Braunscheidel, M.J., Suresh, N.C., 2009. The organizational antecedents of a firm's supply chain agility for risk mitigation and response. Journal of Operations Management 27 (2), 119–140.
[36] Pearson, M., Masson, R., Swain, A., 2010. Process control in an agile supply chain network. Int. J. Production Economics 128, 22–30.
[37] Wu, C., Barnes, D., 2010. Formulating partner selection criteria for agile supply chains: A Dempster–Shafer belief acceptability optimisation approach. Int. J. Production Economics, 284–293.
[38] Ji-peng, W., Jing, X., Tian-lin, W., 2011. Interface Implementation of Manufacturing Industry Agile Supply Chain Nodes Based on Service Agent. Procedia Environmental Sciences 11, 111 – 117.
[39] Ngai, E.W.T., Chau, D.C.K., Chan, T.L.A., 2011. Information technology, operational, and management competencies for supply chain agility: Findings from case studies. Journal of Strategic Information Systems 20, 232–249.
[40] Wang, D.,Zhao, Y., Wang, H., 2011. The design of dynamic coordination architecture and supporting platform for agile supply chain. Procedia Engineering 15, 3318 – 3322.
[41] Costantino, N., Dotoli, M., Falagario, M., Fanti, M.P., Mangini, A.M., 2012. A model for supply management of agile manufacturing supply chains. Int. J. Prod. Econ. 135 (1), 451–457.
[42] Azevedo, S.G., Govindan, K., Carvalho, H., Cruz-Machado, V., 2012. An integrated model to assess the leanness and agility of the automotive industry. Resources, Conservation and Recycling 66, 85–94.
[43] Ahn, H. J., Childerhouse, P., Vossen, G., & Lee, H. (2012). Rethinking XML-enabled agile supply chains. International Journal of Information Management, 32, 17–23.
[44] Vinodh, S., Devadasan, S.R., Vimal, K.E.K., 2013. Design of agile supply chain assessment model and its case study in an Indianautomotive components manufacturing organization. Journal of Manufacturing Systems 32, 620–631.
[45] Liu, H., Ke, W., Wei, K.K., Hua, Z., 2013. The impact of IT capabilities on firm performance: The mediating roles of absorptive capacity and supply chain agility. Decision Support Systems 54, 1452–1462.
[46] Yusuf,Y.Y., Gunasekaran, A., Musa, A., Dauda, M., El-Berishy, N.M., Cang, S., 2014. A relational study of supply chain agility, competitiveness and business performance in the oil and gas industry. Int. J. Production Economics 147, 531–543.
[47] Yang, J., 2014. Supply chain agility: Securing performance for Chinese manufacturers. Int. J.Production Economics 150, 104–113.
[48] Naim, M.M., Gosling, J., 2011. On leanness, agility and leagile supply chains. International Journal of Production Economics 131, 342-354.
[49] Mason-Jones, R., Naylor B. and Towill, D.R., 2000. Lean, agile or leagile? Matching your supply chain to the marketplace. International Journal of Production Research 38 (17), 4061-4070.
[50] Zhang, Y., Wang, Y., Wu, L., 2012. Research on Demand-driven Leagile Supply Chain Operation Model: a Simulation Based on AnyLogic in System Engineering. Systems Engineering Procedia 3, 249-258.
[51] Goldsby, T.J., Griffis, S.E., Roath, A.S., 2006. Modeling lean, agile, and leagile supply chain strategies. Journal of Business Logistics 27, 57-80.
[52] Kisperska-Moron, D., Haan, J., 2011. Improving supply chain performance to satisfy final customers: ''Leagile'' experiences of a polish distributor. International Journal of Production Economics 133, 127-134.
[53] van der Vorst, J.G.A.J., van Dijk, S.J., Beulens, A.J.M., 2001. Supply Chain Design in the Food Industry. International Journal of Logistics Management 12 (2), 73-86.
[54] Rahimnia, F., Moghadasian, M., Castka, P., 2009. Benchmarking leagility in mass services: The case of a fast food restaurant chains in Iran. Benchmarking: An International Journal 16 (6), 799-816.
[55] Rahimnia, F., Moghadasian, M., 2010. Supply chain leagility in professional services: how to apply decoupling point concept in healthcare delivery system. Supply Chain Management: An International Journal 15 (1), 80-91.
[56] Bruce, M., Daly, L., Towers, N., 2004. Lean or agile: A solution for supply chain management in the textiles and clothing industry?. International Journal of Operations & Production Management 24, 151-170.
[57] Bruce, M., Daly, L., 2006. Buyer behaviour for fast fashion. Journal of Fashion Marketing and Management 10, 329-344.

[58] Soni, G., Kodali, R., 2012. Evaluating reliability and validity of lean, agile and leagile supply chain constructs in Indian manufacturing industry. Production Planning & Control: The Management of Operations 23, 864-884.
[59] Purvis, L., Gosling, J., Naim, M.M., 2014. The development of a lean, agile and leagile supply network taxonomy based on differing types of flexibility. International Journal of Production Economics 151, 100-111.
[60] Mason-Jones, R., Naylor, B., Towill, D.R., 2000. Engineering the leagile supply chain. International Journal of Agile Management Systems 2, 54-61.
[61] Herer, Y.T., Tzur, M., Yucesan, E., 2002. Transshipments: An emerging inventory recourse to achieve supply chain leagility. International Journal of Production Economics 80, 201-212.
[62] Chan, F.T.S., Vikas, K., 2009. Performance optimization of a leagility inspired supply chain model: a CFGTSA algorithm based approach. International Journal of Production Research 47 (3), 777-799.
[63] Ramanaa D.V., Raob K.N., Kumara J.S., 2013. Evaluation of performance metrics of leagile supply chain through fuzzy MCDM. Decision Science Letters 2, 211–222.

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

A Supplier Selection and Order Allocation Methodology for Green Supply Chains

Gülfem Tuzkaya [1], *Hüseyin Selçuk Kılıç* [2], *Canan Ağlan* [3]

Abstract

Due to the fact that the natural resources are limited and the demand increase level has accelerated, being an environmentally benign organization is getting more and more important. Various environmental regulations and strategies have been embedded to the organizational processes in recent years. Green supply chain management is one of these important topics and the focus of this study is to design a supplier selection and order allocation methodology for this managerial aspect. Different from the most of the supplier selection studies of the related literature, multi-item and multi-supplier case is considered. A multi-criteria decision making methodology is embedded in and a multi-objective mathematical model is proposed for this case. Finally, a numerical example is presented and the results are analyzed.

Keywords: Multi-Objective Linear Programming, Reverse Logistics, Green Supply Chain, Supplier Selection, Order Allocation

Introduction

In today's global competitive environment, the issue is not only selecting the most cost effective supplier but also environmentally conscious suppliers. Environmental consciousness requires awareness on environmental pollution issues [1]. Environmental events such as global warming, air and water pollution and other events impose firms on being aware of environmental aspect for activities they performed [2]. Sarkis [3] and Lee et al. [4] listed the environment care practices as; life cycle analysis, total quality environmental management, Green Supply Chain Management (GSCM) and ISO 14000 standards.

The key criteria in selecting the best supplier have been changed through the years. In the late 1970s and early 1980s cost was the first criterion to select the best suppliers.

Whilst, in 1990s, cycle time and customer became the main factors to select the best supplier. However, in 2000s environmental factors became a key success issue in supplier selection. This factor created a new paradigm that gives rise to Green Supply Chain [1].

Environmentally conscious initiatives started with reducing energy consumption, emissions and waste and then clean technologies emerged to reduce the environmental impact in production process and nowadays the environmental aspect is involved in every step of the supply chain [2].

[1] Gülfem Tuzkaya, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, gulfem.tuzkaya@marmara.edu.tr

[2] Hüseyin Selçuk Kılıç, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, huseyin.kilic@marmara.edu.tr

[3] Canan Ağlan, , Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, canan.aglan@marmara.edu.tr

Considering the environmental aspect of supply chain, generates the term green supply chain. The difference between traditional and green supply chain is the environmental issues [5]. Shen et al. [2] divide the environmental issues into two main approaches; one is proactive which includes environmentally conscious design and manufacturing, and the other is reactive approach which tries to avoid penalties that cause environmentally unconscious events. Environmental issues play a vital role in green logistics. The cost components of environmental issues include, recycling, clean technology, pollution reduction capacity and environmental cost [6].

Green supply chain concept started to become a must for organizations since environmental laws and regulations. Environmental performance of a firm is assessed with respect to its conformance to the environmental laws and regulations [1].

Reverse logistics which can be defined simply as the recovery of the used products [7]. Materials flow from customer to supplier in reverse logistics. The aim of reverse logistic activities is to maximize the value of the used product by means of a suitable way such as recycling, reusing or disposing [8].

Min and Ko [9] state that product returns constitute 1% through 35% of total sales depending on the industry. Product reuse in manufacturing is a profitable one and also supports green logistics by improving environmental awareness [8]. This emphasizes the importance of reverse logistics activities in the supply chain.

Reverse logistics activities assist used materials being involved to their life cycle again by planning and operating the return of products [10]. The difference between reverse and forward logistics is that, reverse logistics controls the inbound flow and storage of used products to create value and dispose the used products [11]. The relationship between reverse logistics and environmental legislations comes from the requirement of reuse, recycling and proper disposal of dangerous products. The importance of collection, packaging, storage, sorting, transaction processing, delivery, integration and correct disposal which are the same with forward logistics becomes important again in reverse logistics activities [10].

There are several industries that utilize reverse logistics such as; automobiles, plastics, carpets, papers, chemicals and medical items [8].

The management of reverse logistics activities can be handled; by the company, by reverse logistics providers, by cooperatives of waste pickers or municipal organizations [12]. Specialization in reverse logistics activities requires a special information system for tracing/tracking data and thorough equipment for returns [8].

The advantages of specialized third party reverse logistics providers (3PRLP) are reduced logistics costs and companies can concentrate on their own business [8]. Reverse logistics provides advantages on reducing cycle time and increasing delivery performance. By using 3PRLP, a company can get the advantage of economies of scale of 3PRLPs which results important cost savings.

Another reason to use 3PRLPs is that product nature may require different reverse logistics activities .The ambiguity of unit cost differences on returned products, different space requirements in the warehouse may lead firms to work more than one 3PRLPs [13].

Assigning suppliers for reverse logistics activities is a critical task for sustainable supply chain [10]. There are important criteria in selecting the best supplier for reverse logistics. Aissaoui et al. [14] state that purchasing costs consist of more than 50% of expenses. This cost proportion implies the importance of purchasing activities for the firms.

The selection criteria should be identified carefully for 3PRLPs. One of the most important criteria is the environmental consciousness [15]. Quality, capability, flexibility, production and process innovation are the other criteria in selecting 3PRLP [16]. Efendigil et al. [13] considered on time delivery ratio, confirmed fill rate, service quality level, operation cost, capacity usage ratio, cycle time flexibility index, index of integration level, increment in market share, research and development ratio, environmental expenditures, and customer satisfaction index criteria in selecting the best 3PRLPs.

There are two types of supplier selection option. One is single supplier selection problem. In this option, one supplier is selected for all purchasing activities. The next option is multiple supplier selection [1]-[17]. The issue in multiple supplier selection is selecting best suppliers and allocating the optimum order quantities based on several criteria.

Several methods in the related literature can be found on supplier selection problems. Ho et al. [18] listed approaches for multiple supplier option. They concluded that an integrated approach consisting of Analytic Hierarchy Process (AHP) and Goal programming is commonly used in solving multiple supplier selection option. The other methods that are used in the literature; LP, Multi objective programming, total cost ownership, data envelopment analysis and simulation is included in class of single models. The integrated models which are commonly found in the literature can be listed as; AHP and Linear programming, AHP and Fuzzy set theory, Data envelopment analysis and multi objective programming [1].

Besides these Fuzzy set theory is the mostly utilized topic in assigning weights to suppliers [19]-[20]-[21]-[22]-[23]-[24].

In this study, a two phase fuzzy goal programming approach is applied to the multi-objective reverse logistics supplier selection and order allocation problem. Objective functions are assumed as fuzzy functions and proper membership functions are constructed for them. In the second section, a literature review of the research scope is presented. In the third section, proposed methodology is summarized. In the fourth section, a numerical example and results are given and the final section is the conclusions.

Literature Review

In this part of the study the literature considering both green supply chain management and 3PRLPs selection studies are handled. The methodologies and criteria considered in literature are briefly discussed.

Frequently used criteria in the literature in GSCM are quality, delivery price/cost, manufacturing capability, service management, technology, pollution production, resource consumption, Eco-design, green image, environmental management system, commitment of GSCM from managers, use of environmentally friendly technology, use of environmentally friendly materials and staff environmental training [2]-[18].

Awashthi et al. [25] constructed a hierarchy for supplier selection problem and determined criteria weights using fuzzy AHP and fuzzy TOPSIS method and select the best supplier. They listed criteria in GSCM as; availability of clean materials, environmental efficiency, green image, environmental costs, green products, environmental and legislative management and green process management. They developed a fuzzy multi objective linear programming approach to allocate order quantities to selected suppliers.

Kannan et al. [1] applied fuzzy multi attribute utility theory and multi objective programming approach to select suppliers and assign order quantities. They utilized fuzzy AHP and TOPSIS methods to assign the subjective importance weights to criteria they considered to rank the alternatives. Multi objective linear programming model is incorporated to define quality control, capacity constraints and several objectives. The objective of multi objective linear programming model was to maximize the total value of purchasing at the same time. They applied the method in an automobile manufacturing company.

The sustainability also serves the green supply chain. Brandenburg et al. [26] identified 134 papers on qualitative, formal models which focus on sustainability in supply chain.

The reverse logistics activities are an important part of green supply chain management [27]. As stated earlier, the technology and process are different in reverse logistics activities and require specialized information tracking capability, firms generally consider working with 3PRLPs. Guarnieri et al. [10] focused on outsourcing reverse logistics activities which are imposed by Brazilian government. They proposed a systematic approach to select 3PRLP and a conceptual framework utilizing multi criteria decision aid modeling. They also performed a brief literature review to define set of the set of criteria for decision makers. They divided 6 groups of criteria; forward logistics, reverse logistics, financial, capacity, and environmental alliances. The interesting criteria under each group can be listed as; tracking and tracing, service quality level, system flexibility index, increment in market share, research and development ratio, cost of maintaining a repair facility, recapturing value, capacity usage ratio, technical and engineering capability, green products, mentoring of suppliers, formation of strategic alliances and product recovery options.

Efendigil et al. [13] proposed a combined artificial neural network and fuzzy logic to determine the best 3PRLP. Min and Ko [9] proposed a mixed integer programming model and a genetic algorithm to select the location of repair facilities for 3PRLPs. They applied the developed methodology in a numerical example.

Kannan et al. [8] developed a multi criteria group decision making model to choose the reverse logistics provider. Since the selection process involves vagueness they utilized fuzzy set theory. They used interpretive structural modeling and fuzzy TOPSIS method. The effectiveness of the model is illustrated on a battery producer in India.

Regarding the reviewed studies, it can be concluded that the number of studies including the selection of suppliers in green supply chains is limited. This study aims to fill this gap with a multi-objective model under multi-item/multi-supplier environment.

Proposed Methodology

The proposed methodology has two parts as shown in Figure 1. In the first part, the Reverse Logistics Score (RLS) of each supplier is obtained via taking the expert opinions and then the obtained scores are used as inputs in the developed multi-objective mathematical model. There are two objectives in the mathematical model. The first one is to maximize Total RLS score and the second one is to minimize the total cost including variable and fixed costs.

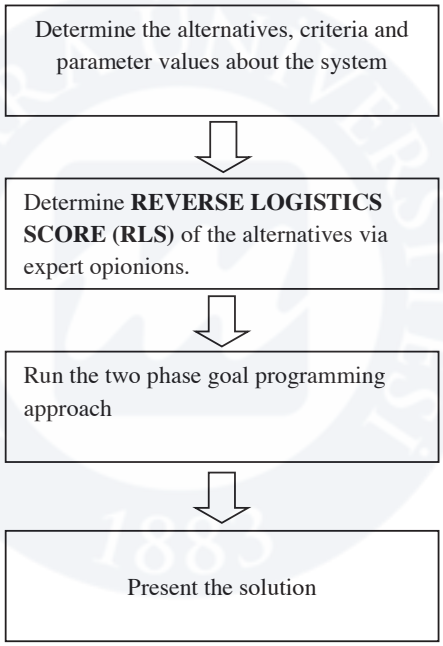


Figure 1. The steps of the proposed methodology

The related information about the used methods is provided in the following sub-sections.

Mathematical Model

A mixed integer linear programming (MILP) model is developed to determine the suppliers and allocated demand to them. There are two main objectives in the model. The first one is to maximize the score specifically called **"Reverse Logistics Score (RLS)"** obtained from the evaluation of alternatives with respect to the determined criteria via expert opinions by direct scoring. However, the other objective is to minimize the **"Total Cost"** including variable and fixed costs. The proposed model is as follows:

Assumptions

Each recycling material in a region can be allocated to only one of the alternatives.
The amount of recyclable material expected to occur in a region is deterministic

Indices

i Index for suppliers i∈ I
j Index for region $j \in J$
k Index for recycling material $k \in K$

Parameters

C_{ik} Capacity of supplier "i", with respect to recycling material *"k"*

D_{jk} Amount of recycling material "k" to be collected in region *"j"*
F_{ijk} Fixed cost of each supplier *"i"* for each region *"j"* for recycling material *"k"*
M A big number
$MaxR_j$ Maximum number of suppliers allowed in region *"j"*
$MaxS$ Total amount of suppliers allowed in the system
RLS_i Reverse Logistics Score of supplier *"i"*
V_{ijk} Variable cost of each supplier *"i"* for each region *"j"* for per ton of recycling material *"k"* (TL/ton)

Decision Variables

X_{ijk} Supplier *"i"* is assigned to recycling material *"k"* in region *"j"*
Y_{ij} Supplier *"i"* is assigned to region *"j"*
Z_i Supplier *"i"* is selected or not selected (1 or 0)

Objective Functions

Objective 1: First objective function is the maximization of Total Reverse Logistics Score (TRLS)

Max **TRLS** $= \sum_i \sum_j \sum_k (RLS_i * X_{ijk} * D_{jk})$ (1)

Objective 2: Second objective function is the minimization of total cost (TCOST)

Min **TCOST =** $\sum_i \sum_j \sum_k (X_{ijk} * D_{jk} * V_{ijk}) + \sum_i \sum_j \sum_k (X_{ijk} * F_{ijk})$ (2)

Constraints

$\sum_i (X_{ijk} * D_{jk}) = D_{jk}$ $\forall_j, \forall_k$ (3)

$\sum_j (X_{ijk} * D_{jk}) \leq C_{ik}$ $\forall_i, \forall_k$ (4)

$M * Y_{ij} \geq \sum_k X_{ijk}$ $\forall_i, \forall_j$ (5)

$M * Z_i \geq \sum_j \sum_k X_{ijk}$ $\forall_i$ (6)

$\sum_i Y_{ij} \leq maxR_j$ $\forall_j$ (7)

$\sum_i X_{ijk} = 1$ $\forall_j, \forall_k$ (8)

$\sum_i Z_i \leq maxS$ (9)

$X_{ijk}, Y_{ij}, Z_i \in \{0,1\}$ *binary integers*, $\forall_i, \forall_j, \forall_k$ (10)

- (1) The first objective of the model is to maximize the Total Reverse Logistics Score (TRLS) including the sum of the multiplications of each supplier's Reverse Logistics Score (RLS) by the quantities assigned to them.
- (2) The second objective of the model is to minimize the Total Cost (TCOST) including the sum of the variable and fixed costs.
- (3) The demand of each region *"j"* with respect to each material *"k"* is satisfied.
- (4) The capacity of each supplier *"i"* with respect to each recycling material *"k"* is not exceeded.
- (5) A supplier "i" is assigned to a region *"j"*, if any of the *"k"* recycling material at that region is provided by it.
- (6) A supplier *"i"* is selected if any of the recycling material *"k"* at any region *"j"* is provided by it.
- (7) Maximum number of suppliers in a region is restricted by an upper value.
- (8) A *"k"* recycling material from a certain "*j*" region can only be collected by one supplier type "*i*".
- (9) Maximum number of suppliers in the system is restricted by an upper value.

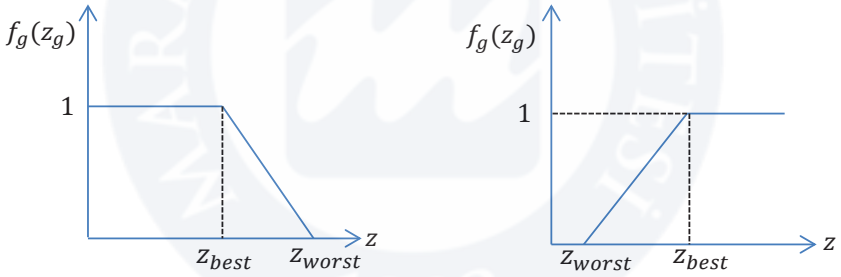
- (10) The decision variables are binary integers.

Two phase fuzzy goal programming approach

In this study, two phase fuzzy goal programming approach is applied. First of all, best (z_{best}) and worst (z_{worst}) values for each objective functions is to be found. Objective function value is z_g .Those values are used to establish membership functions ($f_g(z_g)$) (Figure 2). Membership functions for minimization (Figure 2a) and maximization (Figure 2b) are given in Figure 2 and related equations are given in Equation 11 and 12, respectively [28].

$$f_g(z_g) = \begin{cases} 1 & z_g \le z^g_{best} \\ \frac{z^g_{worst} - z_g}{z^g_{worst} - z^g_{best}} & z^g_{best} \le z_g \le z^g_{worst} \\ 0 & z_g \ge z^g_{worst} \end{cases} \quad (11)$$

$$\begin{cases} 1 & z_g \ge z^g_{best} \\ \frac{z_g - z^g_{worst}}{z^g_{best} - z^g_{worst}} & z^g_{worst} \le z_g \le z^g_{best} \\ 0 & z_g \le z^g_{worst} \end{cases} \quad (12)$$



a) Membership function for a minimization function

b) Membership function for amaximization function

Figure 2. Membership functions for objective functions [29]-[30].

Two phase approach is adapted from Liang [31] and details are given below:

Phase 1. Max-min approach: This approach tries to improve the satisfaction degree of the objective function which has a minimum satisfaction degree. General satisfaction degree (GSD1) is tried to be maximized and for each objective function, $f_g(z_g)$ values should be more than or equal to GSD1.

$$Max\ GSD1 \quad (13)$$

$$s.t.$$

$$0 \le \text{GSD1} \le f_g(z_g) \qquad \forall g \quad (14)$$

Equations (3)-(10)

Phase 2. Weighted sum approach: In this phase, objective function satisfaction degrees obtained in the first phase ($OFSD^1_g$) are taken as a constraint (a minimum bound) for each objective function satisfaction degree. Each objective function's satisfaction degree ($OFSD_g$) obtained in this phase is weighted considering the relative importance of the weights. Total weighted objective function satisfaction degrees is tried to be maximized and this total is general satisfaction degree (GSD2).

$$Max\ GSD2 = \sum_{g=1}^{K} w_{g*} OFSD_g \quad (15)$$

$$s.t.$$

$$OFSD^1_g \le OFSD_g \le f_g(z_g) \qquad \forall g \quad (16)$$

$\sum_{g=1}^{K} w_g = 1$ (17)

Equations (3)-(9)

$0 \leq GSD2 \leq 1$ (18)

$0 \leq OFSD_g^1 \leq 1 \quad \forall g$ (19)

$0 \leq OFSD_g \leq 1 \quad \forall g$ (20)

$0 \leq w_g \leq 1 \quad \forall g$ (21)

Numerical Example

The proposed methodology is applied in a numerical example. The numerical example is constructed by benefiting from the real applications in the municipalities. Within the numerical example, there is a municipality and it wants to outsource the collection of four recyclable materials such as battery, glass, package and electronic waste. The related outsourcing firms will not only collect the recyclable material but also construct the infrastructure by providing the containers that are suitable for the storage of them.

While selecting the related suppliers, four criteria such as **timeliness** (conforming to the delivery schedule), **operation time** (loading-unloading time which affects the traffic condition), **environmentally friendliness** of the containers and the equipment used for handling them and **financial situation** of the supplier. Since this is a numerical example it is assumed that expert opinions are taken to evaluate the suppliers and weights are obtained as 0.01, 0.09, 0.5, 0.1, and 0.3 for supplier 1, 2, 3, 4 and 5 respectively.

There are 10 regions (shown with "R") within the land of municipality. The expected quantities to occur for each recyclable material within each region are depicted in Table 1.

Table 1. The expected quantities of recyclable materials to occur in 10 regions

Quantities (ton)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Battery	25	10	30	15	18	20	36	33	23	28
Glass	1,000	600	1,200	750	1,000	900	1,500	1,250	950	1050
Package	9,000	6,000	10,000	7,500	8,000	8,000	12,000	11,000	8,500	7,000
Electronic Waste	12	8	15	9	10	11	18	16	12	10

There are 5 alternative outsourcing firms to collect the recyclable waste. The firms have limited capacities with respect to each recyclable material as shown in Table 2.

Table 2. The capacities of alternatives with respect to each recyclable material

Capacity (ton)	Battery	Glass	Package	Electronic Waste
Alternative 1	375	-	125	150
Alternative 2	50	25	150	-
Alternative 3	275	20	112,5	250
Alternative 4	325	22,5	137,5	300
Alternative 5	-	25	75	275

The variable costs mainly including the transportation and handling costs that suppliers offer change depending on the region and recycling material type. The related parameters are shown as in Table 3. Although the variable costs could change with respect to recycling material type, they are accepted as same within a region in this example.

Table 3. The variable costs offered by each alternative with respect to each region from R1 to R10 for each recycling material type

Variable cost (TL/ton)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Alternative 1	24	35	33	25	40	34	28	36	27	42
Alternative 2	33	40	26	36	35	28	41	25	37	29
Alternative 3	25	25	35	40	28	36	30	24	25	33
Alternative 4	40	20	27	25	30	39	22	27	38	27
Alternative 5	25	44	30	33	24	29	39	41	23	38

Besides the variable costs, there is the cost of containers. Each of the supplier demands a fixed cost for containers for each region. The fixed costs could also change with respect to each recycling material type, but they are also accepted as same within a region in this example (Table 4).

Table 4. The fixed costs offered by each alternative with respect to each region from R1 to R10 for each recycling material type

Fixed cost (TL)	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Alternative 1	25,000	10,000	28,000	15,000	17,500	18,000	30,000	29,000	26,000	28,000
Alternative 2	24,000	11,000	30,000	14,000	16,000	20,000	27,000	28,000	27,500	29,000
Alternative 3	27,000	12,000	35,000	18,000	19,000	19,000	33,000	32,000	30,000	31,000
Alternative 4	22,000	9,000	29,000	20,000	18,000	24,000	31,000	34,000	28,000	27,000
Alternative 5	30,000	13,000	32,000	19,000	22,000	23,000	32,000	33,000	31,000	30,500

Results

First of all, the model is solved for single objective functions to find the best and worst values of the objective functions. Also, it should be noted that, maximum number of supplier is accepted to be three for the explained numerical example. Solution of the model with the first objective (OF1) gives us the best value for the first objective function (z^1_{best}). The values of the decision variables under this case are used to find the value of the second objective (OF2). Second objective value under these circumstances gives the worst value for the second objective (z^2_{worst}). Next, the model is solved with OF2, and (z^1_{worst}) and (z^2_{best}) values are found. Summary of the results for single objective solutions are given in the Table 5. Following the best and worst value of objective functions determination phase, membership functions are constructed using Equation 11 and 12. When the model is solved for Phase 1, a solution is obtained for the multi-objective case. For this phase, general satisfaction degree value is obtained as 0.6423685. Since, GSD1 should be less then and equal to membership values of the objective functions (Equation 14), its value is found equal the worst membership value which belongs to second objective function.

Table 5. Best and worst values for objective functions and Phase 1 results

Objective function type	Maximization	Minimization	Membership functions	
	OF1(z_1)	**OF2** (z_2)	$f_1(z_1)$	$f_2(z_2)$
(Single objective) OF1	48779 (z^1_{best})	3945035(z^2_{worst})	1	-
(Single objective) OF2	15129 (z^1_{worst})	3358456 (z^2_{best})	-	1
Multi-objective solution	36744	3568205	0.6423685	0.6424199
General satisfaction degree (GSD1) for the multi-objective solution (Phase 1)			0.6423685	

With the second phase, the general satisfaction degree level and the satisfaction degrees for each objective function is tried to be improved. For the second phase, model is re-written like as shown in Equations 15-21. Objective function satisfaction degrees obtained in first phase are set as minimum acceptable level of related objective functions (Equation 16). For phase two, objective functions weights are determined as 0.3 and 0.7 for OF1 and OF2, respectively. For the investigated numerical example and the data, with Phase 2 the results are not improved. Same general satisfaction degree and membership values are obtained with the Phase 1. The reason of this situation is the very close objective function membership values obtained in the Phase I. The meaning of this situation is that with the current conditions (with the data given in the example), parallel results can be obtained for the both objective functions. Since their membership values are close to each other, second phase approach would not provide an improvement opportunity. Results are summarized in Figure 3. Supplier 1 and 2 were not assigned to any region or recycling material. In the Figure 3, the recycling materials shown with green boxes are assigned to the third supplier; pink boxes are assigned to the fourth supplier; and blue boxes are assigned to the fifth supplier.

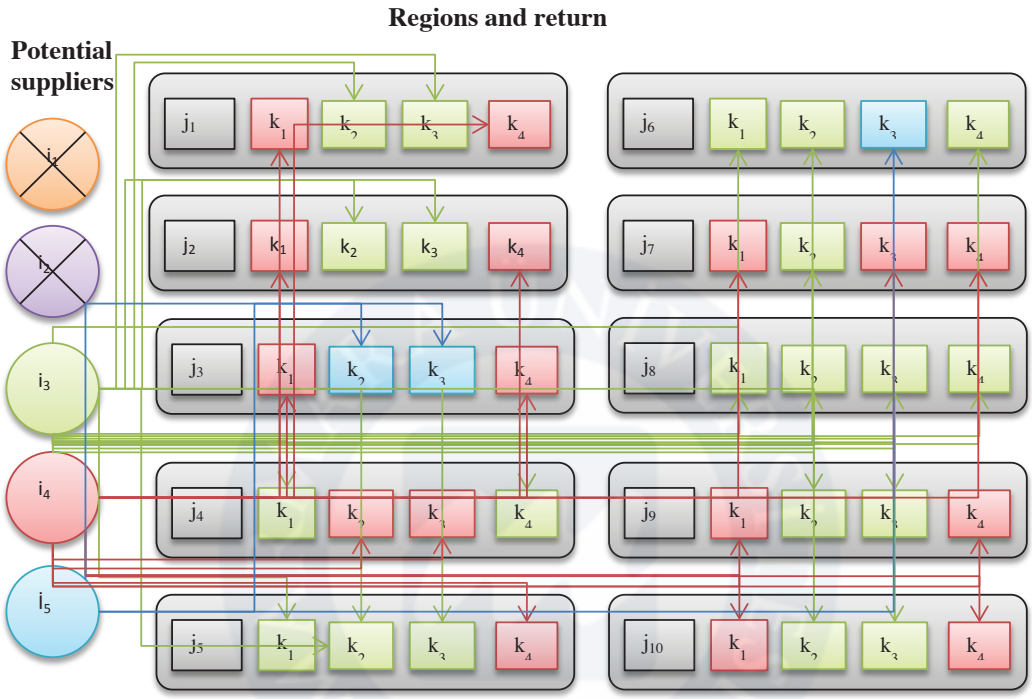


Figure 3. Supplier assignments

Conclusions

In this study, a multi-objective supplier selection and order allocation model is investigated for reverse supply chain networks. Different types of return products for different regions are tried to be assigned to the proper suppliers. As a solution methodology, two phase fuzzy goal programming is applied. At the first phase, a max-min operator is applied to integrate two objective functions into one objective function. Since only the objective function with the worst satisfaction degree is tried to be improved with this operator, an improvement opportunity is investigated with the second phase. At the second phase, a weighted sum operator is applied to integrate objective functions. During this phase, objective function membership degrees obtained at the first phase are put as constraints for related objective functions satisfaction degrees. An improvement is not observed since the first phase objective function membership degrees are very close to each other.

For the future researches, a real life case may be investigated. Also, membership functions of objective functions may be set as piece-wise linear function which may provide us to make a more detailed analysis. Also, some of the parameters such as demand volumes and cost values may be set as fuzzy numbers considering the vague nature of those kinds of environments.

Moreover, for determining the reverse logistics score (RLS) of the suppliers, a scoring system can be improved by validating multiple criteria decision making techniques such as fuzzy AHP and ANP.

References

[1] Kannan, D., Khodaverdi, R., Olfat, L., Jafarian, A., Diabat, A., 2013, Integrated fuzzy multi criteria decision making method and multi-objective programming approach for supplier selection and order allocation in a green supply chain, *Journal of Cleaner Production*, 47, 355-367.

[2] Shen, L., Olfat, L., Govindan, K., Khodaverdi, R., Diabat, A., 2013, A fuzzy multi criteria approach for evaluating green supplier's performance in green supply chain with linguistic preferences, *Resources, Conservation and Recycling*, 74, 170-179.

[3] Sarkis, J., 1998, Evaluating environmentally conscious business practices,E*uropean journal of operational research*, 107(1), 159-174.

[4] Lee AHI, Kang HY, Hsu CF, Hung HC., 2009, A green supplier selection model for high-tech industry, *Expert Systems with Applications*,36,7917–27.

[5] Seuring, S., Müller, M., 2008, From a literature review to a conceptual framework for sustainable supply chain management, *Journal of Cleaner Production*, 16(15), 1699–1710.

[6] Amin, S. H., Zhang, G.,2012, An integrated model for closed-loop supply chain configuration and supplier selection: Multi-objective approach. *Expert Systems with Applications*, 39(8), 6782-6791.

[7] Kilic, H. S., Cebeci, U., Ayhan, M. B.,(2015, Reverse logistics system design for the waste of electrical and electronic equipment (WEEE) in Turkey, *Resources, Conservation and Recycling*, 95, 120-132.

[8] Kannan, G., Pokharel, S., Sasi Kumar, P., 2009, A hybrid approach using ISM and fuzzy TOPSIS for the selection of reverse logistics provider, *Resources, conservation and recycling*, 54(1), 28-36.

[9] Min, H., Ko, H. J., 2008, The dynamic design of a reverse logistics network from the perspective of third-party logistics service providers, *International Journal of Production Economics,* 113(1), 176-192.

[10] Guarnieri, P., Sobreiro, V. A., Nagano, M. S., Marques Serrano, A. L., 2014, The Challence of Selecting and Evaluating Third-Party Reverse Logistics Providers in a Multicriteria Perspective: A Brazilian Case, *Journal of Cleaner Production.*

[11] Fleischmann, M., 2001, Quantitative models for reverse logistics, *Lecture Notes in Economics and Mathematical Systems*, 501.

[12] Bai, C., Sarkis, J., 2013, Flexibility in reverse logistics: a framework and evaluation approach. *J. Clean. Prod.* 47 (1), 306-316.

[13] Efendigil, T., Önüt, S., Kongar, E., 2008, A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness, *Computers & Industrial Engineering*, 54(2), 269-287.

[14] Aissaoui, N., Haouari, M., Hassini, E., 2007, Supplier selection and order lot sizing modeling: A review. *Computers & operations research*, 34(12), 3516-3540.

[15] Carter, C. R., Ellram, L. M., 1998, Reverse logistics: A review of the literature and framework for future investigation, *International Journal of Business Logistics*, 19(1), 85–102.

[16] Talluri, S., Sarkis, J., 2002, A model for performance monitoring of suppliers, *International Journal of Production Research*, 40(16), 4257–4269.

[17] Kilic, H. S., 2013, An integrated approach for supplier selection in multi-item/multi-supplier environment, *Applied Mathematical Modelling*, 37(14), 7752-7763.

[18] Ho, W., Xu, X., Dey, P.K., 2010, Multi-criteria decision making approaches for supplier evaluation and selection: a literature review, *European Journal of Operational Research*, 202, 16-24.

[19] Amid, A., Ghodsypour, S. H., O'brien, C.,2006, Fuzzy multiobjective linear model for supplier selection in a supply chain. *International Journal of Production Economics*, 104(2), 394-407.

[20] Bevilacqua, M., Ciarapica, F. E., Giacchetta, G., 2006, A fuzzy-QFD approach to supplier selection, *Journal of Purchasing and Supply Management*,12(1), 14-27.

[21] Chou, S. Y., Chang, Y. H., 2008, A decision support system for supplier selection based on a strategy-aligned fuzzy SMART approach, *Expert systems with applications*, 34(4), 2241-2253.

[22] Önüt, S., Kara, S. S., Işik, E., 2009, Long term supplier selection using a combined fuzzy MCDM approach: A case study for a telecommunication company, *Expert Systems with Applications*, 36(2), 3887-3895.

[23] Shu, M. H., Wu, H. C., 2009, Quality-based supplier selection and evaluation using fuzzy data, *Computers & Industrial Engineering*, 57(3), 1072-1079.

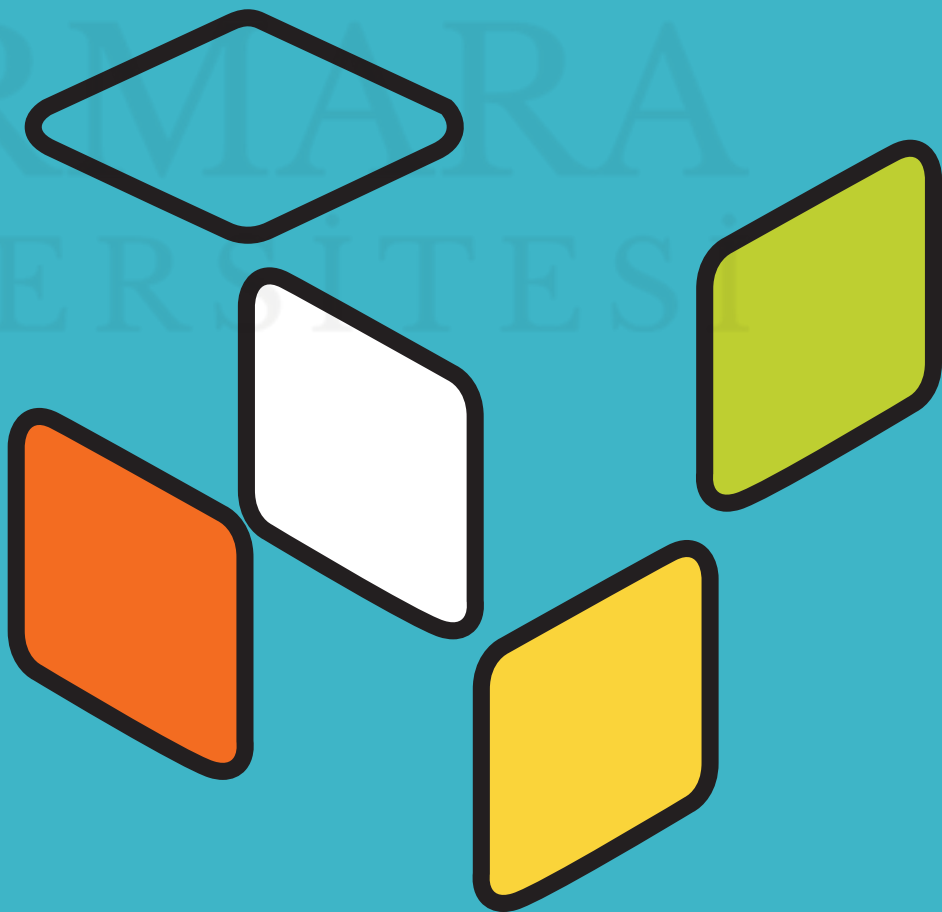
[24] Wang, J. W., Cheng, C. H., Huang, K. C., 2009, Fuzzy hierarchical TOPSIS for supplier selection, *Applied Soft Computing*, 9(1), 377-386.

[25] Awasthi, A., Chauhan, S. S., Goyal, S. K., 2010, A fuzzy multicriteria approach for evaluating environmental performance of suppliers, *International Journal of Production Economics*, 126(2), 370-378.

[26] Brandenburg, M., Govindan, K., Sarkis, J., Seuring, S., 2014, Quantitative models for sustainable supply chain management: Developments and directions, *European Journal of Operational Research*, 233(2), 299-312.
[27] Sbihi, A., Eglese, R. W., 2007, Combinatorial optimization and green logistics, *4OR*, 5(2), 99-116.
[28] Amid, A., Ghodsypour S.H., O'Brien, C., 2011, A weighted max-min model for fuzzy multi-objective supplier selection in a supply chain, *International Journal of Production Economics*, 131(1).
[29] Ashayeri, J., Tuzkaya, G., 2011, Design of demand driven return supply chain for high-tech products, *Journal of Industrial Engineering and Management*, 4(3): 481-503.
[30] Kongar, E., Gupta, S., 2006, Disassembly to order system under uncertainty, *Omega*, 34, 550-561.
[31] Liang, T.-F., 2010, Applying fuzzy goal programming to project management decisions with multiple goals in uncertain environments, *Expert Systems with Applications*, 37,8499-8507.

MARMARA ÜNİVERSİTESİ YAYINEVİ

VALUE CHAIN MANAGEMENT



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Traveler's Idle Time and the Value Chain at Airports

Cağlar Üçler [1], Luis Martin-Domingo[2]

Abstract

There is a high growth in the air traffic supported by the global trade and tourism and due to airport congestion travelers are spending more time at airports, which are competing to attract airlines with lower aeronautical costs reducing their profitability. The growing transit time spent at airports together with the waiting time in front of check-in, passport, security control or baggage claim is an idle time of the air traveler, which is not generating any value. The perception of waiting is also mostly negative, that the associated airports are disliked, leading to loss of revenue in commercial offerings. Another problem is that due to the high variety in the customer profile, the shops at the airports need to carry a high inventory over a wide spectrum of items required, which is not creating any value as well. Thus in order to deliver a sustainable value chain at the airport, an innovative customer focused integrated approach is proposed herewith, based on a smart phone platform called Gate Ø, facilitating the idle times of the air traveler. This strategic approach is evaluated successfully within a value chain analysis showing up its potential across the value chain stakeholders.

Keywords: Airport, Air Travel, Innovation, Mobile Application, Supply Chain, Value Chain Analysis

Introduction

Air travel did grow over the last 27 years annually by 5.9 % on average in terms of passenger–kilometer performed (PKP), and by 6.1 % in terms of ton–kilometer performed (TKP), [1]. With the increasing air traffic airlines are utilized above 10 hours per day reaching a load factors above 80% [2]. As a result the forecasted annual traffic growth is around 4.8 % thru 2036 [3], surpassing 9 billion passengers annually by 2025 [4].

Despite the growth in aviation, the economic constrains narrowed down the profit margins in aviation. Consequently smart customization leading to advanced segmentation is driving innovative business models with the aid of new technologies on the airline side [5]. This resulted in the reengineering of the airport concept. With the privatizations of the airports, they have become major business centers offering commercial development [4]. Today's airports are multifunctional public spaces not only processing passenger movement, but offering spa centers, boutiques and restaurants [6]. The worldwide commercial revenue average is around 48% [7], but e.g. Schiphol is an airport city generating 70 % of its operating result is by non-aviation-related income benefiting from the experience economy [8]. This change in business focus and increased environmental sensitivity drive together the innovation at the airports [9], which also positively effects airport's marketing performance [10]. Moreover considering that the commoditization is pushing the price as the key buying criteria; companies need to differentiate in the offerings [11], which implies innovation as well.

When changes necessarily drive towards innovations [12], productive use of inputs via continual innovation is due to maintain competitiveness [13]. Moreover some companies see the innovation as the enabler of additional growth [14]. Airports do leverage local monopolies in the aviation value chain [5]. By delivering products and services together with the flight processing they compete with each other to become successful hubs, centralizing the intermediary stations of the connection flights. Airports are trying to satisfy airlines technically, but also travelers with smooth operations and with a wide range of commercial offerings that they can innovate in strategy and vision, leadership, culture, processes or work environment [14].

[1] Caglar Ucler, Ozyegin University, School of Aviation, Istanbul, Turkey, caglar.ucler@ozyegin.edu.tr
[2] Luis Martin-Domingo, Ozyegin University, School of Aviation, Istanbul, Turkey, luis.martin@ozyegin.edu.tr

Innovation is about interaction of technology, market and organization, where competitive advantage can be generated in the ways in which product and service offerings are created and delivered [15]. This is enabling also quality time spend at the airport, which must be offered by successful airports [8]. As of today some airport related innovations are self-service check-in, electronic permanent bag tags, self-service passport control, millimeter-wave technology security scans [8], mobile passenger identification, off-airport bag drop [16], automated border control machines, personalized real-time information using RFID [17]. The trend in functional airport partitioning is from sharp to fuzzy, breaking down categories by pointing out to social trends and technology [18], where information technology (IT) is used as a business enabler [19]. As a result the innovation at the airport shall include state of the art communication media based on IT and thus shall response to the online community as well.

The air travelers are from a higher socio-economic group [20]. Controlling their own trip, today's they are part of the online community and want to experience increasing transparency, corporate responsibility and efficiency [8]. The new social media is delivering many new communication channels that most of the passenger are actively part of. With an increasing trend (see Figure 1), over 78% of the passengers traveled in 2013 with a smartphone that airports provide Internet mobile services and flight updates via Mobile [21]. Which means, when the air traveler is at the airport, he/she is online. Moreover there is a positive correlation between the time spent at the airport terminal and the level of expenditure [22, 23], but e.g. 40% of the Schiphol Airport's passengers transfer to a connecting flight and are in the Netherlands just for a few hours [8]. As a result the traveler's commercially available time at the airport is adjusted by scheduling of transit flights [6].



Figure 1. Smartphone Penetration for Air Passengers based on [24, 25]

In addition to that considering the waiting times in front of check-in, passport and security control and baggage claim together with the time on the way to/from the airport, there is a huge amount of idle time, where the traveler is not within the value chain of the airport. Moreover the air traveler, who is mainly online, is virtually somewhere else that he/she is also mentally not integrated into the system as well. However this idle time can be utilized by providing an online system incorporating the traveler as an active member into the airport community by providing information regarding the flight, but also offering commercial products and services such as duty-free, ground transportation, fast tracks etc., which is proposed and explained in detail next.

Gate Ø: The Air Traveler Portal

Mobile check-in becoming bigger than web check-in indicates that passengers are ready for commercial mobile offerings as well [16]. Motivated with that, Gate Zero (Gate Ø) is the innovative software portal proposed herewith, which is leading the way to utilize the idle time of the air traveler into the value chain of the commercial airport cities. It is integrating the commercial offerings at the airports and enables the traveler an online access through smart mobile devices such as phones and pads, which can be used by the travels in their idle times (see Figure 2). In general it is a showcase of all the offerings available, but it is also a business platform and is an interactive communication channel suitable for marketing campaigns and for user evaluations.

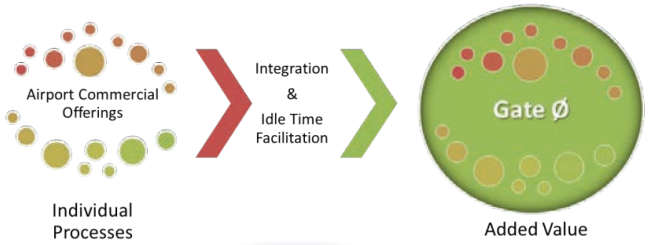


Figure 2. Gate Ø as the Integrator and commutator

The classical airport experience is associated to the physical airport, where a linear flow of processes is fallowed, i.e. for a departure flight after arrival by ground transportation, security check, check-in, baggage drop, passport control, last security check when due and there is just a short free time available prior departure. This chain can diversify depending on the airport, but it is physically there. There are sometimes also innovative approaches using IT to crash some processes, but these processes always physically do happen, when even in a faster manner. By using Gate Ø first of all the airport will be virtually accessible at any time, meaning the traveler can prepare for a flight at home. Alternatively on the way to the airport, when stuck in the traffic, the time could be used to go for a fast track option combined with duty free as well. Since the system is also connecting to the commercial stakeholders, they can prepare a basket with procured goods and can get delivered at the gate in front of the aircraft. Marketing campaigns can be prepared and delivered to the customer, which can be accessed when visiting a city in the hotel or in a café downtown. Moreover the traveler can comment or read comments of other travelers, creating the content of Gate Ø providing visibility, which is further supporting comparison possibilities of Gate Ø. As a result a traveler can access Gate Ø when being at home, base in City X, or on the way to the Airport A, at Airport A, during the flight from Airport A to B, at arrival in B during immigration queue or baggage claim, during ground transport to City Y and in City Y (see Figure 3).

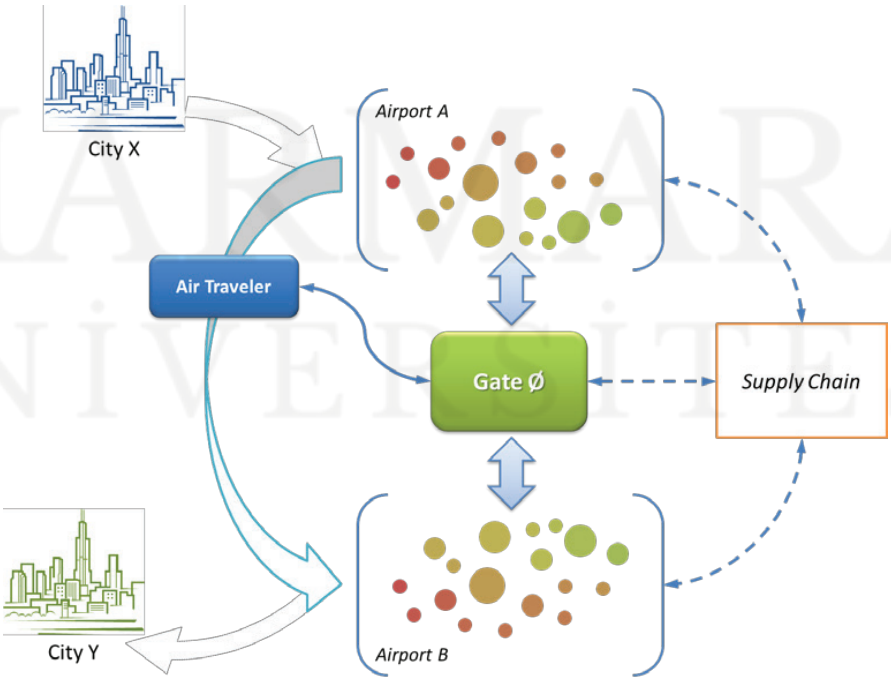


Figure 3. Positioning of Gate Ø in the air travels commercial chain

Furthermore Gate Ø is integrating the commercial spaces at several airports, here A and B, including free shops at several locations linking supply chains together. Since all stakeholders in the value chain of the airport do have access to Gate Ø, it is a business platform for them as well. Additionally to the sales & marketing efforts a joint inventory and procurement for the commercial stakeholders at several airports is possible, providing quantity discount in procurement. Moreover the ecosystem incorporating several airports enables a delivery at the final destination of the traveler. Successively several discount models attached to inventory carrying principles can be offered to travelers given they log in early enough to provide enough time for just in time (JIT) inventory keeping. The delivery can be even done later on at home, allowing that the duty free shops are only showcases where the traveler can touch and feel the items only. Moreover Gate Ø enables the facilitation of food courts of smaller airports by building in shop corners as showcases as well.

During the initial implementation Gate Ø can be used in a limited manner providing some additional capability only. Even this would mean for a smaller airport without the facilities a wide variety of offerings hence a radical improvement. When being used on the wide basis the stakeholders of Gate Ø are (i) travelers, (ii) commercial service & product providers directly along with (iii) airports indirectly.

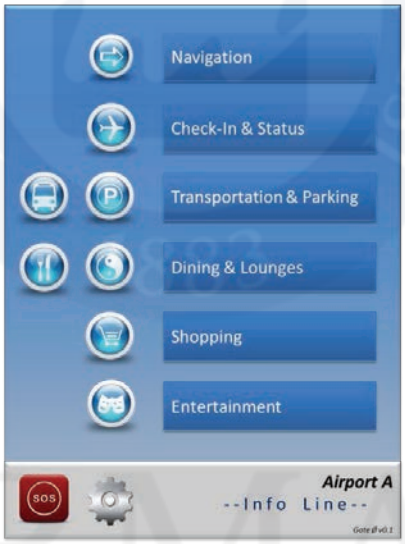


Figure 4. Mobile GUI Structure of Gate Ø

When using the Gate Ø the customer has a lean mobile graphical user interface (GUI) as shown in Figure 4. Since the system is using positioning services it can enable the navigation through the airport facilities. It uses interactive maps with destination selections from a searchable library including landmarks such as gates or administrative locations and commercial spaces as well. Under the Check-In & Status branch all associated services and detailed information are available. Also fast tracks and the digital boarding card is included herein. With the Transportation and Parking branch the standard transportation means to and from the airport can be studied including time plans and procurement possibilities for packages of city public transportation cards together with offers of other commercial services available at the airport. Moreover daily, weekly or monthly subscriptions for the parking can be done where also the parking place is stored for later usage. Dining & Lounges branch includes a presentation of available food court, lounge and airport hotel facilities including sleeping cubes, with the option to buy special combination packages. Shopping branch is mainly an e-commerce site, where visibility over product comparisons is provided. It includes all duty-free procurement options with several delivery options. Within the entertainment branch the associated facilities at or around the airport are promoted. Moreover movie channels are provided for a time based imbursement. The Info line includes streaming data according to the phase of the travel. Prior flight the time to boarding and

departure info such as delays, gate number and flight number are shown in this line. After arrival the baggage claim belt number associated to the flight is indicated here, followed by the car park position when available. Also important information and advertisement are streaming here on a lower frequency. An alerting and communication system with pup-ups is available as well, where advertisements can be turned off in the settings branch, iconized at the lower part together with the SOS button. The SOS functionality is informing the authorities with the coordinates of the mobile device in the case of an emergency, where massages indicating the situation can be send as well. Finally it has to be mentioned that the commercial users have a sophisticated desktop GUI enabling them e-commerce transactions and other functionalities, which is not shown here.

Method

In order to assess Gate Ø, value chain analysis is used. "The value chain is a general framework for thinking strategically about direct, indirect or quality activities involved in any business assessing their relative cost and role in differentiation, since the competitive advantage cannot be seen by looking at a firm as a whole" [26]. Consequently all stakeholders of Gate Ø are to be analyzed within the value chain including the suppliers, the commercial service & product suppliers at the airport, the travelers and at least the airport itself.

Due to the lack of the ability to fully conceptualize the complex adaptive nature of service innovation and value [19] the assessment of Gate Ø is not an easy mathematical computational task. Traditional value chain analysis is very structured and uses isolated processes and appropriate costs and incomes. According to [27] the principal steps are first identifying the firm's value-creating processes to determine the portion of the total cost of the product or service attributable to each value creating process, which can be used to identify the cost drivers for each process and to identify the links between processes. However IT innovations enable a user value, which cannot be measured by traditional accounting and economic based measuring techniques [19], where the customer contribution is further boosting the value. Moreover operational performance is measured against non-financial value drivers such as operational efficiency, service quality, environmental responsibility and corporate sustainability [19]. Consequently a more qualitative approach is used herewith for the primary and support activities based on the generic value chain [26] as shown in Figure 5.

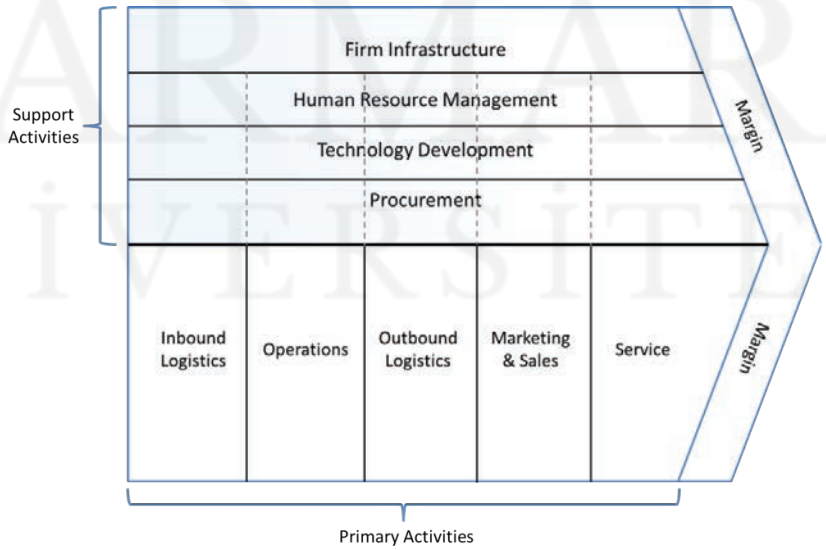


Figure 5. The Generic Value Chain based on [26]

The qualitative value chain analysis of Gate Ø is summarized in Picture 6. The infrastructure delivers a customer focused system enabling the collaboration across all stakeholders including the streaming of the voice of the customer (VOC). It is a superior management information system (MIS), integrating sales & marketing with the tracking of key performance indicators (KPIs) enabling financial reporting as well. Successively it is a top management support tool including but not limited to selling strategy. The infrastructure is delivering an electronic data interchange (EDI) environment, enabling computer to computer exchange of business documents preventing manual interaction limiting error sources and streamlining all processes. Moreover it provides a great overview of the current as-is situation by delivering transparency to the customer leading to a higher image perception.

For inbound logistics processes Gate Ø is capable to be used as a web based training resource with the provided online catalogue. With shared resources as a main character, Gate Ø can facilitate online support on all primary activities reducing the need of human resources (HR). The automated processes require a lower work force and increase the quality of work together with the efficiency. On the top of this Gate Ø is not only a customer focused system, the customer acts in Gate Ø as the content provider, i.e. it is generating content within the processes. This implies that the customer is as well functioning as an associate in the self-organizing concept. He/she uses the information on the system, realizes his own transactions, but guides also other participants. By taking over some of the load from the sales force the customer also supports the organization to get leaner, enabling free resources which then can be converted to higher skilled back office personnel, who can increase the level of value and quality. Moreover Gate Ø is integrating the supplier into the value chain on a collaborative basis that some outbound duties of the stores can be taken over from the suppliers such as delivery or inventory, which again mitigates the requirement on HR. On the top of this the shared resources on several locations provide a much better coverage on global basis and deliver a higher level of visibility.

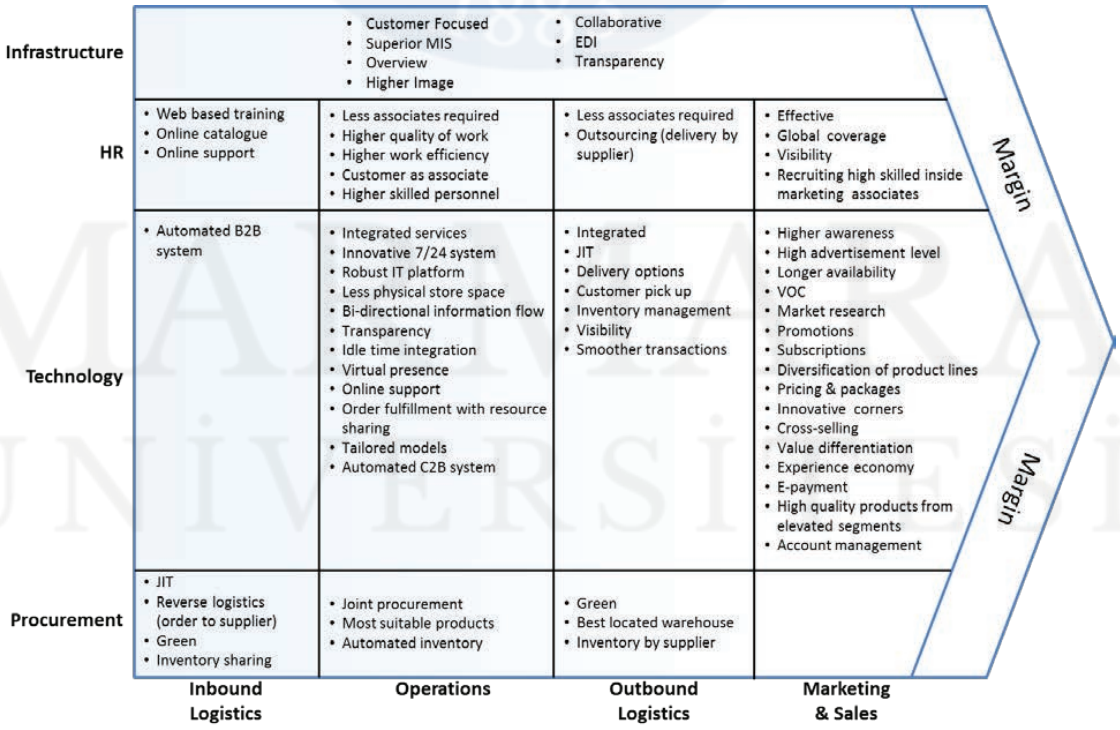


Figure 6. The Value Chain Analysis for Gate Ø

As an innovative platform Gate Ø has its main contributions on the technology development activities.

Being an automated business to business (B2B) system it enables the smooth information exchange between the suppliers and the companies. As a result the inbound logistics is made on a fault free basis in shortest time possible. There are several services of the airports available in Gate Ø in an integrated context, which is 7/24 available to access. The lean system is providing a robust IT platform and since most of the transactions are carried in virtual reality the need of physical department store space at airports decreases. The bidirectional information flow is contributing to the transparency. The idle time integration into the value chain is one of the main assets of Gate Ø. The traveler, here the customer, is virtually present at all times and can follow up the content provided to fulfill even transactions, where the required support can be provided in an online manner. Moreover the service/product providers can use shared resources to fulfill the requirements of the orders. E.g. while a store in Airport A is passing by the delivery of one selected item which is not currently available to another store at Airport B, it can still give out beverages locally. Many similar tailored business models can be worked out to maximize the profit of all contributing parties.

Being a customer to business (C2B) system it is also an integrated system enabling just in time (JIT) logistics with wide spectra of delivery options. The customer therefore can choose to pick-up the goods on a designated site for cost cutting or can prefer to have an in-house delivery against a small reimbursement fee. All in one the inventory management captured by Gate Ø provides a good visibility and enables smoother transactions. Providing a higher awareness level to the online community and streaming information over mobile devices a higher advertisement level can be achieved by Gate Ø. Moreover the availability period is extended by two means; (i) the shared resources enabling physical access and (ii) the virtual environment providing access making the ecosystem available over a longer period without time lapses.

Qualitative VOC together with the quantitative metrics extracted from Gate Ø can be used to conduct extensive market research making successful promotions possible. Moreover with subscriptions with longer term commitments special offers can be arranged to increase total profit. Moreover there are practically no physical restrictions anymore. Theoretically any product can be included virtually in the offerings enabling a diversification of product lines as well. Special pricing and packaging promotions can be carried out within innovative corners at stores with another core business than retail, which also enables cross selling. Since the customer is benefiting from the experience economy the value differentiation can be achieved as shown in Figure 7, where the positive perceived value is raised by the application of Gate Ø and the negative actual input cost, the actual value, is decreased due to the optimization of processes. Consequently the difference between perceived and actual values of A and B respectively can be used to determine the differentiation value. Moreover the customer has more time to process the transactions by using e-payment. This relaxes the customer and he/she can decide to go for expensive products from elevated segments. All together a new high end customer segment can be created, which can be served by means of account management.

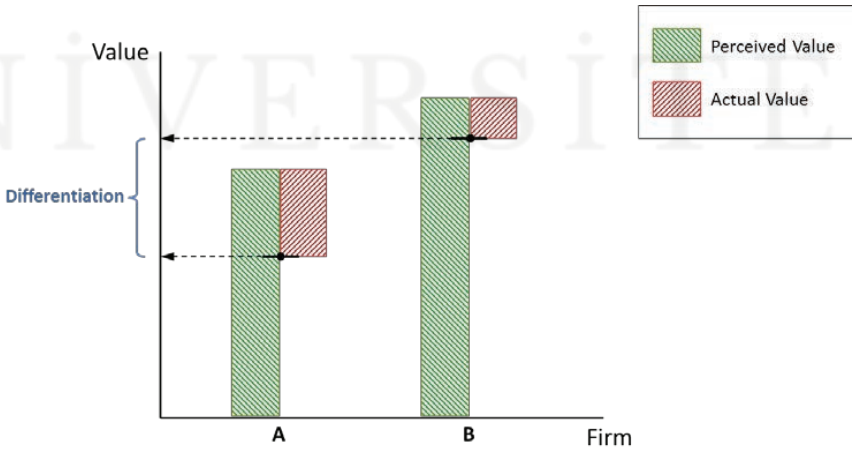


Figure 7. Value differentiation

All in one the JIT procurement with possible delivery options enables a positive environment aspect as well. All goods flown directly with the customer do require a higher amount of fuel consumption due to air transportation. Each kg carried on board is used to calculate the total fuel boarded. In other terms when the customer choses to have delivery at destination it is not just a comfort choice done in order to prevent carrying around the goods, it also results in a lower carbon foot print. Thus shared inventory has a green aspect as well. Moreover the reverse logistics concept, which starts with the procurement of the customer and immediately escalades the information down to the suppliers, is also reducing the unnecessary inventory, lowering space requirements and thus electricity and other overheads financially and environmentally. Joint procurement enables also the selection of most suitable goods to create services. Finally the best located warehouses holding the inventory in the name of duty free shops can be selected to provide the goods on the greenest pathway. As a result interrelationships in joint procurement cover joint interface of Gate Ø, shared financing of the inventory, order processing, advertisement and promotion.

Results and Discussion

The findings of the value chain analysis are consistent with the expectance. By breaking down the processes and focusing on subsystem level it has been found that Gate Ø integrates the idle time of the air traveler into the value chain of the airport.

Focusing on the sustainability criteria for airports as economic efficiency, environment, coordination, and community [4], it has been shown that Gate Ø delivers a suitable platform by providing an integrated collaborative approach involving the JIT, VOC integration and transparency. Especially the new social community wants to be involved in processes, which is satisfied herewith, supported by this transparency referred and the bidirectional information flow. It has been shown that Gate Ø is enabling the required differentiation [26] for sustainable success by reducing the power of price with the perceived value increase due to the IT and participation to the content. Considering that consumers are increasingly aware of social and ecological consequences [28], the indicated green character of Gate Ø cutting down fuel consumption by optimized logistics contributes to the sustainability of both the ecosystem and the business model incorporating Gate Ø.

Moreover Gate Ø implies technological innovation by the adaptation of the mobile platform applications integrating the supply chain of several locations. Cooperation possibilities as indicated in the value chain analysis seek the benefits of centralization and economies of scale shifting a large part of planning and administrative tasks to the central unit, which will save time and resources in stores, increasing negotiation power [28]. In addition to that Gate Ø drives a process innovation from the perspective of the commercial stakeholders. It has been shown that supply chain is totally reengineered by using state of the art ecommerce platform enabling inventory optimization along with several new delivery options. The traveler gets part of the process at all physical locations possible, that idle time utilization has been proven to be correct. The integrated approach also implies paradigm innovation, since it changes the underlying mental model [15] associated to the experience at the airport.

Considering that at airports marketing innovation is found in service companies [10], where the product is simultaneously produced with and consumed by participating customers [11], one can question the positioning of Gate Ø therefore. Since Gate Ø is integrating the customer into the processes it is addressing the required needs as content created by customers. Furthermore communication of special combined offerings such as lounges together with fast tracks or with duty free shopping implies the marketing character of Gate Ø. Moreover competing with each other the airports of today are like big cities. The more they attract people by delivering them a pleasant traveling experience the more the airlines prefer the airports as hubs or home bases. Since Gate Ø is elaborating the travel experience it is also indirectly contributing to the marketing of the airport. Moreover airports have also revenue generating units such as parking, which integration into Gate Ø would make airports direct stakeholders of the system as well. As a result by limited application Gate Ø can be impact incremental innovation contributing to sales and marketing, but has been shown that it is a radical innovation for airports, not

possessing any comparable duty free zone prior implementation. Since in-store technology facilitating purchasing via mobile phone platforms easily gives benefits to retailers and suppliers [28], competitive positioning of Gate Ø adopters is enhanced. The underlined corner logic is in line with shop-in-shop concepts and the fuzzification of food and non-food areas [28].

Moreover enabling further optimization in the organization it also delivers higher efficiency in HR contributing to the reduction of costs. Together with the new optimized logistics and reduced inventory as shown by the analysis, the cost impact is even higher. This contributes to the referred differentiation, which together with the new business opportunities justified the Gate Ø application.

Conclusion

Despite the growth in air traffic the profit margins of aviation is lowered due to competitive positioning of alternative airports, trying to attract airlines with competitive aeronautical fees. Consequently airports are restructuring themselves from operators only towards participants of the experience economy encompassing commercial offerings for air travelers to sustain their profitability. The utilization of commercial spaces in airports is not only restricted to retail and food courts, but airport cities with a socio-cultural environment are developing. The air traveler profile on the other side is also changing. Today most of the travelers are member of the online community and like to accelerate processes by using mobile technologies. However the increasing loads of airports make waiting lines inevitable. Consequently the travelers are virtually somewhere else including but not limited to these moments at the waiting lines and this embodies an idle time of the air traveler when the traveler is not within the value chain of the airports. On the top of this the unpleasant experience of waiting reduces the motivation of the travelers for spending any money. All together the commercial spaces of the airports and consequently the airports do lose money.

In order to overcome this problem an innovative customer focused integrated platform called Gate Ø is proposed and developed. This smart phone platform, facilitating the idle times of the air traveler, as well integrating the commercial stakeholders has been further evaluated by using a value chain analysis. It has been shown that added value has been delivered by integrating the traveler into the processes. Moreover joint operations of several commercial stakeholders have been proven to be beneficial in terms of efficiency but also providing new sales possibilities. It has been shown that using Gate Ø the traveler can be virtually part of the experience economy of the airport, when in waiting lines or when even being physically somewhere else. The idle time facilitation was proven therefore, integrating the traveler into the value chain of the airport commercial ecosystem, which was shown to be beneficial over long time for the airport management as well.

All in one it has been shown that Gate Ø has innovative impacts in many dimensions including technological, process, marketing and paradigm innovation, which delivered together with the efficiency improvements by the Gate Ø application the basis to sustainable success.

References

[1] Mazraati, M., 2010, World Aviation Fuel Demand Outlook, *OPEC Energy Review, Vol. 34, Issue 1*, pp. 42-72
[2] Harned, D.S., Sheehy, F., Cofsky, J., 2007, Commercial Aircraft Cycle: Party Like It's 1999? *White Book, Bernstein Research*
[3] ICAO, 2010, Present and Future Aircraft Noise and Emissions Trends, Assembly, *International Civil Aviation Organization - 37th Session, Agenda Item 17: Environmental protection,* A37-WP/26 EX/9 21/7/10
[4] Stevens, N.J., Baker, D.C. & Freestone, R., 2010, Airports in their urban settings: towards a conceptual model of interfaces in the Australian context. *Journal of Transport Geography,* 18(2), pp. 276-284
[5] Franke, M., 2007, Innovation: The winning formula to regain profitability in aviation? *Journal of Air Transport Management,* 13, pp. 23–30
[6] Nikolaeva, A., 2012, Designing Public Space for Mobility: Contestation, Negotiation and Experiment at Amsterdam Airport Schiphol. *Tijdschrift voor Economische en Sociale Geografie*, Vol. 103, No. 5, pp. 542–554

[7] ACI, 2012, Commercial Revenues' Resilience Key to Airport Investment & Modernisation, *ACI: Airports Council International, Press Release,* http://www.atn.aero/article.pl?id=36324
[8] Nijhuis, J.A., 2012, Creating the i-Port: Innovative strategies to enhance efficiencies and the passenger experience, *Airport Management,* Vol. 7, No. 1, pp. 8–12
[9] Humphreys, I. & Francis, G., 2002, Performance measurement: a review of airports. *International Journal of Transport Management,* 1, pp. 79–85
[10] Halpern, N., 2010, Marketing innovation: Sources, capabilities and consequences at airports in Europe's peripheral areas, *Journal of Air Transport Management,* 16, pp. 52–58
[11] Rothkopf, M. & Wald, A., 2011, Innovation in Commoditized Services: A Study in the Passenger Airline Industry, *International Journal of Innovation Management,* Vol. 15, No. 4, pp. 731–753
[12] Iyer, R.; Laplaca, P.J.; Sharma, A., 2006, Innovation and New Product Introductions in Emerging Markets: Strategic Recommendations for the Indian market. *Industrial Marketing Management*, 35, pp. 373–382
[13] Porter, M.E., 1998a, Clusters and the New Economics of Competition, *Harvard Business Review,* Vol. 76 Issue 6, pp. 77-90
[14] Stamm, B., 2003, The Innovation Wave: Meeting the Corporate Challenge, *Wiley & Sons Ltd*.
[15] Tidd, J., Bessant, J & Pavitt, K, 2005, Managing Innovation: Integrating Technological, Market and Organizational Change, 3rd Edition, *John Wiley & Sons, Ltd*
[16] Léopold, E., 2009. The future of mobile check-in, *Airport Management*, Vol. 3, No. 3, pp. 215–222
[17] Noronen-Juhola, H., 2012, Smart solutions at Helsinki Airport, *Airport Management,* Vol. 6, No. 2, pp. 125–132
[18] Matthews, L., 2000, Airports of the Future: A Manager's View of an Innovation Exercise, *International Journal of Innovation Management,* Vol. 4, No. 2, Special Issue, pp. 187–205
[19] Granta, K., Alefantos, T., Meyer, M. & Edgar D., 2013, Capturing and measuring technology based service innovation – A case analysis within theory and practice, *International Journal of Information Management,* 33, pp. 899– 905
[20] Graham, A., 2009, How important are commercial revenues to today's airports? *Journal of Air Transport Management,* 15, pp. 106–111
[21] SITA, 2014a, Airport IT Trends, Survey 2014, *Société Internationale de Télécommunications Aéronautiques,* http://www.sita.aero/surveys-reports/industry-surveys-reports/airport-it-trends-survey-2014
[22] Torres, E., Dominguez, J.S., Valdes, L. & Aza, R., 2005, Passenger Waiting Time in an Airport and Expenditure Carried out in the Commercial Area, *Journal of Air Transport Management,* 11 (6), pp. 363–67
[23] Castillo-Manzano, J.I., 2010, Determinants of Commercial Revenues at Airports: Lessons Learned from Spanish Regional Airports, *Tourism Management,* 31 (6), pp. 788–96
[24] SITA, 2013, Passenger Self-Service Survey 2012, *Société Internationale de Télécommunications Aéronautiques,* http://www.sita.aero/surveys-reports/industry-surveys-reports/passenger-self-service-survey-2012
[25] SITA, 2014b, Airport IT Trends Survey 2013, *Société Internationale de Télécommunications Aéronautiques,* http://www.sita.aero/surveys-reports/industry-surveys-reports/airport-it-trends-survey-2013
[26] Porter, M.E., 1998b, Competitive Advantage: Creating and Sustaining Superior Performance, with a new Introduction, The Free Press
[27] IMA, 1996, Value Chain Analysis for Assessing Competitive Advantage, *Institute of Management Accountants (IMA),* Montvale
[28] Finne, S. & Sivonen, H., 2009, The Retail Value Chain: How to gain competitive advantage through Efficient Consumer Response (ECR) Strategies, *Kogan Page*

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

The Effect of Energy Policies in Turkey on Transportation Sector: The Analysis of Energy Related Price and Cost in Road Transportation

Celil Durdağ[1], Ersin Şahin[2]

Abstract

Energy policies are seriously affecting economic and social life all over the world as well as in Turkey. When the supply process from the energy resource to the consumer increase in energy cost depending on transport type has important influence.Increase in energy costs in the supply chain is undertaken by all stakeholders.In this study,we examine at which level road transportation costs,which is the most predominant type of transportation in Turkey,is influenced by energy consumption with reference to the energy policies of Turkey and energy consumption of Turkish transportation sector.Thus,certain suggestions reducing energy costs have been made to all parties in the supply chain by considering the distrubition between energy related costs and other costs.

Keywords: Energy, Supply Chain, Transportation

An Overview of Energy Consept

Energy, one of the base quantity of Physics. Energy is a conservative magnitude, it can not be fragmented as it can not be destroyed but it can conversate from one form to another. During this conversion process energy loses occur these loses cause unproductiveness. The form of energy which is conversated or transformed is called "Primary Energy". Primary energy resources: coal, crude oil, natural gas, nuclear, hydraulic, bio-mass, tidal-wave, sunlight and wind. Conversion of primary energy creates a new energy that called "Secondary Energy". Electric, gasoline, diesel oil, coking coal, liquefied petroleum gas are the examples for secondary energy resources. Energy resources on the Earth are divided into two by their generation, fossil and renewable. Fossil (exhaustible) energy resources; hard coal, crude oil, natural gas, uranium, lignite, turf, thorium and asphalt. Because of their generation take ages, they are non-regenative energies, due to uncertainty in rezerves their costs are increasing. Renewable (natural) energy sources classified as solar energy, wind energy, hydraulic energy, geothermal energy, sea origin energies (wave or tidal). Renewable energy sources are less harmful sources than fossil energy sources. This sources are sources which, generally available on the earth and nature without need for any production process, during production of electricity CO_2 emission occur, regenerate with continuous motion and existing in nature as ready to use [1].

Energy Resources And Reserves In Turkey And The World

When we look at the fossil energy resources in the world, there is no problem about their sufficiency. Known producible energy reserves are enough for different time levels such as petrol for 40 years, natural gas for 62 years, coal for 216 years.

[1] Celil Durdağ, Beykoz Vocational School of Logistics, Transportation Services Department, Civil Aviation Cabin Services Program, Istanbul, Turkey, celildurdag@beykoz.edu.tr

[2] Ersin Şahin, Beykoz Vocational School of Logistics, Management and Organization Department of Energy Facilities Management Program, Istanbul, Turkey, ersinsahin@beykoz.edu.tr

Table 1. World Fossil Fuels Status

RESOURCES		WORLD RESERVE	USED DURATION OF WORLD RESERVE	WORLD VALUES OF FOSSIL FUELS		
				PRODUCTION (Mtep)	CONSUMPTION (Mtep)	PRODUCTION RATE (%)
OIL (BILLION TONS)		225.4	54	3995.6	4059.1	38
NATURAL GAS (trillion cubic feet)		208.4	64	2954.8	2905.6	27.2
COAL BILLION TONS	HARD COAL	404.76	112	3955.5	3724.3	34.8
	Lignite	456.18				
TOTAL				**10905.9**	**10689**	**100**

In Turkey according to an opinion, which has been around since 80's, turkeys local energy resources are so little that even if all of them are used, they cannot cover energy gap. In contrast to this Turkey, especially in two resources, is in a lucky condition. These are, hydroelectric which is a clean and renewable resource and lignite which is more than 8 billion tons. However, these resources are not used efficiently in energy producing [2]. According to statistics only 33 percent of our hydraulic and coal resources are used effectively. Our lignite reserves should be used much more efficiently than it already has, especially in clean burning technology stations. In according to this, new researches are clearly suggest that our hydraulic resources 125 billion kwh of which is accepted as economically usable, can be increased to 160-180 billion kwh for the use [3].

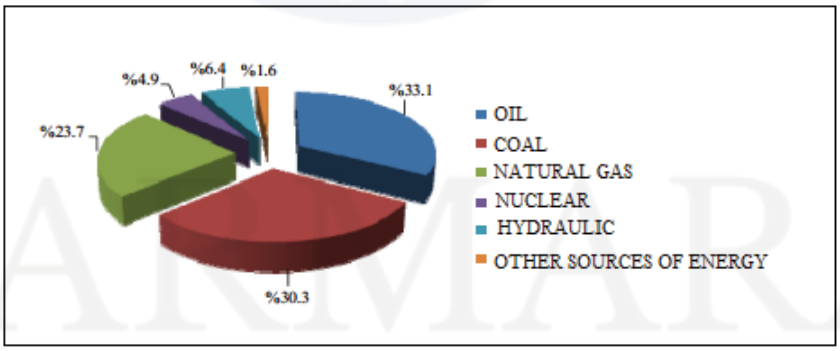


Figure 1. World Primary Energy Usage in 2011

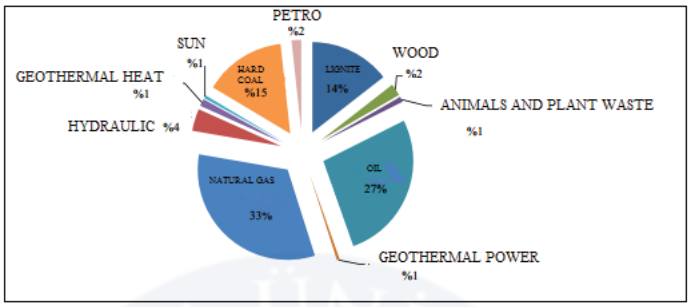


Figure 2. Energy Consumption on Sources Bases in Turkey

1 1.2 Fuel Consept, Fuel Types and Heating Values of Some Fuels

Materails, which chemically or physcally change when they are burnt, are called fuel. Generally speaking, fuels are divided into three different groups: solid fuels, liquid fuels, gas fuels. Nowadays, the energy which we have been using is provided from solid fuels. Population growth, urbanisation, industrialization cause high energy consumption. Running out of energy sources ends up with high prices. Energy value at unit mass or volume is named heating value. Heating value of fuels is a characteristic feature, which is , in other words, energy as a result of burning procedure. It is important to prefer fuels which have high figures of heating value in the aspect of decreasing energy costs [4].

Table 2. Heating Values of Some Fuels

Fuel Type	Heating Value (MJ/kg)
Hard Coal	25.53
Crude Oil	43.96
LPG	45.63
Wood	12.56
Acetylene	59.57

Energy Policies in Turkey and Transport Sector's Place in Energy Policies

The main purpose of Turkey's Energy Policy is to provide energy by taking economic growth and promoting social development and enviromental effects into consideration;on time, adequate, with competitive prices to the consumers.

In this case, main policies and strategies of our country is summerized below:

- Expanding storage capacities of strategic petroleum and natural gas
- Diversification of sources and countries
- Giving priority to use and develop of local sources
- Using and developing different technologies and improving local production
- Benefiting , in the best way, from our country's being potential energy trade center
- Activating demand management and increasing its productivity
- Increasing fuel flexibility (enabling to use alternative energy sources in production)
- Ensuring participation of Middle East and Caspian's petroleum and natural gas in every stage of transport process

- Configuration of energy sector on the basis of clearness and competition as an active market
- Participating in regional cooperation projects and integration
- In every stage considering enviromental effects [3].

Turkey's primary energy consumption's 13.9 % and primary petroleum consumption's 50.8 % are used in transport sector. Almost all of the energy used in the transport sector (97.1%) is petroleum products. Turkey's petroleum production compensates only 7-9 % of consumption and remaining 91-93 % part is compensated with importation, therefore it can be said that energy saving and efficient use of energy in transport sector has a great importance. Energy is not the only factor that effects choosing transport type, but it's an important factor and getting more important. So, getting more economical form to transport sector from the point of energy consumption is becoming an important situation [6].

Economic growth,environmental degradation,energy and transport policies should be recognized in order to improve the energy efficiency in transport sector.All measures that should reduce petroleum consumption and greenhouse gas emissions with out affecting economic growth maybe undertaken To evaluate the energy sustainability degree of transport sector, it is necessary to determine the driving factors influencing transport-related energy consumption such as economic growth, energy price,urban population,transport activity,motorization rate,traveling distance,park structure,vehicle types,vehicle age, urbanization, national road network and transportintensity.The main objective was to define cause and effect relationships between these indicators in order to formulate appropriate policies increasing the energy sustainability in the transport sector [15].

Energy Consumption in Road Transport and Highway Transportation in Turkey

Located largest share in road transport modes of transport in Turkey is generally held to 5 species.

They are;

- Walk
- Bicycles
- Motorbikes
- Private Cars
- Public and School Buses

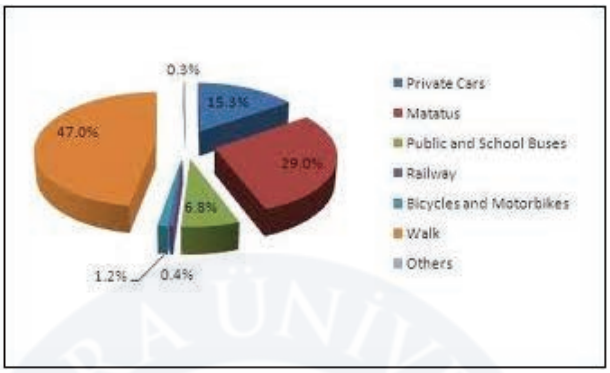


Figure 3. Dispersion of Road Transport Type in Turkey [1]

Fuel is not required for the pedestrian and bicycle transportation but for the most common fuel oil for other transport systems. Transportation with motorcycle needs less energy than a car or public transport. Although Public transport causes high fuel consumption, it is the most useful transportation system in terms of the passenger capacity and occupition of the lowest passenger area.

Dispersion and Alternative Fuels Pursuit of Energy Resources Used in Road Transport in the world and Turkey

In Turkey there are 17,579,349 units of motor vehicles by the end of July 2013. If we look at the fuel types of the vehicles in our country we confront with the data of 2012. Accordingly, a total of 17,033,413 pieces of the vehicle in 2012;

- 5,722,940 units Benzine
- 7,549,806 units Diesel
- 3,649,739 units LPG 110,928 units vehicles are not known.

In 2012 the world there was 89.8 million b / d (barrels / day) oil consumption. In the year 2012, oil reserves in the world has increased from 1.520 billion barrels to 1.637 billion barrels with the 7.7% rise . Together with that increase the life of oil reserves has increased from 44.8 years to 48.8 years in 2012. In Turkey, in 2012, oil production was 2.3 million tonnes. Recently natural gas has also started to be used as a vehicle fuel as well as petroleum derivatives. This fuels are Liquefied Natural Gas (LNG) and compressed natural gas (CNG). Natural gas consumption in the world was 3,348.7 billion m3 in 2012. A 57.96 3% of increase in production of natural gas reserves occurred at the beginning of 2012, and slightly decreased to 57.07 due to the amount of natural gas reserves. Oil is becoming more of a source used for the transport sector. Average of 60% of the oil consumed in OECD countries is used for transportation. In some countries this rate is up to 75%. In most of the developing countries, this rate is around 40%. Utilization of natural gas in the car is low [5]. Alternative energy sources and technologies for heating, power and electricity production were partially filled the place of oil, It does not seem possible, but more so in the near future a substitute fuel in the transport sector on a global scale. Today it is 20% in the transport sector's share in the global energy consumption, 3/4 of it is seen that goes to road transport. Considering that they're still using oil as the main fuel for vehicles traveling on the highways, unless an affordable alternative to replace it cannot be found , fuel oil will maintain its importance at least the first half of this century

[7]. The new energy sources are alternative fuels for motor vehicles. Sustainable energy supply can continue to be provided with alternative fuels. Besides reducing the environmental pollution is the subject of alternative fuels promise. NEV is defined as the four-wheel vehicle using unconventional vehicle fuel as the power source,which includes hybrid vehicle(HV),battery electrical vehicle(BEV),fuelcell electric vehicle(FCEV),hydrogen engine vehicle(HEV),dimethyl ether vehicle(DEV)and other new energy(e.g.high efficiency energy storage devices)vehicles.NEV is also one of the most important future road transport Technologies which has attracted a growing attention from both the industry and academics [14]. The main conclusion of the analysis is that it is not possible to point to one technology/fuel as the best option. In fact, the most solid recommendations concerns options that are not favourable in terms of energy efficiency. The electric vehicle is, and most likely will continue to be, a considerably more energy-efficient option than hydrogen, at least for electricity as a starting point. On the other hand, the issue of the vehicle range points to hydrogen as the superior fuel rather than electricity, and hydrogen vehicles can in principle become very similar to conventional vehicles in the future [9]. Regional and local environmental impact can motivate the use of alternative fuels instead of petrol and diesel in certain traffic situations, even if the cost of CO2 emission is not regarded. Then it is the fossil-based alternatives (natural gas or fossil-based methanol) that are competitive. At current CO2 tax level biogas from waste is competitive where no natural gas is available. To enable a greater use of biomass-based fuels, the economic valuation of CO2 emission would have to be 2±2.5 times higher than current CO2 taxes [13].

The economic valuation of regional and local environmental impact is important in making alternative fuels viable. Future valuations of local and environmental impact are difficult to assess as the knowledge of the damage due to different pollutants will increase. Furthermore, the eco-nomic valuation of environmental impact may increase with time. Such an increase in environ-mental concern will improve the competitiveness of low-polluting transportation fuels [13].

The continuing reductions in emission factors for diesel and petrol will, however, reduce the absolute advantage of using alternative fuels. The cost e [illegible] for conventional fuels instead of using alternative fuels has, however, not been studied since cost data for such improvements have not been available [13].

Calculating the Cost of Energy and Fuel Costs for Road Transport

The total energy cost was calculated as the sum of the direct energy cost (fuel and lubricant consumption) and indirect energy cost (energy used for the vehicle construction). Excess demand on goods and private road transport may cause increase transport cost It is divided into two groups: Internal and external. Estimation of internal cost is easy, but of external cost is difficult. The both internal and external cost of the highway transport need to be decreased. Litman (1998) obtained the transport cost as 0.35$/pass-km [11]. At the present, energy costs are rising sharply, and fossil fuel prices are likely to remain consistently high or even increase in the near future. Increasing energy costs have a differing influence on the cost of truck, ship and rail transport [10]. The fuel price increases have an impact on the variable costs of transport modes [12]. Road transport-related energy consumption, transport value added, transport CO2 emissions and road infrastructure are mutually causal in the long-run. Also, there is an unidirectional causality running from fuel price to road transport-related energy consumption with no feedback in both the short and long runs.The fuel price and the road infrastructure are significant in the causal chain [15]. There are many diffrenet types of road tax for motorized vehicles in Turkey. It can be classified into two main groups: static and dynamic. Static tax can be defined as the yearly tax that is collected from motorized vehicles (MOT) according to their age, weight and cylinder capacity as well as the tax is

paid by purchase (PT). In addition, the vehicle insurance (VIT) and the Motor Inspection (MIT) taxes are also compulsory and static. Dynamic road tax can be defined as the fuel tax (FT) that vehicle users pay during the purchase of the fuel [11]. The most important variable is the cost of road transport in fuel expense represents the fuel expenses incurred during the journey. One of the most important items of costs incurred in a road time is fuel costs. Of the most important cost of fuel goes, there are two main reasons. they are; fuel consumption of commercial vehicles is more than periodic hikes in the fuel unit costs are day by day and periodically heavy tax in Turkey. For use as fuel expenses at the highest rate in the variable costs should be monitored regularly. Fuel expenses floor of the vehicle with the route length and the vehicle (tractor or truck) is associated with the fuel consumption rate. Fuel consumption per kilometer is calculated by dividing the total consumption of kilometers to be traveled. The fuel cost per time with the amount of fuel used during the time the fuel is calculated by multiplying the unit price. Fuel unit price may vary. Because every fuel purchase unit price is not the same. In addition, the determination of the total mileage of the vehicle which is the total of the vehicle's empty miles and the vehicle's loaded miles in a specific time is important to calculate the true cost [8].

Table 3. Oil Prices [2005-2050]

Year	Resource cost for petrol (pence/l)			Resource cost for diesel (pence/l)			Resource cost of domestic electricity supply (pence/kWh)
	Low	Central	High	Low	Central	High	
2005	30.76	30.76	30.76	34.41	34.41	34.41	11.72
2010	42.57	42.57	42.57	44.31	44.31	44.31	12.35
2015	43.50	53.06	62.00	48.38	59.01	68.96	16.20
2020	40.58	56.35	70.66	45.14	62.68	78.59	17.96
2025	37.85	59.83	80.55	42.10	66.55	89.59	19.74
2030	35.31	63.55	91.80	39.27	70.69	102.11	20.60
2035	34.96	64.17	92.69	38.89	71.38	103.10	20.29
2040	34.62	64.79	93.59	38.51	72.07	104.10	19.22
2045	34.27	65.41	94.48	38.12	72.76	105.09	19.22
2050	33.93	66.03	95.38	37.74	73.45	106.09	19.17

Conclusions and Recommendations

Energy issues seems to maintain their importance today and in the future. Showing an upward trend in all scenarios in the perspective of oil prices in 2050 will directly affect the country's economy. Working with existing technologies in the short term, especially in the field of transport vehicles powered by alternative fuels, petroleum products, car show up that they are not widespread. However, this need as well as Turkey's economic balance will not change the fact that they should work on alternative fuels to lose its competitive advantage in strategic sectors such as transport in terms of countries dependent on foreign oil. The fuel cost increase in road transport is known to be proportional with distance. Combined transport applications are widely applied in the reduction of fuel costs. However, taking advantage of combined shipping facility's every move is not possible. Therefore, to reduce the fuel cost of road-based transport energy radical solutions are needed. The vast majority of Turkey's energy consumption is met by oil and gas. Basic point of Turkey's gradual improvements to be made to reduce the energy costs will be seen in transportation. Turkey should ensure that its work with high calorific values of fuels vehicles carrying passengers and cargo, especially in the period ahead. The government should provide the necessary support to increase their share of vehicles running on alternative fuels in the presence of total vehicles in Turkey. The alternative fuel vehicles, except the government's legal requirements should direct the correct transport stakeholders. Besides being more cost of fuel produced from oil and its derivatives are known that polluting effect of high emission levels. Turkey should give priority to research and development activities for the production of vehicles powered by hydrogen energy. Turkey's civil society organizations and academics also have duties outside the government in increasing the profitability of the transport sector by reducing the lower carbon emissions to improve the quality of life using the tools and perform the fuel in transportation costs. Turkey's civil society organizations can create their studies with the public to increase the preferred alternative fuel vehicles. Academics can illumine society and transport stakeholders with the scientific studies.

References :

[1] Koç, E., Şenel, M. C. 2013. "*Energy Situation Overview in the World and Turkey*," Mühendis ve Makina, cilt 54, sayı 639, s. 32-44
[2] Öztürk,H.Hüseyin.,YIL, *Renewable Energy Resources*, Birsen publishing house, March 2013
[3] *Thermal power plants in Turkey*, Koray TUNCER,Mechanical Engineer ROOM Chamber of mechanical engineers Energy Unit /2013
[4] Pamir, A. Necdet., *Energy in the World and Turkey*, Turkey's Energy Resources and Energy Policies, 2003
[5] Gür, Aslan., Energy Efficiency in Road Transport and Diversification of Energy Sources,2013,Ankara
[6] Solak, A. O., 2013, Reducing Energy Consumption of Transportation Sector in Turkey: A Scenario Approach, *Journal of Economic and Social Research*, 1, 125-140.
[7] Bayraç, H. H., Economic Analysis of International Oil Market, 2005, Eskişehir.
[8] Ercan, Melis., 2006, The Costing System in International Road Freight Transportation and an Application, Istanbul University Social Sciences Institute, Istanbul.
[9] Jorgensen, K, 2008, Technologies for Electric, Hybrid and Hydrogen Vehicles: Electricity from Renewable Energy Sources in Transport, *Utilities Policy*, 16, 72-79.
[10] Rauch, P, Gronalt, M, 2011,The Effects of Rising Energy Costs and Transportation Mode Mix on Forest Fuel Procurement Costs, *Biomass and Bioenergy*, 35, 690-699.
[11] Haldenbilen, S, Ceylan, H, 2005, The Development of a Policy for Road Tax in Turkey, Using a Genetic Algorithm Approach for Demand Estimation, *Transportation Research Part A*, 39, 861-877.
[12] Macharis, C, Hoeck, V, E, Pekin, E, Lier, V, T, 2010, A Decision Analysis Framework for Intermodal Transport: Comparing Fuel Price Increases and The Internalisation of External Costs, *Transportation Research Part A*, 44, 550-561.
[13] Johansson, B, 1999, The Economy of Alternative Fuels When Including The Cost of Air Pollution, *Transportation Research Part D*, 4, 91-108.
[14] Yuan, X, Liu, X, Zuo, J., 2014, The Development of New Energy Vehicles for A Sustainable Future: A Review, *Renewable and Sustainable Energy Reviews*, 42, 298-305.
[15] Abdallah, B, H, Belloumi, B, Wolf, D, D, 2013, Indicators for Sustainable Energy Development: A Multivariate Cointegration and Causality Analysis from Tunisian Road Transport Sector, *Renewable and Sustainable Energy Reviews*, 25, 34-43.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Identification and Ranking E-commerce Infrastructure E-Readiness Indicators

Morteza Mahmoudzadeh[1], *Alireza Bafandeh Zendeh*[2], *Masoud Askarnia*[*3]

Abstract

In this study, have been tried to identification and prioritizing infrastructure e-readiness factors by using a descriptive analytical method. There are several models to assess the readiness of e-commerce infrastructure that consider difference set of variables for evaluating indicators criterion. Since there is no standards and specification models for e-readiness infrastructure assessment in Iran, affecting variables on e-commerce identified by studying various models and using interviews with70 of professionals and experts in the field of Information Technology and variables that had little impact omitted. Till a model with34 variables in four dimensions as: technological, economic, political and social specific for Iran e-commerce infrastructure readiness is achieved. Questionnaire was prepared by using a Likert spectrum then number of experts and specialists in management and behavioral sciences confirmed content validity of questionnaire and by the method of calculate reliability, Cronbach's alpha coefficient came0.83 which indicated the reliability of questionnaire. Also, by analyzing and processing the results of the questionnaire that was performed under the Friedman analysis of SPSS software, variables and 4dimensions of them in order of importance and influence have been prioritized that showed technological dimension and information infrastructure and communication variable has the greatest impact on e-commerce infrastructure readiness.

Keywords: E-Commerce Infrastructure Readiness, Assessment Model for E-Readiness, Friedman Analysis, Ranking, E-commerce Indicators

Introduction

By establishment and increasing spread of the Internet, could see new words, new ideas and innovative forms of Internet-related activities in the field of international trade. Concepts such as E-government, E-commerce, Extranet, Intranet etc are such forms of international business activity that has improved with the expansion of globalization. The importance consequence of globalization on the economies is development of e-commerce. The market of electronic, electronic data interchange and e-trade are components of e-commerce, which demonstrate the close relationship between ICT management with market and management processes. Due to the rapid growth of electronic commerce in the developed countries and competitive advantages that forces developing countries to immediately rethink on their business strategies and policies. To achieve the proper perspective regarding the current situation and the problems of e-commerce in developed and developing countries requires e-commerce accurately checked and analyzing its components, elements, indicators and factors that affecting on it. Should be assessed the inputs, process, outcome and efficiency of the e-business to ensure the achievement of desired goals.

E-commerce offers a variety of services and review and evaluate all of these services is very hard and requires a long period of time also coordination is more hard. Therefore, this study examines and identifies the variables of e-commerce in the view of digital economy, social, law and public policy and

1 Department of Industrial Management, Tabriz Branch, **Islamic Azad University**, Tabriz , Iran, m.mahmoudzadeh@srbiau.ac.ir
2 Department of Management, Tabriz Branch, **Islamic Azad University**, Tabriz , Iran, bafandeh@iaut.ac.ir
3 Department of Information Technology Management, Mizan, Institute of Higher Education, Tabriz, Iran, masoud.askarnia@gmail.com *Corresponding author

communications and technology infrastructure [1] means to eventually reach the conclusion that, what variables and with what priority impact on e-commerce infrastructure readiness. So the overall aim of this study was to identify the components of e-commerce services infrastructure e-readiness and response to this question that readiness of e-commerce service infrastructure is most affected by which variables, which extent and with what priority.

Hypothesis and Research Background

E-commerce has been one of the most widely used and most popular fields of trade and economic over the years which was developed every day in both the scope and the extent of it. This terminology and its concepts of evidence according to its two components, electronic and business, involves a wide range of topics and issues. E-commerce (EC) with its techniques and models is one of the phenomena of Information and Telecommunication Technology (ICT), which the information is its main yeast[2]. Today information in societies leads to complex relationships between its members in the areas of economic, cultural, political, social, etc. Based on views of Mr. Alvin Toffler's book The Third Wave and Peter Druker in industrial society book this age is called Information Age which have two main axes, technology and Market. Because the greatest impact of EC is on, reducing transaction costs for customers and vendors, increasing management efficiency, reducing transaction times, establishing close relationships with the business customers and increasing loyalty and trust between the customers[3].

As a newly entered country to the field of commerce and e-banking, Iran has a long way to go to achieve an acceptable level. For the development of e-commerce in the country, entry into global markets and membership in organizations such as WTO and have an efficient banking system are essential requirements. Therefore, the use of information and communication technology is important for development of electronic banking in the banking system [4]. Development of e-banking requires a certain economic and social infrastructure. Importance of this infrastructure include: communication and telecommunication networks, secure information sharing, infrastructure, legal appropriate and cultural readiness of public & enterprises to adopt and use electronic banking services [5]. In most contexts, meanings of e-readiness indicators and indexes that are used in this study are equivalent to the requirements or the basic concepts [6]. There are different models to assess e-readiness such as CSPP, CID, APEC, MOSAIC, EIU and ITU. These have offer different ways & indicators to measure e-readiness. E-readiness assessment models cause to more accurate planning to enter into the era of information and providing a infrastructure to monitor the performance of executive agencies[7]. For example, since 2000, every year, IBM Institute, provides e-readiness ranking of the world countries according to the EIU model[8]. In this context, researchers and companies have offered a set of factors that influence e-readiness in the form of models and assess the e-readiness of countries and rank them by these indicators. different models based on several factors is considered in e-Commerce infrastructure readiness analyze, these models and the most important affecting parameters gathered in table below[9].

Table 1.e-readiness models by separated variables [9]

Diminutions	Telecommunications infrastructure & Technology							Society					Digital Economy					Legal & Public Policies				
Factors / methods	Suitable telecommunication networks	In Security communication	IT infrastructures	services support	internet availability	Speed and quality of internet connection	ISPs	Skilled work force	Cultural readiness	Satisfaction and trust	Online users	education	Economical environment	ICT competition	Costs and prices	consumers	growth GDP	E-commerce support	Digital signature	Privacy security	Suitable law implementations	E-government
Tassabehji, 2003	*			*	*	*	*	*			*	*	*	*	*	*	*	*		*	*	
Groups and scopes of E-readiness					*				*				*								*	
CID e-readiness a direction to developing countries	*				*	*						*	*								*	*
Harvard's factors of E-readiness NIR	*		*					*				*	*								*	*

World economy seminar	*																			*	
(BOLERO2[10]	*	*							*										*	*	*
Frame work of assessment of E-readiness				*	*	*			*						*					*	
(USAID):					*							*				*				*	*
Sweden international agency for developments	*												*								
WITSA regarding E-readiness								*		*			*		*	*				*	
Mosaic	*				*			*					*								
CIDCM					*				*			*	*	*						*	*
worldwide technological factors : Metric-net	*							*					*	*							
McConnell International business risks	*				*			*				*	*	*	*				*	*	
knowledge assessment matrix :KAM	*							*				*	*								
IDC	*		*		*				*												
Pyramidal research of e-readiness	30%			10 %					5 %				20 %			20 %				15 %	
APEC assessment of E-readiness	*				*	*		*		*		*	*	*						*	
Measuring tools	*		*		*							*	*	*						*	
Network reachable assessment	*		*	*	*	*															
CPSS Guidance	*		*	*	*								*						*	*	
Readiness Index - Determinants	*		*					*				*	*							*	*
Seyed javad & Seghtchi[11]	*								*											*	
Center for International Development at Harvard University[12]					*				*			*	*							*	
Economist Intelligence Unit and Pyramid Research	25%								15 %				20 %			20 %		5 %		15 %	
EIU e-readiness rankings [8]	30%			10 %					5 %				20 %			20 %				15 %	
Mosaic Group	*				*																
Abundance	21	1	6	6	15	5	1	9	10	2	1	11	19	6	4	6	1	2	1	4	20	6

The e-readiness assessment methodologies are some of the methods of analyzing e-readiness have been shown in the table below.

Table 2. Methods of analyzing E-readiness [13]

Model	Questioner	Properly model	Successful experiences	Event analyses and last works
CSPP	*	*		
CID	*	*		
APEC	*	*		
WITSA	*	*		
McConnell		*	*	*
Crenshaw & Robinson		*		
CIDCM		*	*	*
Mosaic	*	*	*	*
USAID		*		*

Methodology

Since e-commerce infrastructure readiness comes from 4 different Diminutions this paper looks on the factors influencing e-commerce infrastructure readiness by interviews with experts in this field and using a library approach study to analyze past events and records. As well as some statistics on variables that reflect Successful experiences in this field is collected and discussed by evidence way. The information gathered by the questionnaire stored in Excel2013 and were analyzed by using SPSS (v.19) Friedman analyze. Thus indicated frequency scores and statistics from prioritization obtained some results, which analyzed. The presented study is a basic - applied research. Because the researcher did this study to improve their understanding of the relevant research issues that normally occur at organizations and on the other hand aims to use research findings to improve the situation of under study area. In order to identify the variables and data collection and information which used in the present study, by 70 experts directors of interaction with e-commerce organizations that have the educational background and work experiences, particularly in the areas of community, the digital economy, law and public policy and communications[14] infrastructure and e-commerce technologies and the faculty members of universities and explore papers in e-commerce as well as books, dissertations and several papers were used. Population size is all organizations can engage in e-commerce and individuals associated with these companies and organizations in the considered areas. After the interviews and publish questionnaires among 20 experts from the field of e-commerce and the estimated variance of 95% of the original sample, the sample size was calculated using the following formula: $\boldsymbol{n} = \frac{\boldsymbol{Z}_{\frac{\alpha}{2}}^{2} \times \boldsymbol{S}^{2}}{\boldsymbol{d}^{2}}$ According to calculations, 70 as the sample for the study was estimated that was selected by snowball sampling survey with a random sample of experts in the field of information technology and e-commerce, especially in the four dimensions of technological, political, economic, social in East Azerbaijan eparchy. The general characteristics of the sample formed as 17 (24%) were female and 53 (76%) male thus 23 are bachelor's degrees, 15 master's and 32 PHDs. In total 9 people was under 30 years old, 36 people between 30-40 years old, 16 people between 40-50 years old and 9 people were older than 50 years old. To collect the required data in the study and describe the foundations of the model, the library collection methods including a review of relevant literature through reference books, theses and papers, observation, statistical records were used. The method used in this research is descriptive and analytical method which Friedman analysis technique was used for analyzing and presenting the results. So after literature review of previous research and interviews with experts and a comprehensive study, a group of effective variables can be extracted. Then the model has been studied with managers and experts in e-commerce-related organizations and their comments will be taken through a questionnaire to prioritize Friedman analysis performed on variables. Based on theory of Churchill (1979) to create a scale when parts of study were identified must set of items associated with each of the following occur [15] By studying the same texts, detailed interviews and discussions with professors and advisors and specialists and managers, according to the study, intended items to measure each dimension identified, analyzed, and finally a multi-dimensional screening, led to the approved validity by the scientific and clinical experts, was developed. The questionnaire was developed from the literature and expert opinion and were used native and in accordance with the general atmosphere of the study. The questionnaire used in the study generally consists of two general and expertise questions. The first set of questions was about respondents' personal characteristics such as gender, age, education and work experience that has discussed earlier. The second set of questionnaires that are specialized questions are designed to test the study hypothesis. For quantity rating and worth specific questions, Likert scale include a rating from one to five, is used. To determine content validity, some questionnaires were given to the number of scholars and teachers, management and behavioral sciences and their opinions about the questions and hypotheses evaluation, polled to confirm validity. It is also reliability capability calculating way, Cronbach's alpha by calculating coefficient of variance of test questions and whole variance, with using the formula, alpha coefficient was calculated 0.83 which shows its reliability.

Data Analysis and Findings

In this section, obtained by the literature review, interviews with experts, officials and documents data are analyzing. All variables related to e-commerce obtained past studies, statistics, interview with experts in the field, results in the recorded books and articles included in the interview questions then the key variables influencing in ecommerce have been chosen by the opinions of experts and the remaining cases were excluded. Also the variables that had a greater impact were selected and accordingly more focus and more studies have been done on these variables and developed till effective and appropriate indicators identified as a model. It should be noted that variables such as accidents, international conditions and explosion policies has not been considered in this study. The model developed in this study is a preliminary attempt to analyze the affecting factors on e-commerce infrastructure readiness. After defining the problem considered in this study, a comprehensive study conducted on literature and previous research. Based on these studies, important variables identified and terms in four dimensions showed. Affecting factors on e-commerce readiness include four dimensions technological, political, economic & social which also caused a number of each of following table variables.

Table 3. E-readiness infrastructure variables

Confidence and satisfaction with e-services	social	Suitable telecommunication networks	technological
Fear of information theft		Companies providing electronic services	
Skilled work force		Security In communication	
Cultural readiness		IT infrastructures	
Trust and satisfaction		services support	
Online users		Access network such as the Internet	
Education		Speed and quality of internet connection	
Willingness to use again		Ability to issue digital signatures	
Digital signature	political	Economical environment	economic
Privacy security		ICT competition	
Appropriate legislation and legal provisions		Consumers	
E-government		Costs and expenses	
E- commerce support		growth GDP	
Political barriers such sanctions		The number of e-commerce services users company	
Electronic banking boom		Finance and Investment	
Legal support in the areas of e-commerce		Demand and Digital Signatures	
Governmental organizations that are authenticated with digital signatures		Unwillingness of financial transparency	

The questionnaire form was created with the theme of model variables and the impact of have been identified variables, based on questionnaires taken from experts which prepared by Likert scale, Friedman analysis was performed with using SPSS software, below is the results table that include the mean value, standard deviation, minimum and maximum bounds percentage.

Table 4. SPSS output for Friedman analysis

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum	Percentiles 25th	50th (Median)	75th
Suitable telecommunication networks	70	4.56	.644	3	5	4.00	5.00	5.00
Companies providing electronic services	70	3.64	.964	0	5	3.00	4.00	4.00
Security In communication	70	4.38	.855	2	5	4.00	5.00	5.00
IT infrastructures	70	4.28	.970	0	5	4.00	4.50	5.00
services support	70	4.00	.808	2	5	4.00	4.00	5.00
Access network such as the Internet	70	4.26	.876	2	5	4.00	4.50	5.00
Speed and quality of internet connection	70	4.10	.909	2	5	3.75	4.00	5.00
Ability to issue digital signatures	70	3.62	.923	1	5	3.00	4.00	4.00
Economical environment	70	3.80	1.325	0	5	4.00	4.00	5.00
ICT competition	70	3.86	1.069	0	5	3.00	4.00	5.00
Consumers	70	3.62	.830	2	5	3.00	4.00	4.00
Costs and expenses	70	3.62	.901	2	5	3.00	4.00	4.00
growth GDP	70	3.76	.916	0	5	3.00	4.00	4.00
The number of e-commerce services users company	70	3.84	1.017	0	5	3.00	4.00	4.25
Finance and Investment	70	3.94	.956	1	5	3.00	4.00	5.00
Demand and Digital Signatures	70	3.54	.952	1	5	3.00	4.00	4.00
Unwillingness of financial transparency	70	3.80	.833	2	5	3.00	4.00	4.00
Confidence and satisfaction with e-services	70	4.20	1.010	2	5	3.00	5.00	5.00
Fear of information theft	70	4.02	.915	2	5	4.00	4.00	5.00
Skilled work force	70	3.74	1.103	1	5	3.00	4.00	5.00
Cultural readiness	70	4.18	.896	2	5	4.00	4.00	5.00
Trust and satisfaction	70	4.12	.872	2	5	4.00	4.00	5.00
Online users	70	3.70	.886	2	5	3.00	4.00	4.00
Education	70	3.84	.955	1	5	3.00	4.00	4.25
Willingness to use again	70	3.32	.999	1	5	3.00	3.00	4.00
Digital signature	70	3.70	.931	1	5	3.00	4.00	4.00
Privacy security	70	3.80	1.107	0	5	3.00	4.00	5.00
Appropriate legislation and legal provisions	70	4.44	.951	0	5	4.00	5.00	5.00
E-government	70	4.06	1.018	0	5	4.00	4.00	5.00
E- commerce support	70	4.34	.939	2	5	4.00	5.00	5.00
Political barriers such sanctions	70	3.90	.839	2	5	3.00	4.00	4.25
Electronic banking boom	70	4.28	.701	2	5	4.00	4.00	5.00
Legal support in the areas of e-commerce	70	3.98	.958	2	5	4.00	4.00	5.00
Governmental organizations that are authenticated with digital signatures	70	3.52	1.129	1	5	3.00	4.00	4.00

The scoring based on Friedman analysis obtained for each of the variables. Radar chart shows total and mean scores in each of the 4 Diminutions, that each of them is a set of variables result.

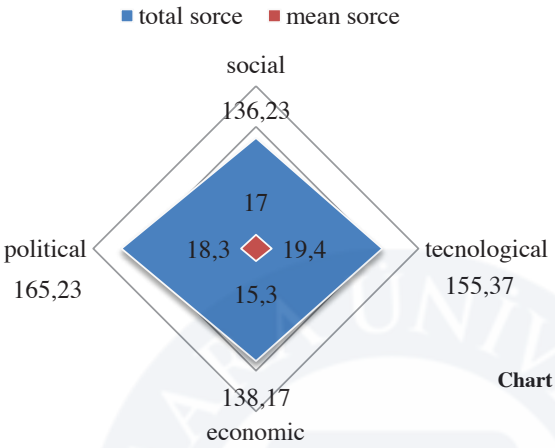


Chart 1 . Total and mean scores for each dimension

There is all variables rank based on Friedman analysis in the following table.

Table 5. Variables mean rank SPSS output

Rank		Mean Rank	Rank		Mean Rank
1	Suitable telecommunication networks	24.33	18	ICT competition	17.06
2	Appropriate legislation and legal provisions	23.13	19	Political barriers such sanctions	16.97
3	Security In communication	22.52	20	Education	16.35
4	Privacy security	22.34	21	Legal support in the areas of e-commerce	16.16
5	IT infrastructures	21.84	22	The number of e-commerce services users company	16.15
6	Access network such as the Internet	21.21	23	Skilled work force	15.70
7	Electronic banking boom	21.03	24	growth GDP	15.47
8	Trust and satisfaction	20.86	25	Unwillingness of financial transparency	15.10
9	Cultural readiness	19.91	26	Digital signature reliability	14.88
10	Confidence and satisfaction with e-services	19.88	27	Online users	14.44
11	Speed and quality of internet connection	19.40	28	Companies providing electronic services	14.21
12	E-government	19.32	29	Ability to issue digital signatures	14.15
13	Fear of information theft	18.51	30	Costs and expenses	13.58
14	E- commerce support	18.09	31	Consumers	13.35
15	services support	17.71	32	Governmental organizations that are authenticated with digital signatures	13.31
16	Finance and Investment	17.33	33	Demand and use Digital Signatures	12.83
17	Economical environment	17.30	34	Willingness to use again	10.58

Conclusions

The conclusions in this study include literature review and interviews with experts in the field of e-commerce results, leading to identify e-Commerce infrastructure variables influencing e-readiness, and questionnaires analysis. Research questions have been answered in the conclusion. It also proposed offers to researchers and managers in the area of e-commerce. Parameters table that obtained with study old documents and interview with experts, can be used as a flagship model for Iran. Also, based on what is

observed in the output analysis, preference of variables are shown in table , starts with 'communications networks' variable with the highest priority to lowest priority 'interest to use electronic services again' variable. The highest priority in dimensions is for technological dimension then the political and social have while the economic dimension has the lowest priority as shown on the chart1. Therefore, the technological dimension continuous improvement process, which has the highest priority in Iran, would be a direct positive impact on Iran's e-commerce infrastructure readiness. Data security and privacy variables have high priority that their improvement can be used to reduce the impact of negative variables such as fear of information theft. Also, due to the weakness of e-commerce readiness in our country, in dire need to government's financial support from information technology and government's interest to use information technology that must be associated with electronic government. In this case, both investment promote to cover economical dimension and technological dimension will be provided and by law state support, clear and precise rules in the field of e-commerce will be developed that could be paving way for electronic commerce. It should be noted that another negative variable that impact on model's variables are political obstacles like sanctions, by overcoming them can be produced ecommerce infrastructure readiness growth path.

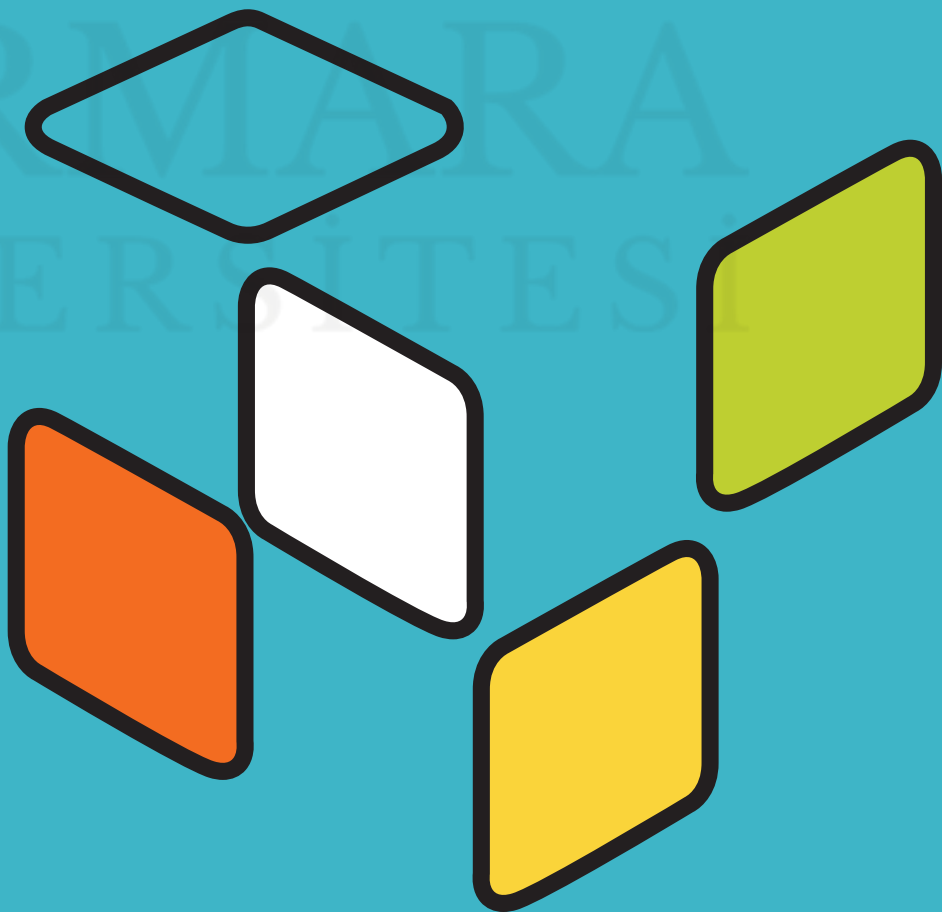
It is recommended that future researchers develop study model by expanding the system boundaries and taking more exogenous variables in the model, developing this model through input other relevant institutions such as organizations that are active in this field and customize the study model at companies with micro- looked and check system behavior under different scenarios to increase the study scope. It should be noted that the present study has some limitations as any other scientific research. To make the model behavior correct, all the model variables must expressed but due to time and information constraints, the affective variables have shown in this study, on the other hand, variables obtained through interviews with experts that may be have not answered carefully due to interview less time and only with 70 people of entire community of specialists in this field were interviewed and the experts in each of four districts can't comment on interdisciplinary issues, this causes an error in discussions which made work very difficult.

References

[1] Fatheian, M. (2005). Effective indices for assessing the e-readiness of small and medium enterprises. *Third international conference of management* .
[2] Poorsalimi, D. (2007). Check the status of the B2B-EC in the current market. *National Conference on Electronic Commerce* (p. 12). Tehran: SID.
[3] Kalakota, R., & Whinston, A. (1999). Electronic Commerce : A Manager's guide. *MA: Addison Wesley longman* , Inc.
[4] (2012). Statistical tools and equipment Electronic Payment. Central bank.
[5] seyed javadiyan, r., & seghatchi, m. (2006). Electronic Banking Syrthvl in Iran. *Tadbir* , p. 170.
[6] Tassabehji, R. (2003). *Applying e-commerce i n business*. london: SAGE.
[7] Hagel, J., & Seely Brown, J. (2008). From Push to Pull: Emerging Models For Mobilizing Resources. *Journal of Social* Service .
[8] ibm_ereadiness, EIU; economist;intelligence unit. (2009)
[9] Askarnia, m., & Rahimzadeh holagh, s. (2014). Assessing E-Commerce Infrastructure readiness , Case study Iran. *1st International Conference on Computer Sciences, Communication and Information Technology*. Tbilisi.
[10] Kahzadi, N. (2003). e-Commerce. First conference of e_Commerce. Tehran.
[11] Seyed javad, R., & Seghtchi, M. (2006). The development status of e-banking in Iran. *Monthly Tadbir*. , p. 170.
[12] Clemons, E. (2002). Business review. HARVARD .
[13] Fathian, m., & mahdavi nur, s. (2007). Resources and information technology management. tehran: Iran *University of Science and Technology*.
[14] (2013). Telecommunication status 2006 to 2013 years. *Iran Telecommunication Company*.
[15] Sin, l. e. (2005, September). Conceptualization and scale development. *European Journal of Marketing* , pp. 1264 – 1290.

MARMARA ÜNİVERSİTESİ YAYINEVİ

BRAND MANAGEMENT



MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Brand Management Benchmarking (BMB) for Global Arena

Gonca Telli Yamamoto[1], Özgür Karamanlı Şekeroğlu[2], Murat Kaykusuz[3]

Abstract

***Enterprises** are essentially required to change and evolve continuously and keep up with the innovations under the fierce competition, which has developed in parallel to globalization in our era. Together with the advancement of the technology, access to information has become more convenient and in a setting with diversified customer expectations, having the best practices to become a leading enterprise or face the competition has become critical. Particularly, it is vital and critical for the companies to pursue innovations on the crucial issue of brand management, accomplish the best practices, and develop their own processes. Benchmarking becomes the key in this respect. Benchmarking is also an important tool, which is defined as the comparison with the best, learning from the best and integrating those learned and into the structure, processes and culture of the enterprise, as an important tool to increase the effectiveness of strategic management. This study elucidates the structuring of brand management processes -particularly of the enterprises which are globally operating or desiring to act globally- through benchmarking, and quests for an answer to the question of what it reverberates on the organization.*

Keywords: Brand Management, Benchmarking, Global, Strategic Management, Global Benchmarking

Introduction

Benchmarking is a strategic process which enables enterprises to compare their products, services and business processes against those of the competitors, and others, evaluate and adopt those best product, service, brand or business development processes in the market by means of the new communication methods and technology, and create role-models from them in accordance with their own requirements and circumstances. Even though benchmarking is mostly considered as the comparison of products, services and business processes; the comparison of brand management has also gained further importance gradually in the global market where processes and products are getting similar to each other, which is on the grounds that it is not possible to create true integrated marketing strategies without examining how brand values are created and scaled in the best practices, and how they are used in the global market, thus priming the conditions of managing the organization's own brands compared to the benchmarked brands. Creating a strong brand is a very important factor to take the front lead in the competition. In brand management, the essence of benchmarking may be considered as encouraging continuous learning and leveraging companies to high competition levels. Benchmarking practices in brand management prompt the development of strategies to boost customer satisfaction to new heights and subsequently the optimization of the work performance by attaining internal and external information and effective practical standards, and particularly by problem-solving.

Benchmarking is the identification of the "best practice" either internal or external, and its integration into the organization to maximize performance. Benchmarking is not just a comparison; it is measuring against other organizations, finding the best practices and accommodating them into the organization's own structure and processes. In this respect, the concept of benchmarking may be defined as the “adaptation of best practices” [1] It is different than copying. Benchmarking is a tool for the systematic assessment of the competitive power of

[1] Gonca Telli Yamamoto, Professor of Marketing, Marmara University, Institute of Pure and Applied Sciences, Department of Industrial Engineering, Istanbul, Turkey, gonca.telli@marmara.edu.tr
[2]Özgür Karamanlı Şekeroğlu, PhD, Okan University, Distance Education Center, Istanbul, Turkey, ozgursekeroglu@gmail.com
[3] Murat Kaykusuz, Lecturer, PhD Candidate, Okan University, Distance Education Center, Istanbul, Turkey, kaykusuz@yahoo.com

an enterprise. As a matter of principle, it is your comparison with another organization in your own industry or in other industries. It may be exemplified with the benchmarking of a leather manufacturer on a company from the automotive industry; accordingly, the questions such as who are best, and how did they do it require answers for the issues investigated by the enterprise. The enterprises may gain a great momentum if they consider benchmarking practices in brand management particularly when these questions are answered properly and accurately, and the adaptation processes are conducted in accordance with the codes of project management.

Likewise, benchmarking provide the enterprises with standardization data. Not knowing what the standard is will hamper self-assessment of enterprises. For instance, when a customer asks "What is your average service time?", it is possible to say 5 hours in average. However, knowing your own timing is not enough *per se* to subsist in the competition. The enterprise's cognizance on the position of the average given by the enterprise with respect to the market is decisive in differentiating the enterprise against the competitors to ascertain customer's preference. Digression from standardization, thus having something not measurable forestalls demonstrating its superiority or difference. For example, if the average service time in the overall industry is between 3 and 7 hours, it shall mean that the enterprise in question serves at an average time. In contrast, if the competitors serve in 4 hours, then the customer may prefer the competitors. At this point, particularly, the importance of benchmarking brand management processes for globally-operating enterprises increases as becoming a recognized. Globally-famous brand is not a simple process. It requires correct perceptions, analysis and correct choices. Benchmarking is an expensive process in that, you may require various travels for a research about your enterprise, and require serious figures and time to analyze the environmental aspects of the organization to be benchmarked. Certain costs, in the process of adaptation of an innovation identified during benchmarking, are also natural. Nonetheless, it is not expensive at all considering its results. The process should be planned carefully. Another way of controlling costs is to carry out benchmarking in gradual steps. For example, minimizing the travel and welcoming expenses by planning them according to the objective, or acting carefully during budget periods; and acting meticulously during budgeting terms and working effectively and efficiently for the objective may reduce costs.

There are several examples of benchmarking in the world. Xerox applied successfully benchmarking between 1980-1985 in various departments, such as production, accounting, distribution, etc. related to these benchmarking projects, The company's unit production cost has been decreased 50 per cent; the number of machine malfunction has been diminished 90 per cent, the company's marketing productivity has been increased 30 per cent; the distribution channels' productivity has been increased 10 per cent and white collar workers' cost has been decreased 30 per cent. [2] On the other hand, the market share of Xerox in the printing field has been increased from 18 per cent to 80 per cent. [3]

In Turkey, Beko Elektronik, Arçelik, Eczacıbaşı Group, Benchsa (a benchmarking company established by Sabancı Holding companies: Brisa, Beksa, Kordsa, Dusa and Olmuksa) are well known companies, which have applied successfully several benchmarking projects.

According to Kornberger branding is management's weapon of choice to structure the internal functioning of organizations. [4] Creating and maintaining a new global brand is already challenging, while two fundamental strategies are considered: launching own successful local brand to the international market and expanding, or creating a global brand at the beginning. Global benchmarking is a critical and analytical element to assess the successful applications of these two fundamental strategies. The study contemplates benchmarking conceptually and through a brief literature review, and clarifies what the companies can gain with benchmarking practices in brand management.

Benchmarking Concept

Benchmarking concept is a continuously repeated process which foresees adaptation of the best practices into the circumstances, structure, objective and culture of the enterprise with the addition of creativity and without replication, by comparing the enterprise with other enterprises without discriminating industries, through realizing that learning and development are perpetual processes to ensure quality, improve processes, increase

customer satisfaction, operational performance and competitive strength by virtue of the ever-augmenting competition. [5]

Benchmarking is also the process of comparing one's business processes and performance metrics to industry bests or best practices from other companies. These dimensions typically measured are quality, time and cost. In the process of best practice benchmarking, management identifies the best firms in their industry, or in another industry where similar processes exist, and compares the results and processes of those studied (the "targets") to one's own results and processes. In this way, they learn how well the targets perform and, more importantly, the business processes that explain why these firms are successful. [6]

Benchmarking includes measuring products, services, and processes against those of organizations known to be leaders in one or more aspects of their operations. Additionally, benchmarking can help you identify areas, systems, or processes for improvements, either incremental (continuous) improvements or dramatic (business process reengineering or innovation) improvements. [7]

Benchmarking is an increasingly common management practice. [8], [9], [10], [11], [12] It remains, however, a concept loosely connected to management theory, and is the subject of disagreement between those who embrace it as a tool of performance improvement and good quality practice, and those who regard it as a fad or bandwagon. [13], [14]

According to American Productivity and Quality Center (APQC) benchmarking is a systematic process whereby a comparison of work processes and performance indicators is accomplished, in order to identify and apply best practices from the same industry or from different industries. Basically, benchmarking is a learning process which needs to be ongoing in our company's live. Benchmarking is the practice of being humble enough to admit that someone else is better at something, and being wise enough to learn how to match them and even surpass them at it. [15]

The benchmarking approach is viewed as an effective and efficient management tool in industrial companies. [16] According to Kozak [17], benchmarking allows improvement of business practices by building upon "performance comparison, gap identification and change management process". Scholars distinguish between external and internal benchmarking; the former refers to comparisons against other organizations in the industry, while the latter is concerned with comparing units and ideas within the same organization. [18], [19]

Based on all of these definitions the concept of benchmarking is the process of determining who is the very best, who sets the standard, and what that standard is.

The Purposes of Benchmarking

Benchmarking has certain purposes similar to other management techniques. These purposes may be considered as follows [20],[21],[22],[23] Help the identification of the goals and objectives of the organization,

- Identify best practices to achieve goals and objectives,
- Validate goals, objectives and practices,
- Revise and optimize the corporate culture,
- Ensure strategic management of the enterprise,
- Reveal better internal practices,
- Reduce costs,
- Motivate the employees further,
- Bolster competitive edge and corporate performance.

Benchmarking is related with processes and practices. It is also an instrument of defining the processes that require major changes. Comparison is conducted in the cases when win & win solution may be created between the enterprises which may either be competitors or not.

Types of Benchmarking

There are three primary types of benchmarking that are in use. These are process benchmarking, performance benchmarking, and strategic benchmarking. [18] Process benchmarking focuses on the day-to-day operations of the organization. It is the task of improving the way processes performed every day. Some examples of work processes that could utilize process benchmarking are the customer complaint process, the billing process, the order fulfillment process, and the recruitment process. [18]

All of these processes are in the lower levels of the organization. By making improvements at this level, performance improvements are quickly realized. This type of benchmarking results in quick improvements to the organization.

Performance benchmarking focuses on assessing competitive positions through comparing the products and services of other competitors. When dealing with performance benchmarking, organizations want to look at where their product or services are in relation to competitors on the basis of things such as reliability, quality, speed, and other product or service characteristics.

Strategic benchmarking deals with top management. It deals with long term results. Strategic benchmarking focuses on how companies compete. This form of benchmarking looks at what strategies the organizations are using to make them successful. This is the type of benchmarking technique that most Japanese firms use. [18] This is due to the fact that the Japanese focus on long term results.

Benchmarking implementations have started with strategic financial concerns. Benchmarking does not only consider financial indicators. In benchmarking, the enterprises compare their practices against the best organizations in their industry, or compare different functions of the enterprise against each other and attempt to close the performance gaps. However, financial indicators are important assessments. They should not be ignored.

Advantages of Benchmarking

The company which apply benchmarking successfully gets the following advantages: [24][25][26][27]

a) Improving product quality
b) Increasing sales and profits
c) Lowering labor costs
d) Comparing performance between product lines or business units
e) Understanding the performance of the company relative to close competitors
f) Holding employees more responsible for their performance
g) Developing a standardized set of processes and metrics
h) Providing a mindset and culture of continuous improvement
i) Better understanding what makes a company successful
j) Performance improvement
k) Making detailed competitive and sector analyses
l) Looking for the best production and selling performance continuously

Disadvantages of Benchmarking

Applying benchmarking can cause the following disadvantages [26]:

a) The danger of complacency and arrogance due to the becoming the leader of the sector
b) Considering benchmarking as a stable process
c) Lack of adapting benchmarking process to the corporate culture

Problems of Applying Benchmarking

There are a lot of problems that can occur during the application process of benchmarking [28]:

a) **Lack of top management's support:** The team which apply benchmarking in the company, needs a brilliant leader. In the case that the top management of the company does not appoint a successful leader to the benchmarking team and does not support them, the failure of the benchmarking process is inevitable.
b) **Selection of inefficient persons to the benchmarking team:** The members of the benchmarking team should be qualified and well informed of benchmarking.
c) **Ambiguous mission of the benchmarking team:** In the case that the mission of the benchmarking team's mission is not well defined, the team will not finalize the benchmarking process.
d) **To give more importance to the performance output instead of benchmarking process:** The benchmarking team should focus to the benchmarking process more than the performance output.
e) **Weak relationship between benchmarking and corporate strategies:** The top management of the company should strengthen the relationship between benchmarking and the strategic management of the company.
f) **Lack of understanding of company's mission and targets:** In order that the benchmarking process is finalized succesfully, the company's mission and targets should be completely explained to the company's employees.
g) **Imitating instead of benchmarking:** The most important and common problem, which occur in the benchmarking process, is that the company imitates the benchmarking partner's activities instead of adapting them to the company.

Primary Financial Gains Applying Benchmarking

a) The value of the tangible and intangible assets of the company, which applies benchmarking process succesfully increases.
b) The successful benchmarking application provides cost minimization to the company in the applied area.

The value of the company's brand, which applies benchmarking process, increases.

Conclusions

The yields of benchmarking process in the global arena for companies against further importance when the process can be realized at or above an optimal level. The main objective of the benchmarking process is to identify the dynamics of the competition between the global objectives and the enterprise, translate threats into opportunities, and identify the actual correct strategies for the enterprise.

Many successful companies with brands in the world manage their processes accurately and overcome the challenges and gain success despite the fierce competition in the global market. Becoming a global brand is a very important indicator of the proper functionality of the enterprise's communication process in terms of creating a role-model for other companies. At present, any initiative which opens a business on the Internet is actually a global arena player. Therefore, companies should choose the correct role model among the major and successful players. That's why benchmarking should be reviewed, its benefits should be exploited, and a new field of action should be created. The brand management comes into play then.

With Brand Management Benchmarking various scenarios may be developed globally and as a result, the results of alternative strategies may be tested somehow. The most suitable alternative will be leading in the identification of the actual goals and objectives of the enterprise. The alternatives which are considered negative may be identified as the areas which are not to be risked. Besides, global companies' practices may also constitute a source for the occurrence of new and different ideas. So, each benchmarking processes which is successfully completed in the company will be the machine of initiating new benchmarking processes in the global arena.

Related to the successful benchmarking in any department of the company, the company's profitability and also the company's brand awareness increase. Therefore, the market value of the company rises for the reason that the brand value is currently one of the most important factors in the company's valuation. New models for brand management benchmarking (BMB) should be built for the further studies.

REFERENCES

[1] Aktan, C.C (1999). 2000'li Yıllarda Yeni Yönetim Teknikleri. İstanbul: TÜGİAD Yayınları.

[2] Saraç, O., 2005, Benchmarking ve Stratejik Yönetim, *Sayıştay Dergisi*, 56, 53-77.

[3] Atasever, M., 2013 Benchmarking, http://usakubyo.blogspot.com.tr/ (08/02/2015).

[4] Kornberger, M. (2010). Brand Society: how brands transform management and lifestyle, Cambridge: Cambridge University Press.

[5] Özer, P.S.,1999, Benchmarking. İzmir: Vizyon Yayınları.

[6] Wikipedia, 2015, https://en.wikipedia.org/wiki/Benchmarking (07/02/2015)

[7] Revelle, J. B., 2004, *Quality Essentials: A Reference Guide from A to Z* , ASQ Quality Press, Milwaukee.

[8] Boston Consulting Group, 1994, Leading the way: a study of best manufacturing practices in Australia and New Zealand'(3rd edn). Melbourne: Australian Manufacturing Council.

[9] Foster, T.O.,1992, Logistics benchmarking: searching for the best. Distribution, 91, 330-6.

[10] MacNeil J. and Rimmer, M.,1993, Benchmarking in Australia: the state of play, Asia Pacific Joumal of Quality Management, 2, 3, 30-45.

[11] Richardson J. and Taylor, C., 1993, Strategic benchmarking: the co-evoludon of competitor intelligence and quality management'. Paper presented at the American Academy of Management, Atlanta, Ceorgia, August 8-11.

[12] Cox, Mann and Samson, 1994, A home for theoretical orphans? Using sociotechnical systems theory to understand the forming of hybrid organizations. Unpublished paper. Department

[13] Bernowski, K.,1991, The benchmarking bandwagon, Quality Progress, 24, 1, 19-24.

[14] Boxwell, R.J. 1994, Benchmarking for Competitive Advantage. New York: McGraw-Hill.

[15] Nicolae, P., Florin D. and Alexandru, 2014, "Benchmarking For The Romanian Heavy Commercial Vehicles Market", http://steconomiceuoradea.ro/anale/volume/2014/n1/115.pdf, 03.02.2015

[16] Kaplan, R. and Norton, O., 1996, The Balanced Scorecard, Harvard Business School Press, Boston, MA.

[17] Kozak, M. , 2002, Destination benchmarking, Annals of Tourism Research, 29 (2), 497-519.

[18] Bogan, C.E. and English, M.J., 1994, Benchmarking for Best Practices: Winning Through Innovative Adaptation, McGraw-Hill, New York, NY.

[19] Watson, G.H. 1993, Strategic Benchmarking: How to Rate Your Company's Performance Against the World's Best, John Wiley & Sons, New York, NY.

[20] Özgen H. ve Ölçer F., 1998, Toplam Kalite Yönetimine Giriş ve Uygulamada Başarıyı Engelleyen Faktörler., Standart Ekonomik ve Teknik Dergi. Sayı: 440.

[21] Bedük, A., 2000, Yeni Yönetim Tekniği "Benchmarking" Dış Ticaret Dergisi. Sayı:19 Ekim. s.131-144

[23] Fisher, J.G., 1998, Kıyaslama (Benchmarking) Yoluyla Performans Nasıl Artırılır?. İstanbul: Rota Yayınları

[24] Turhan,M., 2002, Eğitim Örgütlerinde Kıyaslama (Benchmarking), Fırat Üniversitesi, Sosyal Bilimler Enstitüsü, Yayımlanmamış Yüksek Lisans Tezi, Elazığ.

[25] Suttle, R., 2015, The Advantages of Benchmarking for an Organization, *Chron*, http://smallbusiness.chron.com/advantages-benchmarking-organization-30952.html (04/02/2015).

[26] Roberts, M., 2014, 7 Benefits of Benchmarking Your Manufacturing Performance [DATA], *LNS Research*, http://blog.lnsresearch.com/blog/bid/192183/7-Benefits-of-Benchmarking-Your-Manufacturing-Performance-DATA (03/02/2015).

[25] Nayab, N., 2010, Pros and Cons of Benchmarking, *Bright Hub*, http://www.brighthub.com/office/entrepreneurs/articles/82292.aspx (04/02/2015).

[27] Dokuzer, B. and İnal, M. E., 2008, Örnek Edinmenin İşletmeler Tarafından Bilinirliği ve Uygulanırlığının Saptanmasına Yönelik Bir Araştırma – Niğde Örneği, *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 13 (2), 371-401.

[28] Demirci, E., 2014, Örnek Edinme (Benchmarking) in *Yönetim Organizasyon*, Chapter 15, Anadolu Üniversitesi Açıköğretim Fakültesi Yayınları.

MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

A Digital Literacy Campaign as a Social Responsibility Project:A Case Study

Nejla Karabulut[1]

Abstract

In recent years, the number of Turkish corporate social responsibility (CSR) projects has risen significantly. These bodies help organizations to improve their image in the eyes of target audiences and provide great opportunity to differentiate from competitors. CSR projects usually take shape according to the needs of the sector or society in which an organization operates. The focal points of CSR projects in Turkey are usually centred upon education or increasing awareness around issues of societal concerns like public health and environmental and cultural protection. Compared to European countries, low literacy still remains a major issue in Turkey. Both private corporations and state entities support projects that aim to provide solutions to this problem. However, today we face another type of literacy handicap: That of digital literacy. This study focuses on the digital divide and digital literacy issues in Turkey and aims to highlight the necessity of organising CSR projects that address this educational shortcoming. The benefits of such projects are exhibited through the example of Beykoz Vocational School of Logistics' social responsibility project called "Everyone in Beykoz Will Learn to Use Computers!" The project was conducted between October 2009 and October 2010 in Beykoz where the school is located.

Keywords: Digital Literacy, Digital Divide, Corporate Social Responsibility, Corporate Reputation, Social Stakeholder

Introduction

The fact that corporate social responsibility (CSR) projects play an important role in creating a positive perception of organizations in the eyes of internal and external target audiences and in their differentiation from competitors is a commonly recognized reality today. The studies conducted demonstrate that consumers are influenced not only by the criteria of quality and cost in their choice for products and services, but also by the social responsibility efforts conducted by organizations offering those products and services. According to the 2013 results of GlobeScan, a Canada-based organization conducting studies in the fields of reputation management and measurement in 26 countries including Turkey, 35% of the global audience believe that organizations need to work towards creating a better society beyond merely conducting their business based on ethical values and recognized standards. The rate of those that say "Organizations should only focus on their business, making profits, paying taxes and creating employment" remains at 23% in the report. As for Turkey specifically, 58% of participants state that they only buy from companies that comply with ethical values and assume social responsibilities [24].

The effect of CSR on corporate reputation and brand value, regarded as a strategic value for companies, is a topic that attracts the attention of funders and investors in the merger and acquisition processes, as well. Today, social responsibility activities are handled as a separate headline in the scope of performance assessments conducted before investing in an organization [2]. In the past, the concept of social responsibility was perceived only as the performance of doing business in line with ethical standards and realizing efforts that are environmental/nature friendly; however, its meaning and scope became wider over time and it has come to be shaped according to the needs and problems of the community and/or sector of the particular organization. The majority of social responsibility efforts conducted in Turkey is composed of education and awareness-raising activities conducted in various fields.

Campaigns that target the problem of literacy [Ana-Kız Okuldayız (Mother-Daughter at School), Kardelenler (Snowdrops), Baba Beni Okula Gönder (Father, Send me to School), literacy courses for adults, etc.], which is still at a low level especially as compared to European countries, also supported by commercial organizations and conducted with success. However, another problem of literacy that has emerged as a result of today's technological advances appears to be related to digital literacy. Digital texts/applications require a different

[1] Nejla Karabulut, Beykoz Vocational School of Logistics, Turkey, n.karabulut@yahoo.com

method of reading compared to standard texts. With general literacy, information is typically presented in a linear format that requires reading from the beginning to the end whereas information in digital environment information is presented in more of a semantic network in which multiple related sections of the text are connected to each other. The user needs to establish an association among the inter-connected sections within this entity of information [15].

The fact that computer technologies have become widespread in both business and daily life, and even obligatory for certain uses -like government e-applications- requires individuals to become digitally literate. The first step into digital literacy is the acquisition of basic technical and hardware knowledge related to computers. Following this step, the phenomenon of digital literacy assumes different dimensions such as access to information in the Internet world, the use and generation of information, as well as the identification of its reliability. This study aims to explore the problem of digital literacy at the basic level in Turkey, and to highlight the necessity of organizing CSR projects that address this educational problem. In that respect, the phenomenon of digital literacy will firstly be tackled on a conceptual level, the situation of literacy in Turkey will be explored and the CSR project titled "Everyone in Beykoz Will Learn to Use Computers!" conducted in the academic year 2008-2009 by Beykoz Vocational School of Logistics will be explained in detail as a case study.

Digital Literacy

A review of the literature on digital literacy shows that several definitions about this phenomenon have been made and that these definitions are related to the concept of information literacy. In definitions of literacy, the overarching themes essentially include the use of information resources, using information in the processes of problem solving and decision-making. The first definition made in 1974 by Zurkowski purported to explain the concept by means of the qualities that an information-literate person needs to have. Accordingly, an information-literate person is someone who generates information-based solutions specifically for the problems encountered in the workplace and has the required skills and techniques to use the information resources in the best possible way [19].

The definitions made after Zurkowski until the 1980s preponderantly focused on the best use and control of the rapidly increasing amount of information, the new skills required and the economic as well as cultural changes caused by computer technologies, which were becoming widespread. According to definitions that are becoming wider in scope, an information-literate person is a person who performs research on information and technology, is productive in a democratic society, able to comply with a rapidly changing environment, prepares a better future for new generations, finds the proper information to solve personal and professional problems and is capable of using a computer [1]. In time, concepts such as efficiency in work life, quality of life, citizenship rights, democracy, technology, social integration and social acceptance also came to be associated with information literacy [19].

The inclusion of digital literacy as a separate definition took place in the second half of 1990s when digital technologies started to become widespread in every walk of life. Richard Lanham, attempted to explain digital literacy in his article published in 1995 in Scientific American by means of the multimedia properties of new media [20]. The most important reference pointing out to the definition is the book entitled Digital Literacy published in 1997 by Paul Gilster. According to Gilster, who explains this concept shortly as “being literate in the digital age”, digital literacy is not limited to technical capabilities such as pressing the keys of a keyboard. It is also very important for the individual to be able to ascribe a meaning to what s/he sees on the screen, finds what s/she looks for and uses it in a competent way in practice. Gilster defines digital literacy as a special way of mindset and thinking far beyond effectively using digital resources [5]. The definition by Gilster that makes a reference to the lifestyle has become more prominent along with the developments that occurred in digital technologies. Computers and mobile phones are no longer used for a sole purpose. Acts related to all areas of life such as work, entertainment, communication, learning, education, socializing and shopping now take place by means of these technologies. Referring to this new feature of new technologies, Buckingham terms digital literacy as a cultural understanding [8]. Buckingham's definition shows us the reflection of every novelty occurring in information technologies onto the concept of digital literacy. In a way that is identical to information literacy, digital literacy concept also has an increasingly expanding scope.

The acquisition of cognitive and emotional skills in the use of digital technologies and the understanding of the nature of these technologies enable individuals to successfully implement living, learning and working methods required by a digital society. Being digitally literate has become important even in managing private life.

Although this concept is defined in various ways and the scope of definition is increasingly expanding, the first step of digital literacy is to learn the technical use of computer technologies and essential computer software programs. At this point, the situation is not different from traditional literacy processes. The traditional literacy process that starts with learning the alphabet continues with syllables, simple words, sentences and essential grammatical rules. An individual learning these can go up to higher levels if s/he continues her/his development: Learning new information, ascribing meaning to information and ensuring correct use and integrity of information in all fields of life. In the process that starts with primary school and continues to undergraduate (and graduate) studies, the individual acquires a foundation, then progresses by building every step on top of the previous one as s/he needs or desires. This also applies to digital literacy. After learning the essential computer hardware and software, one switches to the higher levels. Furthermore, s/he is able to use what s/he learned at the essential level in learning new software and hardware. The example tackled in this study encompasses the learning of essential steps in digital literacy and acquisition of skills required for an individual to survive in the digital world.

Today, versions of literacy that are specific to new media technologies and applications that emerge out of a combination of computer and information technologies are also mentioned: social media literacy, Internet literacy, network literacy, electronic literacy, etc. All these concepts are directly related to digital literacy because all these media emerged as a result of digital developments in the mentioned technologies. An individual who does not have the technical capabilities for using them cannot possibly access such media. Even if s/he has access, failure to know the language required by these media (commands on the screen, terms in the menu bar, etc.) again causes problems for the individual.

Necessity to Become Digitally Literate

In economic and commercial life, the integration of computer and Internet technologies in business processes have brought about new business models, methods and approaches. Having to comply with the technological changes in the changing global conditions, private enterprises and public institutions have not only given priority to candidates having computer and software skills in their recruitment processes, but they have also started to conduct on-the-job training so that existing workforces can keep up with these changes. The priority factor leading individuals to learn computer technologies in the first place was to increase their employability. This factor is still applicable today. According to the Workforce Market Trends Index Study, 80% of companies consider it necessary for employees to have computer certification when increasing their workforce [14]. In the report by Turkish Statistics Institute (TÜİK) entitled, “A Survey on the Use of Information Technologies in Enterprises - 2013”, the rate of computer use at enterprises is stated as 92% [17].

This transformation that started in business processes has also taken part in the private lives of individuals. The fact that private and public institutions have shifted the services they offer to electronic media in order to increase efficiency, accelerate processes and reduce costs have required even individuals who are not in work life to use computer technologies. Several services are offered online today in both private and public sectors. Furthermore, the placement of applications online emerges as a requirement to be able to receive certain services. For example, if a teacher or a student who would like to receive an Istanbul card from IETT (Istanbul Electric Tram and Tunnel Company) does not apply through an educational institution (such a situation may emerge if the application deadline is missed) the only remaining options are online and by e-appointment (http://skart.iett.gov.tr/). A similar situation also occurs in the process of receiving healthcare services from state hospitals. Citizens who would like to benefit from healthcare services can only make an appointment at a state hospitals via phone and online systems. The line 182 to which patients are referred in order to make an appointment is hard to reach due to being busy, whereas the online appointment systems offer individuals an easier course of action. Even such a facility is an important factor in forcing individuals to use e-applications.

At the web site https://www.turkiye.gov.tr, the address for e-government applications and services, one can see that 380 services are provided online under the 43 administrative units (Presidential Office, Prime Ministry, Ministries, Head Departments, General Directorates, etc).

According to a measurement survey conducted among people above the age of 11 in 25 countries in relation to digital literacy, Turkey turned out to be the last country with 2.6 points. Necdet Ünüvar, Chairman of the Parliamentary Commission on Internet and Information Technology for the year 2012, expressed that it was necessary to have a mobilization towards digital literacy in his press release on the topic [27].

Along with this digital transformation that has changed individual, social and economic lives, a new concept of citizenship has been born: digital citizenship. The emergence of a such concept per se is the best summary of the requirement to become digitally literate. A digital citizen is an individual who is able to use digital tools as part of daily life, respects ethical rules and personality rights on a digital platform and knows how to use these tools with an awareness of safety and responsibility [12]. The qualities of a digital citizen are in line with the way of mindset and style of life recommended by Gilster in his definition of digital literacy [5].

The problem of digital literacy may occur not only at the level of using essential/basic computer technologies and programs, but it may also appear at advanced levels. A problem of digital literacy is mentioned even for individuals who are well-educated and are at senior positions in work life. The main reason behind this is the perception of these people as being deficient in some cognitive dimension. Since the developments in digital technologies have continuity, a digitally literate person should also continuously learn and develop herself/himself. The reflection of digital changes on private and work lives should be perceived in a cognitive dimension and should be able to be used in practice. A survey conducted by CA Technologies globally with 615 CIOs demonstrates that digital literacy is not adequate even at the level of board members. Marco Comastri, the President of CA Technologies, expresses that the deficiency of digital literacy at senior management levels of companies constitutes a barrier in the efficiency and growth of a company:

“The situation of inadequacy in digital literacy at senior professional management brings about failure to notice/realize emerging market developments, causes them to miss business and investment opportunities, a weak understanding of competitiveness and inability to respond timely to the market. Most often, management teams perceive the IT as a cost of doing business rather than seeing it as an asset to grow the organization, change the processes and provide the company with agility.” [9].

Digital Inequality: Digital Divide

The phrase 'digital divide' is generally used to express the inequality between those who have access to computer and Internet and those who do not [13]. However, this is a limited definition. There are different levels of inequality. The studies conducted in 1990s generally focused on the physical and basic access by population to computer technologies. The penetration and increase of the Internet use has caused the inclusion of those who have or do not have access to the Internet in the scope of studies. [18]. As online access has become widespread, differences between the various Internet use, potential and skills of individuals has also begun to take their place in studies on digital divide. In summary, physical access to computer, online access and Internet and computer use capabilities emerge as the main themes that are related to the digital divide.

According to the report dated 2004-2013 on Information Society Statistics by TÜİK (Statistics Institution of Turkey), the rate of Internet use in the population is only 49.9%. This means that 50% of the population still lacks access to information technologies in an era when we are going through an important digital transformation. According to the same report, the Internet access rate in households is 49.1% [7]. A significant part of the aforementioned access takes place in urban areas. According to the report dated 2013 on the 'Use of Information Technologies by Households', the use of computer and Internet is around 58%-59% in urban areas while this rate is 28.6%-29.5% in rural areas (http://tuik.gov.tr/PreHaberBultenleri.do?id=13569).

As can be seen, geographical differences come to the fore in digital literacy as is the case with traditional literacy. The educational level of individuals is also one of the determining factors in the digital gap. In the report by TÜİK, the rates of computer use sorted by educational status are provided. Accordingly, 3% of those who are not graduates of any school, 19% of primary school graduates, 61.3% of primary/secondary and

equivalent school graduates, 61.3% of high school and equivalent school graduates and 92.4% of faculty and higher education graduates are computer users.

A Case Study on the Problem of Digital Literacy

In this part of the study, the social responsibility project "Everyone in Beykoz Will Learn to use Computers!" conducted by the Beykoz Vocational School of Logistics for the people living in the Beykoz district is explained in detail.

Purpose and Scope of the Case Analysis

The Beykoz Vocational School of Logistics implemented a social responsibility project titled "Everyone in Beykoz Will Learn to Use Computers!" between October, 2009 and October, 2010 in order to contribute to the community that the school is in. The project "Everyone in Beykoz Will Learn to Use Computers!" is a good example of the requirements and positive results of contributing to the solution of the digital illiteracy problem at an organizational level - the core matter of this study.

The analysis of the aforementioned project is aimed at showing organizations in general the following positive results that they can be obtain by developing projects to contribute to the solution of digital illiteracy problem. The analysis aims to:

i) demonstrate the opportunity such projects provide to establish positive relations with the target audience and social stakeholders,
ii) provide organizations with ideas in the project design phase,
iii) exhibit the weaknesses of the project in order to help organizations not to go through the same problems and help them develop more successful projects.

The project "Everyone in Beykoz Will Learn to Use Computers!" enabled BLMYO to access individuals from Beykoz who did not have the chance to receive education in the fields of essential software and hardware, to contribute to their personal development and to cooperate with the local government bodies in Beykoz to develop long-term relations. Thanks to this project, BLMYO managed to have its name recognized by the people in this district. In that respect, this project may also be considered a good example of opportunity management for organizations.

Selection of Analysis Units

After the idea of tackling the problem of digital illiteracy as part of corporate social responsibility emerged, the largest amount of data among the samples defined as a result of the preliminary study conducted was obtained through the campaign organized by BLMYO. Therefore, it was decided to use BLMYO as an example. Since BLMYO put the project into implementation between October, 2009 and October, 2001, only this period was taken into account.

Data Collection Method and Process

The data about the project were obtained by means of face-to-face interviews with the BLMYO Secretary General and Information Technologies Department employees, and through an examination of the web site prepared for the project and campaign-related news articles appeared in the local press.

In the initial phase, the Secretary General, who was also in charge during the implementation of the project was contacted; then a meeting was held with the employees of the Information Technologies Department who were actively working in the realization of the project at that time. At the meeting, the development of the project, its design and implementation were discussed, the official correspondence with the social stakeholders of the project, documents related to project such as activity reports of the school were obtained and examined as a part of the study.

Findings

Purpose of the Project

The Beykoz Vocational School of Logistics is the first higher education institution established in the area of Beykoz, Istanbul. As an institution of higher education, BLMYO has identified the development of mechanisms to enhance interaction with the society as its strategic objective and has adopted the principle of organizing activities in local and national levels towards this objective. The essential aim of the project was identified as contributing to the development of the people in the area. In the text of the protocol agreement signed with the local government, this objective is expressed in the following words: "To ensure that the inhabitants of Beykoz benefit from the planned and implemented training programs by Beykoz Vocational School of Logistics and to contribute to the development of those who are already at the age of learning and in working life through this method."

Project Stakeholders

The BLMYO directors decided to cooperate with the Beykoz District Governorate, Beykoz Municipality and Beykoz District Directorate for National Education for the project in order to ensure the recognition of the college in the area, to facilitate the acceptance of the college by the people in the area and to develop positive relationships with the local governmental bodies.

Beykoz Municipality took an important role in announcing the campaign to the locals in the area. The municipality not only provided the possibility to use its own open air advertising platforms free of charge, but it also served as the application address for those who wanted to attend this training program.

The posters and handouts prepared were hung in public spaces on the buildings of Beykoz District Governorate, Beykoz Municipality and Beykoz District Directorate for Education to be accessed by the target audience. A protocol agreement was signed in a signatory ceremony to which the press was also invited on October 12, 2009 among Beykoz District Governorate, Beykoz Municipality and Beykoz Provincial Directorate for Education and BLMYO.

Design Process of the Campaign

Planning

As explained before, the point of starting of the project was the question about how the School could contribute to its community as a higher education institution. During the meetings held in the institution, the types of problems for which the educational possibilities of BLMYO could be used was discussed and it was decided that the e-learning system prepared by BLMYO for its students could contribute to the computer education of the members of community.

Content of the Education: European Computer Driving License (ECDL) Training Program

ECDL is a training program that was formed in European Union countries in order to ensure the standardization of training and certification programs conducted in the field of computer technologies. ECDL has now become an international standard with global validity in computer education as a result of the efforts pursued by the European Union countries. Turkey, which engages in efforts as part of European Union harmonization, has also adopted this program in the process of raising human resources that are in line with the qualities of an information society as required by the e-Europe Action Plan. ECDL is one of the important building blocks of the project e-Europe. Aspiring to offer its students a world-class education, BMLYO took the decision to choose this program while creating its e-learning infrastructure.

In the project titled "Everyone in Beykoz Will Learn to Use Computers!", the ECDL Base Level Module was used. The technical team at BLMYO, members of faculty at Computer Programming and Applied English-Turkish Translation Program jointly conducted the process of localization of the modules into Turkish. The

voice-overs of the modules were commissioned by BLMYO and they were uploaded to the distant education system of BLMYO.

ECDL Educational Curriculum

The program is composed of seven modules comprising different themes. (http://www.teknoturk.org/docking/yazilar/tt000118-yazi.htm, http://ecdl.anadolu.edu.tr/mufredat.asp)

- **Module 1: Essential Concepts in Information Technology (IT)**: This module aims to ensure that the users receive information about the key concepts related to information technologies. The participant is introduced to the hardware and software that are combined to create personal computers. The topics of data storage, network and software applications, computer security as well as health effects, which are among IT concepts, are taught in this module, too.
- **Module 2: Computer Use and File Management:** This module is aimed to enable the users to equip with the ability to know the general features of personal computers and use the essential functions of the operating system, to effectively operate the desktop environment, adjust the settings, manage, copy, move and delete files, indexes and folders. Furthermore, the skills to use the simple setting tools and printer management tools along with the operating system are also covered in this module.
- **Module 3: Word Processing (MS Word):** This module covers the ability of the user to create, format and prepare to print a file using the word processor as well as the ability to use images and pictures in a document, create, copy and move standard tables and use the email merging tools in such a way as to benefit from these advanced features efficiently.
- **Module 4: Spreadsheets (MS Excel) :** This module covers the essential information on the concepts related to electronic tables and steps in the creation of electronic spreadsheets such as table formatting and use. The module aims to ensure successful completion of the following: formatting tables, changing their structures, adding and editing graphs and charts, using essential formulae and functions to perform mathematical and logical operations.
- **Module 5: Database System (MS Access):** This module that covers the essential database concepts and skills is divided into two sections. The first section encompasses the skills to use data packs to design a simple database and the second section covers the retrieval and query of information from a database, using selection and sorting tools as well as creating and changing reports.
- **Module 6: Presentation Preparation Software (MS PowerPoint):** This module encompasses essential functions such as creating, editing presentations, adding text, graphs, pictures and effects to the presentations, visually editing and modifying the presentations.
- **Module 7: Finding Information Online (Search engines, browsers):** This module enables the users to obtain information on the topics of Internet use and security. This module is also composed of two sections. The first section provides the user with the skills to use the essential web browser applications and search engine tools while the user learns the elements of Internet communication in the second section. The main themes in this section include e-mail communication, security considerations to be cautious about while using e-mail, attaching files in sending e-mails and creating files and folders in order to organize the e-mails.

Distant Education Infrastructure of BLMYO (2009)

During the period the project was implemented, the distant education infrastructure of BLMYO was located and managed on the 10Mbit fiber Internet connection provided by ULAKNET. The installation of ADOBE CONNECT, the distant education and e-learning platform was completed and the localized Turkish modules of CEDL were provided for users to access via the system. For the infrastructure of BLMYO, the programs Moodle, Adobe Presenter and Adobe E-Learning Suite were being used at that time. Moodle is used as the education management platform in online education activities while Adobe Presenter and Adobe E-Learning Suite programs are used for the generation of asynchronous course content for distant education.

Implementation Process

The implementation of project and certification of participants took place in six main steps:

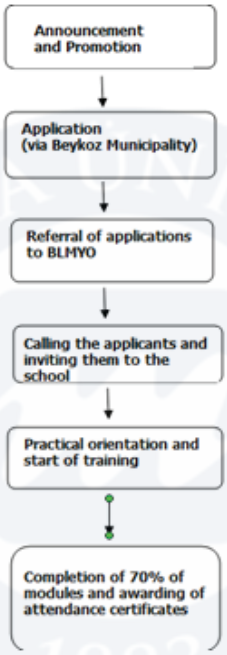


Figure 1. Implementation Process of The Project

Announcement and Promotion

The posters and handouts used to promote the project were prepared by BLMYO. The "Everyone in Beykoz Will Learn to Use Computers!" became the motto of the project. The project was geared towards the people of Beykoz, therefore the announcement and promotion activities were held only within the borders of Beykoz district.

Three graphical materials were prepared: posters, handouts and banners. The posters were displayed for six weeks in the open-air platforms (billboards) belonging to Beykoz Municipality for six weeks and the handouts were placed at points where both employees of the institutions and citizens visiting these institutions could pick them up in municipality and district governorate buildings. In the handout, it was made clear that online education in the use of personal computers would be in line with international standards as well as the general computer applications would be provided for users as a part of the project to be jointly implemented by Beykoz Municipality, Beykoz District Directorate for National Education and Beykoz Vocational School of Logistics.

Banners were hung in the Beykoz district in places with high commercial and social activity in addition to population density. People who wanted to take part in the training were referred to Beykoz Municipality.

In addition to the printed promotional material, a micro-site was created where the project was explained in detail and users could access the system. On the main page of the site www.bbk.beykoz.edu.tr, four main links were included:

- Introduction to e-learning: A link enabling users registered for training to enter the system.

- Basic computer training: The section introducing the training program and training modules offered as part of the project.
- E-learning technologies: The section featuring the specifications of the infrastructure used in the education system.
- Contact: The section including the numbers to be contacted when necessary by the users, address of BLMYO and an e-mail link.

Furthermore, the project was also announced on the web sites of the district governorate, municipality and district directorate for national education and links were provided from the web sites of these institutions to the sites www.bbk.beykoz.edu.tr and the home page of BLMYO. The project was introduced to the local press via the press releases and the members of the local press, employees of the municipality and district governorate, headmasters of schools in the district and the people of Beykoz were invited to the signatory ceremony held in the conference hall of BLMYO on October 12, 2009. The protocol agreement outlining the conditions and limits of cooperation among the parties of the project was signed by the directors of BLMYO, the Beykoz District Governor, the Beykoz Mayor and District Director for National Education. The guests that attended the ceremony were provided with a presentation on the practical functioning of the education program.

Application and Participation Process

The participation of those willing to receive training in the project took place largely through the Beykoz Municipality. The individuals who wanted to take part in the project placed an application at the related department with their identity and contact information; when the number of applications was in the range of 30-40 persons, this department transferred these applications to BLMYO.

The public relations department of BLMYO contacted the applicants forwarded to them and invited them to a practical orientation training organized by the Information Technology Department of BLMYO. At the orientation program held in the computer laboratory of BLMYO, the system was introduced to the participants and they were shown how to enter the system themselves using the passwords and user names assigned to them.

Duration of the Training

Since the project "Everyone in Beykoz Will Learn to Use Computers!" was planned to be a one-year-long project initially, the users attending the training in the computer laboratory of BLMYO were informed that the system would be open until October, 2010 and that they could benefit from the training as they wished during this period. No limitations were placed on the duration of training for the participants apart from the end-date of October, 2010. The users could access the modules as they wished, complete modules in their own time and receive their certificates. The essential requirement to be able to receive an attendance certificate was set as the completion of 70% of the training. In the orientation trainings provided, it was stated specifically that the BLMYO Information Technologies Department would help the participants with all kinds of problems.

Project Deliveries

At the end of the one-year-long project, 136 participants were awarded attendance certificates. The modules were attended at a higher rate by the employees of Beykoz Municipality and Beykoz District Governorate; this group was also observed to have the highest rate of completion. The project "Everyone in Beykoz Will Learn to Use Computers!" provided the means for the development of positive relations between BLMYO, the first higher education institution in the area, and the local government bodies.

Assessment of the Case Analysis Results

The results of the case analysis of the project "Everyone in Beykoz Will Learn to Use Computers!" will be assessed under four main important elements: a) reputation management, the essential objective of public relations efforts, b) the concept of corporate social responsibility that is the essence of this study, c) the effect of social stakeholders that play a determining role in the success of CSR efforts and d) an assessment of the public relations process and sustainability.

Corporate Reputation Management

In the science of business administration, the assets of enterprises are divided into two: tangible assets and intangible assets. In periods when competition was not very heavy, the total value of an enterprise would be determined based on measurable tangible assets such as its financial worth, amount of raw materials, production and distribution technologies, number of employees, production and storage areas, whereas increasing competition brought intangible assets, such as corporate identity, culture and corporate reputation and knowledge, to the fore. Especially in 1990s, corporate reputation became one of the intangible assets that was highlighted and cherished the most. According to a survey conducted among senior level managers of companies operating in the UK in 1992, the answer received when the managers were asked about the most important intangible asset in the success of their organizations between the years 1987-1990 was reputation [29].

There are various definitions of corporate reputation; however, the common aspect of all definitions is that it is an ensemble of values ascribed to the enterprise by the target audience and social stakeholder and perceived in relation to the enterprise. Considering the article titled 'The Reputational Landscape' by Fombrun and Reil, who have an important role in the literature on corporate reputation, it is possible to see that the definitions employed in various disciplines at that period revolve around the 'ensemble of shared values perceived/attributed by the target audience(s) [16]. The definition made by Anca and Roderick demonstrates the relationship between the enterprise and its stakeholders in a more clear way. According to this definition, corporate reputation is a combination of the assessments about what the enterprise is, how the enterprise fulfils its responsibilities, how it meets the expectations of stakeholders and the global performance of the enterprise in complying with the social-political environment, which is formed in the long run [29].

The definition by Anca and Roderick also incorporates the qualities that indicate the way in which corporate reputation management is performed. The ways in which corporate responsibilities are fulfilled, stakeholder expectations are made and compliance with the environment is assured are part of the corporate reputation management. Corporate reputation management is a part of public relations efforts. According to the first definition on which consensus was achieved in the First Global Public Relations Congress held in Mexico City in 1978, public relations is an art and a social science according to which trends are analyzed, results are predicted, counseling is provided for organizational leaders and planned programs are implemented for the benefit of both the organization and the public [23].

All the activities performed as part of public relations are geared towards enhancing the reputation of the organization. In the results section of the survey conducted by Murray and White among CEOs in the UK, the association between public relations and reputation is summarized in these following phrases: "It is the role of public relations to ensure that the organization gets the credit for the good deeds it does" [22]. The efforts implemented enhance the reputation of the organization in the eyes of its target audience while confidence in the organization is also fostered. Being reputable is associated with being reliable. Reliability is the element that empowers organizations.

The project "Everyone in Beykoz Will Learn to Use Computers!" achieved what is desired for Beykoz Vocational School of Logistics with respect to organizational reputation management.

At the end of the first academic year, directors of BLMYO realized that they were not adequately recognized by the people of Beykoz whom they identified as the priority target audience when the school started taking students the first time. Increasing the level of recognition of the school in the area of Beykoz was required to ensure that it earned organizational reputation. To reverse the situation for the advantage of the vocational school, it was not deemed to be enough to merely advertise in the local press or to feature open-air advertisement platforms. An answer was sought for the question of how contributions could be made to the community by using the school's capabilities within the framework of a modern public relations mentality. The quest for a result that would be positive for all parties involved led to the project "Everyone in Beykoz Will Learn to Use Computers!" which could involve local governments and contribute to the developmental needs and current requirements of the local community. The cooperation with local governments raised the level of recognition of BLMYO by the local community and the fact that the name of the vocational school was mentioned alongside the trustworthy institutions in the area and that a solution was offered for a current problem also contributed to the perception of the school as a reliable institution.

The cooperation also contributed to the reputation of local government since they are also supposed to continuously develop positive relations with the local community. Those who wanted to receive training on computers yet were unable to realize this for various reasons developed the opinion that the municipality, district governorate and district directorate for national education were also working in their favor. The posters and handouts prepared were hung in public spaces on the buildings of Beykoz District Governorate, Beykoz Municipality and Beykoz District Directorate for Education to be accessed by the target audience, which reinforced this perception.

Corporate Social Responsibility (CSR)

The essence of the concept of CSR is underlined by the approach that community and commercial organizations are not two entities that are far from each other; on the contrary, they complete each other [30].

While it was thought in the 1970s that the primary responsibility of enterprises was to make profits [4] in 1990s this opinion came to be replaced by the attitude that organizations also had responsibilities towards the community in which they operated. The concept of CSR was initially perceived as being merely about sensitivity to environmental problems; however, educational, social, cultural and economic subjects also started to be seen as part of CSR over time. Today, CSR is defined as “ethical” and “responsible” treatment of all stakeholders, internal and external, by an organization and as decisions being taken and implemented in this manner [2]. The CSR efforts contribute to the organizations being perceived as good corporate citizens. The allocation of some of the resources owned by organizations to efforts that contribute to the community in which they operate is the best way of showing the responsibility they assume towards their internal and external stakeholders [21]. The CSR efforts are shaped in accordance with the requirements and problems of the sector and/or community at stake.

The project "Everyone in Beykoz Will Learn to Use Computers!" has been a social responsibility project that contributed on a regional scale to the solution of the problem of digital illiteracy, which has become an increasingly more prominent problem in Turkey. The individuals that wish to improve themselves in computer use yet are unable to receive such training for various reasons, have seized the opportunity to overcome an important deficiency in their work and private lives thanks to the mentioned project. As can be seen in the section 'Limitations of the Study', the documents related to the project have been destroyed, hence, it was not possible to access the people that took part in the project as trainees. However, the employees of BLMYO who conducted the project mentioned positive results; for example: an acquaintance working at the municipality who completed the training with success was promoted as a result of this training.

Beykoz Vocational School of Logistics found the opportunity to use its e-learning infrastructure for the benefit of the community and to demonstrate in the best way its goodwill and responsibility for the society.

Management of Social Stakeholder Relations

Social stakeholders are one of the most important factors playing a role in the success of CSR efforts. In the definition of CSR made by the European Commission, the adoption of the principle of volunteerism by organizations in the solution of social and environmental concerns as well as cooperation with social stakeholders and integration with them are emphasized [10]. In the literature on the subject, the concept 'stakeholder' generally refers to all the parties with whom the enterprise is engaged, who are affected by the activities of the enterprise and who affect the enterprise with their activities [2], [28]The basic premise of the theory of 'stakeholder' is as follows: the stronger the relations with the groups outside of the organization are, the easier it would be to achieve shared objectives [2].

Ali Saydam, who explores the concept of perception management and recounts what needs to be done to achieve this in his book Algılama Yönetimi (Perception Management), states that the first step to be taken in perception management is the identification of all the stakeholders to influence the business results and enable the achievement of business objectives [28]. A social stakeholder can be a group or an individual or it can also be identified as multiple social stakeholders. One of the important stakeholders of an organization is the local government of the community in which it operates. Based on an awareness of this fact, the decision was taken to act jointly with the Beykoz District Governorate, Beykoz Municipality and District Directorate for National Education as part of the project "Everyone in Beykoz Will Learn to Use Computers!". This decision not only reinforced the perception of reliability for both the project and the vocational school, but also contributed to the development of long term and positive relations with the institutions that represented the local government. The cooperation that started with this project paved the way to work together on other projects, as well. The trainings that were developed as a result of the relationships of trust cultivated during the project "Everyone in Beykoz Will Learn to Use Computers!" include trainings on communication for the neighborhood headmen and self-employed people as well as trainings on personal development, time and stress management.

As mentioned before, the cooperation achieved also helped fostering the reputation of local governments in the eyes of the local community.

Public Relations Process and Sustainability

Public relations constitute a process. The commonly accepted model regarding the flow of the process is the four-stage model suggested by Cutlip and Center. According to this model, the process of public relations is composed of the stages of defining the problem/research, planning, implementation and evaluation [11]. Considering the project "Everyone in Beykoz Will Learn to Use Computers!", it is seen that steps that were taken were in line with the first three stages. Firstly, the problem needs to be defined. Does the organization indeed have a public relations problem? If yes,

i) can it be reduced?
ii) can it be reversed to be in the advantage of the organization?
iii) can a shared path be found to receive a positive result for everyone? [25].

The directors of BLMYO saw at the end of the first academic year that they were not adequately recognized by the people of Beykoz, whom they identified as the priority target audience and brainstormed about what could be done to solve this problem. They sought ways to contribute to the area by making use of the vocational school's own resources. The definition of problem and quest for a solution to be beneficial for everyone resulted in the project "Everyone in Beykoz Will Learn to Use Computers!".

The first step, in which the problem was defined, was followed by the phases of planning and implementation. In the planning process of the project "Everyone in Beykoz Will Learn to Use Computers!", the training program to be used, the way in which the system would be prepared for access, the way in which participants could apply, the functioning of the education process, the method for announcement and promotional activities as well as budgeting were planned.

The BLMYO officials expressed that the implementation phase was completed without any problems.

The last stage of the public relations process is the stage of evaluation. At the stage of evaluation summarized by Alaeddin Asna as “This is the stage where you see how you scored on a scale of 100” [3]the results obtained in the project are compared against the objectives set at the start of the project, measurements are made and the positive and negative situations encountered in the entire process are reviewed. The picture emerging at the stage of evaluation has a guiding character for the next public relations efforts. Therefore, the stage of evaluation in public relations is not seen as an end, but as the beginning of the next cycle. Evaluation and follow-up are handled together.

In the project "Everyone in Beykoz Will Learn to Use Computers!", implemented by BLMYO, the first three stages of the public relations process were implemented successfully; however, the evaluation stage was seen to have some problems. The recording of data related to the project could not be completely assessed. Since the profile of the participants could not be created, it was not possible to identify those who benefited the most from the project; no surveys were implemented related to the training process, therefore, it could not be exactly identified whether the participants actually had any problems or not, their satisfaction levels could not be measured; a planned follow-up effort was not maintained; hence, it was not possible to identify the contribution that the training made to the lives of the participants (apart from the positive comments about a few acquaintances). The only data about evaluation and measurement were included in the activity report of the vocational school for the period of 2010-2011. In the report, it was stated that the mentioned project was implemented and that 136 participants were awarded attendance certificates. The fact that 136 persons were awarded attendance certificates as part of a district-based project can be accepted as an indication that the project received attention from the local community.

One of the highlights in the literature on CSR is the adoption of the approach of sustainability in relation to the understanding of social responsibility. With sustainability, emphasis is placed on the management of essential environmental and social problems. According to the definition made in 1980s Gro Harlem Brundtland, Prime Minister of Norway, who enjoyed wide acceptance, sustainable development is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" [26]. The project "Everyone in Beykoz Will Learn to Use Computers!", responded to a current need that would also affect the future lives of individuals. As stated in the part “Necessity to Become Digitally Literate” of the study, the fact that the use of computer technologies has become obligatory in today's business world, many institutions transferred their the services to the electronic environment, e-government applications have become widespread has turned digital literacy into an important problem that needs to be solved. The project "Everyone in Beykoz Will Learn to Use Computers!", contributed to the satisfaction of such a requirement that came to the agenda on a local level. Speaking at the signatory ceremony on 12, October, 2009, Ahmet Ergün, Beykoz District Governor, referred to the need that had been felt in the area and the contentment that they had with the solution that was offered: “We had shortcomings with regards computer literacy. The fact that this project was brought to our table while our commissions were conducting research and work on this topic proved to be a great opportunity for us. What was incumbent on us was to support it" [6].

The project "Everyone in Beykoz Will Learn to Use Computers!", had the quality of generating a solution for a current need; however, the fact that the project was realized in only one year caused it to fall short in terms of contributing to sustainable development, which is targeted as part of CSR efforts. CSR efforts need to be sustainable. The answer to the question why the project was not repeated was that it was planned for only one year.

Limitations of the Study

After the development of the idea to tackle the issue of digital literacy as part of CSR, it proved difficult to find an example during the search performed to find a practical example. No detailed information could be obtained for the few examples that were found. The largest amount of data was obtained for the campaign organized by BLMYO. Therefore, it was decided to use BLMYO as an example.

However, it was not possible to access all the data related to the mentioned project implemented between October, 2009 and October, 2010. At the process of registration, the participants had filled in participation forms and sent their identity information, however, the documents sent by the participants for registration were destroyed in September, 2013 since three years had elapsed after the project and it was discontinued. The mentioned documents were not transferred to any databases, so it was not possible to define a user profile.

As for the promotional materials prepared for the project, only the handouts could be accessed.

The information on the project was compiled by means of the interviews held with the members of the project team who are currently actively working, the protocol agreement signed with local government bodies and news articles published in the press.

Conclusion and Assessment

As is the case for traditional literacy, the topic of digital literacy is also one of the topics that needs to be handled in the process of creating an advanced society. The effect of the global digital transformation on work and daily lives obliges individuals to become digitally literate. However, as with traditional literacy, equality of opportunity is an important problem for digital literacy.

The studies performed clearly demonstrate the problem of digital literacy in Turkey. Turkey ranked last with 2.6 points among 25 European countries based on the results of a digital literacy measurement study conducted among participants above the age of 11. After the result of the study was published, Necdet Ünüvar, Chairman of the Parliamentary Commission on Internet and Information Technologies, expressed in his press release that an action had to be taken for digital literacy [27].

Being digitally literate is a requirement in an information society. The organizations that conduct CSR projects for equality of opportunities to solve traditional literacy problems may make significant contributions to overcoming the digital gap that has emerged at various levels. Including digital literacy campaigns in CSR efforts would provide important contributions to being differentiated from competitors, to reinforcing reputations and to enabling organizations to develop positive relations with their community and social stakeholders.

The project "Everyone in Beykoz Will Learn to Use Computers!" is an important effort in the sense that it provided a solution for a current problem and it may constitute an example for several organizations. The mentioned project enabled BLMYO to reach its targeted objectives as a result of a successful CSR effort. Being recognized by the local community, reinforcing reputation in the eyes of the target audience and social stakeholders, laying the foundation for prospectively positive relations with the social stakeholders identified for the project and having the opportunity to show sensitivity towards the local community are important gains of this project.

The project "Everyone in Beykoz Will Learn to Use Computers!" is a good example in demonstrating that higher education institutions can easily contribute to the local community using their resources. Today, distant learning systems are available in several education institutions. These distant learning systems could be used to overcome the problem of digital illiteracy.

The project in this study was ineffective with regard to achieving sustainability. CSR efforts need to be continuous and sustainable. The efforts conducted in relation to a current topic with implications for the future, such as digital literacy, need to be planned not only for one year, but for longer periods.

Digital literacy should be seen not as an alternative to traditional literacy, but as its complementing element. Conducting more academic studies on the requirement for CSR efforts targeting the problem of digital illiteracy would attract the attention of business world to this matter and aid in the implementation of a higher number of solution-oriented projects.

References

[1] Akkoyunlu, S., 2008, Bilgi Okuryazarlığı ve Yaşam Boyu Öğrenme". International Education Technology Conference Keynote Speech. www.ietc2008.home.anadolu.edu.tr/ietc2008/1b.doc. [Date of Access: 29 May 2014]
[2] Aktan, C., Börü, D., 2007, "Kurumsal Sosyal Sorumluluk," in Aktan, C.C. (Ed.), *Kurumsal Sosyal Sorumluluk: İşletmeler ve Sosyal Sorumluluk* İstanbul: İgdaş Yayınları, 11-16.
[3] Asna,A. (1993). *Public Relations,* İstanbul: Der Yayınları,
[4] Aydın, B., Erdoğan, Z., 2013, Restoran Yöneticilerinin Sosyal Sorumluluk Algısı, Faaliyetleri ve Beklentileri Üzerine Keşifsel Bir Araştırma. *Social Business Anadolu,* http://sbau.anadolu.edu.tr/bildiriler/SBCONF-2013-K-06.pdf. [Date of Access: 29 May 2014]
[5] Bawden, D., 2008 "Origins and Concepts of Digital Literacy". Lankshear, C., Knobel, M. (Eds.), *Digital Literacies: Policies and Practices New Literacies and Epistemologies*, Peter Lang, New York, 17-32.
[6] Beykoz'da Bilgisayar Bilmesini Bilmeyen Kalmayacak, 2010, www.milliyet.com.tr, 13.10.2009. http://www.milliyet.com.tr/beykoz-da-ilgisayar-kullanmasini-bilmeyen-kalmayacak---lise-1149774/. [Date of Access: 21 May 2014]
[7] Information Society Statistics 2004-2013 Report, 2014, http://www.tuik.gov.tr/UstMenu.do?metod=temelist [Date of Access: 30 May 2014]
[8] Buckingham, D., 2010, Defining Digital Literacy, Bachmair, B. (Ed.), *Medienbildung in neuen Kulturräumen*, Wiesbaden: VS Verlag fur Social Sciences, 59-72 http://download.springer.com/static/pdf/454/bok%253A978-3-531-92133-4.pdf?auth66=1408882310_ba2d442a005defdbecac1282977511f6&ext=.pdf [Date of Access: 22 May 2014]
[9] CA Profesyonel Dijital Okuryazarlık Araştırma Sonuçları Açıklandı, 2012, *Şirket Haberleri*, (12.06.2012) http://www.sirkethaberleri.com/basin-bultenleri/ca-profesyonel-dijital-okuryazarlik-arastirma-sonuclari-aciklandi-66965 [Date of Access: 25 May 2014]
[10] Commissions of the European Communities Promoting a European Framework for Corporate Social Responsibility. (2001). file:///C:/Users/HP/Downloads/DOC-01-9_EN.pdf. [Date of Access: 21 May 2014]
[11] Cutlip, S. M, Center, A. H., Broom, G.M., 1985, *Effective Public Relations*, 9th Ed. Englewood Cliffs NJ: Prentice Hall.
[12] Çubukçu, A., Bayzan, Ş., 2013. Türkiye'de Dijital Vatandaşlık Algısı ve Bu Algıyı İnternetin Bilinçli, Güvenli ve Etkin Kullanımı ile Artırma Yöntemleri, *Middle Eastern & African Journal of Educational Research*, 5, 148-174.
[13] Dijk, A.G., 2006, Digital Divide Research, Achievements and Shortcomings, *Poetics*, 34, 221-235. http://ac.els-cdn.com/S0304422X06000167/1-s2.0-S0304422X06000167-main.pdf?_tid=6beaeb14-29f9-11e4-81cd-00000aacb361&acdnat=1408711376_2dae5fe876a56d02dced98ea6e4e7fb1. [Date of Access: 23 May 2014]
[14] ECDL. http://www.ecdl.org.tr/tr/presscenter/Haberler/Pages/rci.aspx, [Date of Access: 21 May 2014]
[15] Foltz, P.W., 1996, Reader's Comprehension and Strategies in Linear Text and Hypertext, *ICS Technical Report* #93-01. http://www.colorado.edu/ics/sites/default/files/attached-files/93-01_0.pdf. [Date of Access: 23 May 2014]
[16] Fombrun, C., Riel, V.C., 1997, The Reputational Landscape, *Corporate Reputation Review,* 1(1-2), 5-13. http://reputationinstitute.com/frames/crr/V01/Fombrun_Landscape.pdf. [Date of Access: 30 May 2014]
[17] Household Information Technologies Utilization 2013 Report., 2013, http://tuik.gov.tr/PreHaberBultenleri.do?id=13569. [Date of Access: 30 May 2014]
[18] Hargittai, E., 2002, Second-Level Digital Divide: Differences in People's Online Skills, *First Monday*, 7(4). http://firstmonday.org/ojs/index.php/fm/article/view/942/864 . [Date of Access: 27 May 2014]
[19] http://www.tuik.gov.tr/ [Date of Access: 25 May 2014]
[20] Kurbanoğlu, S., 2010, Bilgi Okuryazarlığı: Kavramsal Bir Analiz, *Türk Kütüphaneciliği*, 24 (4).
[21] Lanham, R., 1995, Digital Literacy, *Scientific American,* 273(3), 160-161. http://www2.idehist.uu.se/distans/ilmh/Ren/lanham-digital-lit.htm [Date of Access: 21 May 2014]
[22] Lantos, G.P., 2001, The Boundaries of Strategic Corporate Responsibility, *The Journal of Consumer Marketing*, 18(7), 595-649.
[23] Murray, K., White, J., 2004, CEO Views on Reputation Management: A report on the value of public relations, as perceived by organisational leaders, Chime Communication Plc. http://www.chimeplc.com/downloads/reputationkm.pdf. [Date of Access: 30 May 2014]
[24] Oliver, S., 2007, *Public Relations Strategy* (2nd Ed.), Kogan Page, London
[25] Öğüt, G., 2013, Sosyal sorumluluk, satışı olumlu etkiliyor. *Radikal Blog*, 26.08.2013 http://www.radikal.com.tr/yazarlar/gurul_ogut/sosyal_sorumluluk_satisi_olumlu_etkiliyor-1147703 [Date of Access: 25 May 2014]

[26] Paksoy, A.Ç., 1999, *Türkiye'deki Halkla İlişkiler Uygulamaları*, Milliyet Yayınları, İstanbul
[27] Porter, M., Kramer, M., 2006, Strategy and Society: The Link Between Competitive Advantage and Corporate Social Responsibility, *Harvard Business Review*, (December 2006), 76-94. http://efnorthamerica.com/documents/events/ccc2008/Mark-Kramer-Keynote/Strategy-Society.PDF. [Date of Access: 27 May 2014]
[28] Sarıoğlu, B., 2012, Dijital Cehalete Karşı Seferberlik. *Hürriyet Gazetesi*, 06.05.2012 http://www.hurriyet.com.tr/ekonomi/20491212.asp. [Date of Access: 23 May 2014]
[29] Saydam, A., 2005, *Algılama Yönetimi*, Rota Yayınları, İstanbul
[30] Uzunoğlu, E., Öksüz, B., 2008, Kurumsal İtibar Riski Yönetimi: Halkla İlişkilerin Rolü, *Selçuk İletişim Journal*, 5 (3), 111-123. http://www.iye.org.tr/wp-content/uploads/2012/12/ebru_uzunoglu_burcu_oksuz_kurumsal_itibar_riski_yonetimi_halkla_iliskilerin_rolu.pdf. [Date of Access: 30 May 2014]
[31] Wood, D.J., 1991, Corporate social performance revisited, *Academy of Management Review*, 16 (4), 691-718.

MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

User Satisfaction and Components of Perceived Usability for a Course Management Software

Oğuzhan Erdinç[1], Harun Karga[1], Ahmet Ürkmez[1]

Abstract

Course Management Software (CMS) have become integral parts of educational technology. CMS are widely used in educational institutions for many purposes such as providing access to course material and effective online communication. User satisfaction for CMS determines the value of these tools and affects quality of the education. Usability is one of the numerous factors that have been found to be related with user satisfaction for information systems. Usability is not a singular measure and includes various components such as quality of information presented or interface design. The insights into the relation between different components of usability and user satisfaction could inform CMS designers and educational technology managers on how to improve their products and to contribute to more effective use of these tools. The current study explored the relation between user satisfaction and components of perceived usability for a CMS using the Turkish version of the Computer System Usability Questionnaire Short Version (T-CSUQ-SV) among the students of a military eudcational institution. The regression analysis demonstrated significant positive relations between user satisfaction and all three components of perceived usability that the T-CSUQ-SV measured; systems usefulness, information quality, and interface quality. Among them, interface quality was the most influential predictor of user satisfaction.

Keywords: Usability, Course Management Software, User Satisfaction

Introduction

Course Management Software (CMS) has been widely used in educational institutions worldwide [1,2,3,15,16]. 2002-2003 statistics showed that in the USA, CMS was used in 94 % of the universities [1]. Main purposes for using CMS include; providing students easy access to course material, enabling and improving teacher-student communication, making course related announcements, grading, and exams [1-3,16]. Studies suggest that CMS are used more heavily for knowledge sharing than communication [2]. Jones ve Jones [1] reported that, in a university in USA, 80% of instructors and 93% of students found the CMS used in the university beneficial for learning. The use of CMS has been found to facilitate collaboration between instructors and students, to contribute to computer skills of students, and to save time for academicians [1,2]. According to Yohon et al [2], the faculty who adopted the CMS used in their university reported that using the CMS improved their teaching. Development and implementation of the CMS in an educational institution entails significant financial investment and organizational effort. In addition, the CMS should be accepted and extensively used by the students and faculty reap its benetifs and to contribute to the quality of education. For acceptance and effective use of the CMS, user satisfaction among target audience should be ensured.

User satisfaction is a basic measure for the effectiveness and quality of the information systems [19,20]. The baseline is that target audience will effectively use an information system only when they are satisfied with it. Authors supported that satisfaction is a subjective construct and involves user's attitude and perception toward a system [19]. Furthermore, the literature provides ample evidence that user satisfaction is multi-faceted; many aspects of an information system such as content, accuracy, reliability, accessibility and ease of use influence and shape user satisfaction [19,20]. For example, Lee and Kim [19] built an overall user satisfaction model using information satisfaction (i.e.content, accuracy, format, timeliness) and system satisfaction (i.e. ease of use, user interface), and evaluated user satisfaction for web based information systems used in the Korean universities.

[1] Turkish Air Force Academy, Dept. of Industrial Engineering, Istanbul, Turkey. corresponding author: oerdinc@hho.edu.tr

Their model was significant and explained 50.4% of the variance in overall user satisfaction [19]. Models related to user satisfaction for various types of information systems commonly include items that measure usability (e.g. ease of use, navigation) as it directly affects user performance and perception toward a system [19-22]. Udo et al [21] found that web content construct including several usability items (e.g. appealing graphics, ease of navigation) was significantly related to web service quality which predicted user satisfaction. Widely used in e-service field to measure e-service quality is the E-S-QUAL model by Parasuraman et al [22], and this model includes number of usability related items within its efficiency construct (e.g. it enables me to complete a transaction quickly).

The inclusion of usability related items in abovementioned models indicates significance of usability in attaining user satisfaction. Likewise, studies highlighted the importance of usability in educational software, and usability of CMS was found essential for user performance, user satisfaction and education quality [2,3,15-17]. Monaco [15] propounded that usability can increase the value and use of the CMS. Johnson et al [13] applied heuristic evaluation and Questionnaire for User Interaction Satisfaction (QUIS) [13] among informatics students to assess usability of Prometheus (i.e., the CMS developed in George Washington University, USA), before and after interface improvements. While participants reported to be satisfied with ability to learn complex systems the most, manuals and online help was the least satisfactory aspect of interaction. Ramakrisnan et al [14] highlighted the importance of user interface design for learning management systems (LMS). They evaluated the interface design of a LMS via eye tracking and interview techniques, and developed improvement alternatives. Daneshmandnia [16] assessed the usability of Moodle, a widely used CMS, using expert reviews and surveys based on seven characteristics: learnability, operationability, efficiency, memorability, errors, satisfaction and attractiveness. Respondents showed the highest agreement above 30% on learnability, memorability and attractiveness of the Moodle. Rosato et al [17] evaluated and compared usability of three CMS; WebCT, Sakai and Moodle using effectiveness, efficiency and satisfaction measures such as error rate, completion rate and modified System Usability Scale (SUS) [13] respectively. They recommended that CMS interface should follow web-usability conventions (e.g.back button) to be more intuitive. Two studies assessed usability of CMS used in Turkish universities [5,6]. Ersoy identified through user tests potential usability problems of a CMS developed in Middle East Techical University [5], and Karahoca et al [6] explored the relationship between usability level of a CMS and cognitive abilities and individual differences of the students. Yohon et al [2] explored adoption of the CMS they used in their university and stressed that usability of the CMS should be evaluated to pinpoint potential usability problems that could adversely affect adoption of the tool by faculty and students.

Usability is a multi-dimensional construct [7-10,18] and different components (e.g. navigation, interface design) can affect user satisfaction differently. Furthermore, usability is evaluated via objective (i.e. performance related; such as task completion rate, error rate), as well as subjective (i.e. perceived usability) measures. Perceived usability provides important insights into how users subjectively view and feel about the usability of the system. While studies highlighted the importance of usability for user performance on the CMS, understanding the effects of different components of usability on user satisfaction appears to need further exploration. It can be suggested that perceived usability and user satisfaction are both subjective measures and could be related such that better perceived usability could lead to higher user satisfaction. Abovementioned studies mostly concentrated on evaluating the usability of CMS, satisfaction of users with interaction features, and effects of usability improvements. However, the studies neither addressed overall user satisfaction nor attempted to establish relationship between components of perceived usability and user satisfaction. The findings in this avenue could inform CMS designers as to which usability component is more influential on user satisfaction.

The current study explored the relationship between user satisfaction and components of perceived usability for a CMS, and thereby attempted to establish predictive relationship between usability perceptions and user satisfaction.

Materials and methods

CMS under study

The CMS under study is developed in-house in a military educational institution and has been in use for three years. It is the official CMS for all courses, thus, all students are required to use it. The CMS enables instructors to use predesigned pages for many purposes such as; sharing course material (e.g. course notes, presentation), announcements, uploading homeworks and exam solutions. The material can be shared for each week separately. The students are required to sign in and follow the course activities on the CMS (e.g. accessing course material, following announcements). They can submit their works (e.g. class projects) to their instructor using the CMS, thereby CMS forms the main communication and knowledge sharing medium. The CMS is considered to increase efficiency in course management, to facilitate instructor-student communication and to improve quality of academic education and therefore extensively used by both instructors and students.

Data collection instrument

Turkish - Computer System Usability Questionnaire Short Version (T-CSUQ-SV) was used to collect perceived usability data. The CSUQ was originally developed and validated by Lewis [9], and adapted and validated in Turkish language by Erdinc and Lewis [10]. T-CSUQ-SV includes 13 positively structured statements. The first 12 items measure various aspects of usability. The last item measures overall user satisfaction, which makes T-CSUQ-SV a proper tool for the current study. The items are rated on a seven point scale ranging from "Strongly Agree (1)" to "Strongly Disagree (7)". Higher ratings indicate i) lower usability levels for the first 12 items, ii) lower satisfaction for the last item. Table-1 shows the T-CSUQ-SV items.

Table 1. T-CSUQ-SV items and mean scores (std.dev.)

T-CSUQ-SV Items	Mean (std.dev.)
1. Overall I am satisfied with how easy it is to use CMS.	2.89 (1.64)
2. It is simple to use CMS.	2.61 (1.81)
3. I can effectively complete my work using CMS.	3.12 (1.54)
4. I feel comfortable using CMS.	2.98 (3.37)
5. It was easy to learn to use CMS.	2.41 (1.79)
6. I believe I became productive quickly using CMS.	3.67 (1.82)
7. CMS gives error messages that clearly tell me how to fix problems.	4.16 (1.77)
8. The information (such as online help, on-screen messages and other documentation) provided with CMS is clear.	3.26 (1.61)
9. The information provided by CMS is easy to understand.	2.93 (1.53)
10. The interface of CMS is pleasant.	3.86 (1.93)
11. I like using the interface of CMS.	3.87 (1.84)
12. CMS has all the functions and capabilities I expect it to have.	4.51 (1.56)
13. Overall, I am satisfied with CMS.	3.91 (1.65)

The first 12 items form three sub-scales, each of which measures a different component of usability; System Usefulness (SYSUSE), Information Quality (INFOQUAL) and Interface Quality (INTERQUAL). Table-2 shows the sub-scale sctructures.

The sub-scale structure allows analysis of perceived usability across these three usability components. The mean ratings across the items that comprise a sub-scale, gives the "sub-scale score". T-CSUQ-SV items were fit onto a single page and questions to collect demographic data and CMS use profile data preceded T-CSUQ-SV items on the same page.

Table 2. T-CSUQ-SV sub-scales

Items	Subscale
1-6	System usefulnes (SYSUSE)
7-9	Information quality (INFOQUAL)
10-12	Interface quality (INTERQUAL)
13	User satisfaction

Participants

The participant group included 110 students. The second and third authors collected data on T-CSUQ-SV forms among the students in different classes by convenience sampling. The criteria for inclusion in the evaluation were; i) voluntary participation to the study, ii) minimum one year of experience in using CMS, iii) being a native Turkish speaker. Based on the second criterion, first year students' data were excluded. Table-3 shows characteristics of the participant group.

Table 3. Characteristics of participant group

Age	
Range	5 (18-23)
Mean	20.8
Gender	*n (%)*
Male	102 (92.7)
Female	8 (7.3)
Year	*n (%)*
2	43 (39.1)
3	48 (43.6)
4	19 (17.3)

Table-4 shows the CMS use profile of the participants.

Table 4. CMS use profile of participant group

Purposes for using CMS (more than one answer was allowed)	*n*	*(%)*
Accessing course material	103	(93.6)
Communication	27	(24.6)
Announcements	67	(60.9)
Homeworks	52	(47.3)
e-mail	80	(72.7)
Weekly CMS use frequency		
Mean (std. dev.)	6.5 (5.1)	
Weekly CMS use duration (hour)		
Mean (std. dev.)	2.2 (3.4)	

Results

Table-1 above includes the mean scores for T-CSUQ-SV items. Mean sub-scale scores, mean user satisfaction score, and Cronbach alpha values for scale reliability were given in Table-5. Cronbach alpha values for sub-scales ranged between 0.74-0.89, and it was 0.88 for the overall scale. Cronbach alpha > 0.7 is accepted satisfactory [11], therefore these alpha values indicated high scale reliability.

Table 5. T-CSUQ-SV sub-scale scores and scale reliability measures

Subscales	Mean (sd)	Cronbach alpha	
System usefulness	2.90 (1.40)	0.89	
Information quality	3.45 (1.32)	0.74	Overall: 0.88
Interface quality	4.08 (1.58)	0.86	
User satisfaction	3.91 (1.66)		

System usefulness and interface quality had the lowest (2.90) and highest (4.08) mean scores respectively. According to Tukey test results, mean scores for all three sub-scales were significantly different ($p < 0{,}02$).

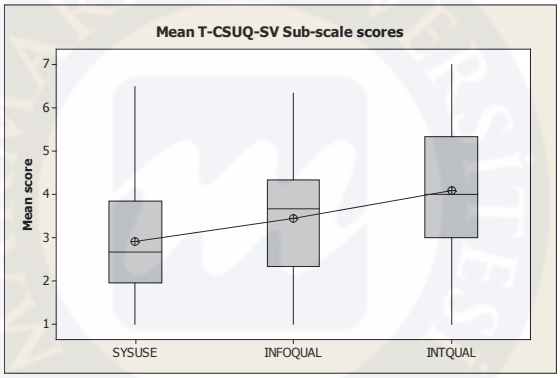


Figure 1. Mean sub-scale scores

A differentiation factor among the participants was the year of study (i.e. class). Potential effect of class was checked by performing one-way ANOVA on mean sub-scale scores and mean user satisfaction scores. The ANOVA results showed that class had a significant effect solely on mean INTERQUAL scores; the mean score of 2nd year cadets (4.50, std.dev. 1.60) was significantly higher (p:0.029) than the mean score of 3rd year cadets (3.64, std.dev. 1.52). No significant difference was found between other sub-scale mean scores ($p > 0.4$) and mean user satisfaction scores (p:0.344) across participant classes.

Relations between usability dimensions and user satisfaction was explored by i) correlations between sub-scale scores and user satisfaction score, ii) applying linear regression models with each sub-scale score as an independent variable (i.e. predictor), and user satisfaction score as the dependent variable. Table 6 gives correlation coefficients and significance levels. Correlation coeffcients showed a positive significant relationship ($p < 0.05$) between sub-scale scores and user satisfaction; while the correlation level was low for system usefulness and information quality (coefficient < 0.5), interface quality had medium correlation (0.5 < coefficient < 0.8) with user satisfaction [12].

Table 6. Correlations between sub-scale and user satisfaction scores

Sub-scales	Correlation coefficients
System usefulness	0.41 (*p:0.000*)
Information quality	0.43 (*p:0.000*)
Interface quality	0.62 (*p:0.000*)

Three regression models were built for each sub-scale and user satisfaction. Table 7 shows β values (i.e. partial regression coefficients), t-test significance levels and R^2 values (i.e. coefficient of determination) for each model. β Values in regression models were positive and t-tests on β for each model showed all sub-scales had significant positive relations with user satisfaction ($p < 0.05$). R^2 values indicated that interface quality explained the highest percentage (38.3%) of variance in user satisfaction. These results supported that perceived usability significantly influenced user satisfaction, and the usability dimension

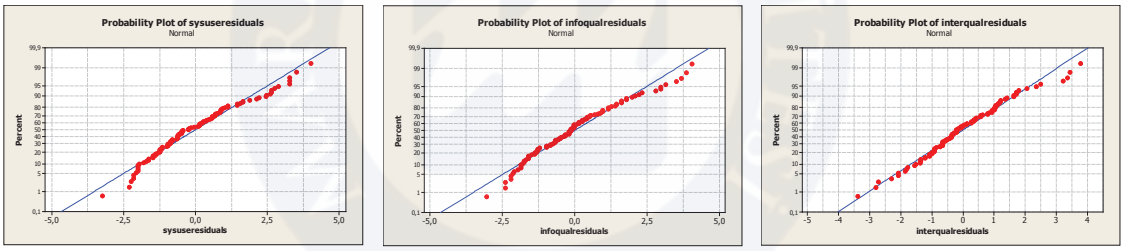
with the greatest effect was interface quality.

Table 7. Regression models

Predictor	β	R^2
System usefulness	0.48 (*p:0.000*)	16.7
Information quality	0.53 (*p:0.000*)	18.1
Interface quality	0.65 (*p:0.000*)	38.3

R^2: Coefficient of determination

Figure-1 shows normal probability plots of residuals for three regression models. Kolmogorov-Smirnoff normality tests were performed on the residuals to check adequacy of the regression models. While residuals of the model with system usefulness slightly deviated from normality (p: 0.01), residuals in models with information quality and interface quality fitted normal distribution (p:0.09 and p:0.098 respectively). Visual inspection of the normal probability plots in Figure-2 supported normality of the residuals and model adequacy was accepted satisfactory.



a.System usefulness b.Information quality c.Interface quality

Figure 2. Normal probability plots for residuals for regression models

Discussion

The current study explored the relationship between user satisfaction and components of perceived usability for a CMS used in a military educational institution. Three components of perceived usability, measured by T-CSUQ-SV; system usefulness, information quality and interface quality were found to influence user satisfaction significantly. T-CSUQ-SV mean sub-scale scores for three components were significantly and positively correlated with user satisfaction scores.

The study extended previous research by ampirically showing that perceived usability influenced user satisfaction. Further, the regression results showed that among the three components of usability, interface quality was the most significant predictor of user satisfaction. These results provided evidence for the role that usability plays in attaining user satisfaction. To increase effectiveness and facilitate acceptance of the CMS, developers and managers should take usability into account, evaluate and improve usability level of the CMS used in their institutions.

The strong relationship between interface quality and user satisfaction implies that interface design assumes particular importance for user satisfaction. Mean sub-scale scores showed the interface quality was rated as the poorest component of usability. The next step should be a usability evaluation focused on the CMS interface feuatures. Detailed user tests coupled with interface-focused expert reviews could guide interface improvement efforts. The CMS under study was developed in-house, therefore the development team should review their design and ensure that the interface follows widely accepted web usability conventions [17].

The proven effect of usability in user satisfaction implies that quality researchers should integrate usability measurement tools and techniques into their toolbox to evaluate user satisfaction for information systems. Concurrent application of usability test methods with a quality measurement tool can provide insights into factors leading to poor user satisfaction and how to improve these factors [21,22].

T-CSUQ-SV is a recently adapted perceived usability assessment tool and it proved effective in the current study. Multi-component structure of the tool allowed authors to explore relations between different components of usability with user satisfaction. High Cronbach alpha values supported the reliability of the tool with Turkish speaking participants [10]. Also, inclusion of user satisfaction item expands the potential use and contribution of the tool in prospective quality studies, as well as usability research. Quality measurement models [e.g. E-SV-QUAL] can include CSUQ items to measure usability related quality aspects of the information systems (e.g. ease of use, navigation).

The study had certain limitations. Participant group included solely students, whereas faculty is also a part of target audience for the CMS. Perceived usability measures showed the relationships between usability components and user satisfaction in subjectvie terms. However particular usability problems that led to poor usability perceptions toward interface qaulity remained unexplored.

In additon to aforementioned extensions (e.g. using CSUQ for quality), futureworks can concentrate on two main avenues. Firstly, the CMS under study could be tested to identify usability problems, development team can improve the CMS in line with test findings, then replicate T-CSUQ-SV track the effects of the improvements on perceived usability as well as user satisfaction. Secondly, in parallel with the mobile expansion in information systems, mobile CMS applications should be developed in accordance with mobile usability principles. A mobile application can greatly increase the availability and effectiveness of the CMS among target audience. In addition, given "sharing" is a common behaviour among digital generation that forms the students population, future CMS should allow students to share their course-related ideas and findings using social media or similar platforms over the CMS such as forums.The results of the study indicated that all these potential improvement and expansions should take usability into account for high user satisfaction.

Conclusions

The study indicated that user satisfaction is significantly related to components of perceived usability. Interface quality was found to be the the most influential predictor of user satisfaction. Better perceived usability can serve acceptance of the CMS by contributing to user satisfaction, thereby culminate in more effective use of investments that educational institutions make for CMS development and implementation. Therefore, usability of the CMS should be constantly evaluated, maintained and improved.

References

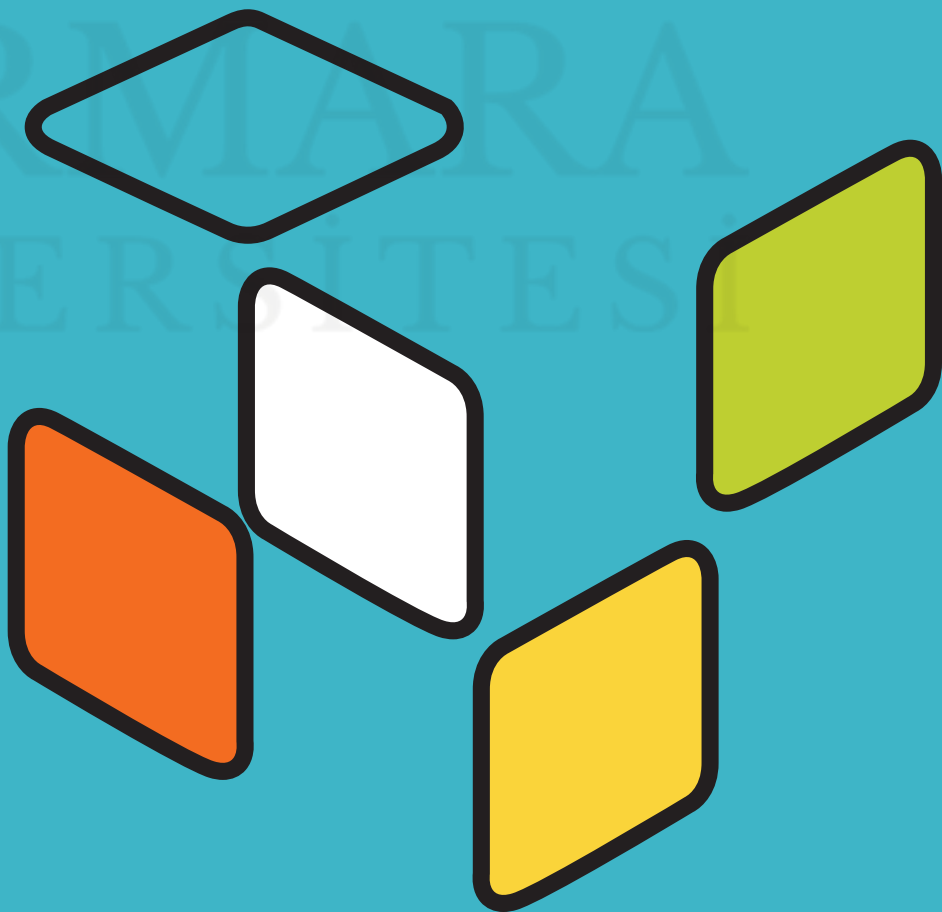
[1] Jones, G.H., Jones, B.H., 2005, A comparison of teacher and student attitudes concerning use and effectiveness of web-based course management software, *Educational Technology & Society*, 8(2) 125-135.
[2] Yohon, T., Zimmermann, D., Keeler, L., 2004, An exploratory study of adoption of course management software and accompanying instructional changes by faculty in the liberal arts and sciences, *Electronic Journal of e-learning*, 22 (2), 313-320.
[3] Johnson, T.R., Zhang, J., Tang, Z., Johnson, C., Turley, J.P., 2004, Assessing informatics students' satisfaction with a web-based courseware system, *International Journal of Medical Informatics*, 73, 181-187.
[4] Noyes, J., Garland, K., 2006, Explaining students' attitudes toward books and computers, *Computers in Human Behavior*, 22, 351-363.
[5] Ersoy, H., 2004, Bir çevrimiçi öğrenim destek sisteminin kullanılabilirlik testi: Planlama, uygulama, değerlendirme, *The Turkish Online Journal of Educational Technology*, 3 (1), 75-82. (*in Turkish*)
[6] Karahoca, D., Karahoca, A., Güngör, A. ve Uçar, T., 2008, E-öğrenme portalinin kullanılabilirliğinin değerlendirilmesinde bilişsel yeteneklerin ve bireysel farklılıkların irdelenmesi, *Proceedings of Symposium for Development of Software Quality Tool (Yazılım Kalitesi Geliştirme Araçları Sempozyumu)*, Istanbul, Turkey, 139-147. (*in Turkish*)
[7] Tullis, T., Albert, B., 2008, Measuring the user experience, Morgan Kaufmann Publishers, Burlington, ABD.
[8] Nielsen, J.1994, Usability engineering, Morgan Kaufmann Publishers, Burlington, ABD.
[9] Lewis, J.R., 1995, IBM Computer Usability Satisfaction Questionnaires: Psychometric evaluation and instructions for use, *International Journal of Human-Computer Interactions*, 7 (1), 57-78.
[10] Erdinc O., Lewis J.R., 2013, Psychometric evaluation of the T-CSUQ: The Turkish version of the computer system usability questionnaire, *International Journal of Human Computer Interaction*, 29 (5) 319-326.

[11] Bland, J.M., Altman, D.G., 1997, Statistics notes:Cronbach's alpha, *BMJ*, 314, 572.
[12] K.H. Zou, K. Tuncali, S.G. Silverman, 2003, Correlation and simple linear regression, *Radiology*, 227, 617–628.
[13] Questionnaire for User Interaction Satisfaction (QUIS), *Official web site* [http://lap.umd.edu/quis/].[Accessed 02 December 2014]
[14] Ramakrisnan P., Jaafar A., Razak F.H.A., Ramba D.A., 2012, Evaluation of user interface design for learning management system (LMS): investigating student's eye tracking pattern and experiences, *Procedia- Social and Behavioral Sciences*, 67, 527-537.
[15] Monaco E.j., 2012, Improving e-learning course design with usability testing, *International Conference, The Future of Education*, 7-8 June 2012, Florence, Italy.
[16] Daneshmandnia A., 2013, A usability study of Moodle, *Proceedings of the Spring 2013 Mid-Atlantic Section Conference of the American Society of Engineering Education*.
[17] Rosato J., Dodds C., Laughlin S., 2007, Usability of course management systems by students, *Proceedings of Midwest Instructional Computing Symposium, Grand Forks, ND*. [http://www.micsymposium.org/mics_2007/Rosato.pdf] [Accessed 02 December 2014].
[18] Brooke J., 1986, SUS – A quick and dirty usability scale [http://hell.meiert.org/core/pdf/sus.pdf][Accessed 02 December 2014].
[19] Lee H.S., Kim J.W., 2010, Student user satisfaction with web-based information systems in Korean universities, *International Journal of Business and Management*, 5 (1), 62-68.
[20] Xiao L., Dasgupta S., 2002, Measurement of user satisfaction with web-based information systems: an empirical study, *Proceedings of Eighth Americas Conference on Information Systems, Dallas, USA*. [http://www.sighci.org/amcis02/CR/Xiao.pdf] [Accessed 02 December 2014].
[21] Udo G.J., Bagchi K.K., Kirs P.J., 2010, An assessment of customers' e-service quality perception, satisfaction and intention, *International Journal of Information Management*, 20, 481-492.
[22] Parasuraman A., Zeithaml V.A., Malhotra A., 2005, E-S-QUAL A multiple-item scale for assessing electronic service quality, *Journal of Service Research*, 7 (3), 213-233.

MARMARA ÜNİVERSİTESİ YAYINEVİ
MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ

ENTERPRISE RESOURCE PLANNING



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Routing of Mobile Resources with PSO using Chaotic Randomness (Chaotic-PSO) for Unexpected Delivery Failures in Manufacturing

Alper Özpınar [1], *Emel Seyma Küçükaşçı* [2]

Abstract

Dealing with short term and long term production planning and scheduling has already been solved with different optimization and artificial methods and approaches. Under normal manufacturing conditions supply and demand progress controlled and supported by decision support systems, ERP and MRP software packages aiming maximum utilization of resources and minimizing the stocks aiming for JIT. These software packages becoming even more intelligent and proactive based on the data in the database systems. However all these systems starts with initial assumption of under normal conditions of flow time ordering to delivering. In case of unplanned stops, failures, malfunctions, shortages of unplanned inventory levels alters these initial conditions and progress to a diverging outcomes and consequences. This paper aiming a dynamic allocation and routing of mobile resources in a manufacturing plant by reallocating them by using a modified Particle Swarm Optimization using Chaotic Randomness.

Keywords: Particle Swarm Optimization, Chaotic Functions, Resource Planning and Routing

Introduction

The balance between the supply and demand has been dramatically changed within the last centuries also changing with the customer requirements. Assuming the industrial revolution has been started within the 18th century where low quality of output and moral laxity on the workforce [1] combined with unplanned actions without the usage of improved machinery except some drills for construction and small lathes for general purpose usage [2] .

As a result of demands driving force on production evolves it in to new way of production namely mass production. This evolution replaces the functional form of production with one based on flow, and the systematic reduction of individual tasks, had all been pioneered mainly by American car manufacturers. Even the conception of a utilitarian vehicle priced for mass consumption had been widely discussed and implemented with the “curved dash” Oldsmobile by American car-makers before the launch of the Ford’s famous Model T which has been produced more than fifteen million cars based mostly on the same design and production line for twenty years [3]. Since the assembly lines have been a significant development for managing operations – a mode that allows high-volume, low-cost, standardized production after the success of Ford’s Model T production in the assembly line. These benefits are often offset by drawbacks: perceptions of Ford style assembly lines consider them to be rigid and inflexible [4]. This may be the main reason of producing the same model for long years as single color which is black. However since the demand higher than the supply even with the mass production of same model, this factor has never been powerful enough for making a change in the way of production.

Ford’s achievement results in high production rates comparatively for those years in the assembly line production. After the 2nd World War, still the demand is higher than the supply but the consumers looking for more choices and quality, another car manufacturing company Toyota makes a huge improvement and reset the rules of the manufacturing game that organizes manufacturing and logistics [5]. The new system named “The Toyota Production System (TPS)” which is still commonly used in most of the biggest manufacturing companies.

[1] Alper Ozpinar, Istanbul Commerce University, Faculty of Engineering and Design, Department of Mechatronics Engineering, Istanbul, Turkey, aozpinar@ticaret.edu.tr
[2] Emel Seyma Kucukasci, Istanbul Commerce University, Faculty of Engineering and Design, Department of Industrial Engineering, Istanbul, Turkey, eskucukasci@ticaret.edu.tr

TPS or in other words the “Toyota Way” can be considered as early development of the nowadays key manufacturing recipe the “Lean production”. Lean production aiming to manufacture without generating waste and scraps also targeting the value with less work. The origin of Waste in manufacturing which is “muda” in Japanese [6] has seven different types namely; waste from over production, waste of waiting time, transportation waste, inventory waste, processing waste, waste of motion, and waste from product defects.

Manufacturing bodies namely factories plan and run their production systems based on the two basic concepts according to TPS. First of all, the thing that corresponds to the first recognition of putting forth all efforts to attain low cost production is "reduction of cost through elimination of waste". This involves making up a system that will thoroughly. Eliminate waste by assuming that anything other than the minimum amount of equipment, materials, parts, and workers (working time) which are absolutely essential to production are merely surplus that only raises the cost. In order to obtain eliminating the wastes result in another popular way of production named as “Just in time-JIT” production. In JIT in order to avoid such problems as inventory unbalance and surplus equipment and workers, companies recognizes the necessity of schemes adjustable to conform with changes due to troubles and demand fluctuations. For this purpose, companies put their efforts in development of a production system which is able to shorten the lead time from the entry of materials to the completion of vehicle. The just-in-time production is a method where by the production lead time is greatly shortened by maintaining the conformity to changes by having "all processes produce the necessary parts at the necessary time and have on hand only the minimum stock necessary to hold the processes together". [6-9] Minimum stock or stockless working principle requires a perfect material flow on the value chain model from supplier to the assembly shop. Even with the JIT operation conditions the material flow on the value chain model made as bulk or grouped transfers due to transportation costs. Most of the factories have main warehouses where the supplier delivers the products the factory area based on the long term weekly or monthly assumptions of production and Kanban systems pull the instant demand for the production. From the days of producing the same car type for decades nowadays manufacturing companies producing the products according to the exact needs of the customer by means of color, specs, extras, motor type, seat covers, electronic controls even the fuel octane filled into the tank.

An FMS (Flexible Manufacturing System) in a JIT (Just-In-Time) production system to be considered here consists various number of workstations labelled, dispatching stations and AGV (Automated Guided Vehicle) and tow trucks namely mobile transfers. AGV’s and tow trucks used for transportation between the different locations within the factory area as single or multiple loads. [10-12]

Problem Overview

According to the original problem under normal manufacturing planning and production conditions mobile resources following the deterministic routes and planned operations, stock delivery and distribution cycles supported by the MRP and ERP systems. Since most of the logistics and transportation still operated by blue collar workers and not fully automated there is a possibility of stochastic and unplanned needs to fulfill Kanban operations such as misinformation, wrong parts delivery, barcode problems, jundate-ticket selection problems, wrong material flow, human error, database error, communication errors and expert system setting and definition errors. Most of these errors due to the rapid development and changes in the standard operating procedures within the factories since the needs for starting the manufacturing operation is most of the time called last minute changes in the system. [5] The problem is originated from the work of the authors based on the AGV routing problem of handling the unplanned equipment transfer. [8] The formulation of the problem is also altered to be formulated as a network optimization problem.

In order to simulate the problem case a general approach for a typical manufacturing factory layout assumed. The factory area is considered as a Euclidean space in a 90x110 rectangular area. Three main warehouses comprising ten shelves provide the main supply in a weekly time table. As a result there are

thirty locations and these locations are distant to the manufacturing area. More closer to the assembly lines, ten assembly warehouses are located. The workers fill the products in these locations based on MRP results in an hourly time table. In order to decrease the work in process inventory, the assembly warehouse capacity is finite and limited. Since there may be different production specifications of similar products manufactured in distinct lines, it is reasonable to consider ten assembly lines located closer to the assembly warehouses. The display of the factory layout is shown in Figure 1.

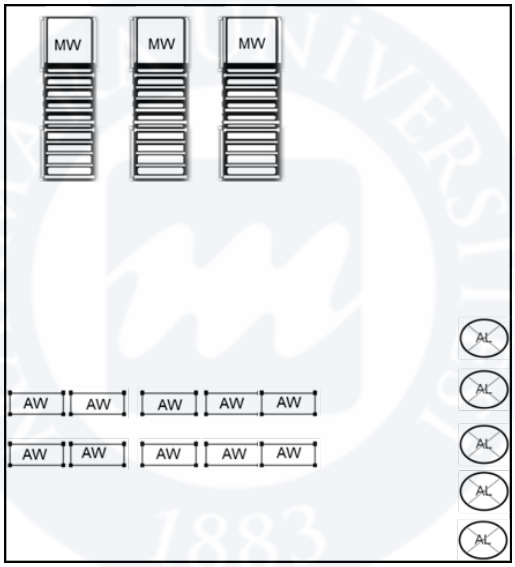


Figure 1. Schema of the Factory Layout for Simulation

There are three basic locations within an ideal manufacturing based on Toyota Production Practices. Supplier delivers the materials based on the long term planning and the sales to the MW Main Warehouse. During the midterm planning week or day materials taken from the main warehouse location to the assembly warehouse destination. (MW-AW job). Depending on the tag times and Kanban system, materials taken from assembly warehouse location to the assembly line destination where they used in the manufacturing line. (AW-AL job). These transfer operations mostly done by AGV's or tow truck vehicles. For this papers scenario it has been assumed that there are two types of AGVs such that type 1 AGV and type 2 AGV controlled by a computer or system center. Both types of AGVs identical like the size, capacity, speed but only difference between them emanates from the assigned distinct travelling areas. When there is a missing part in an assembly line, that part must be picked up from a main warehouse then transfer of the part to the assembly warehouse is a MW-AW job. Latter two jobs are done with a type 1 AGV. At the end, the part is delivered to the demanding assembly line through an AW-AL job by a type 2 AGV.

The problem can be constructed as a minimum cost flow (MCF) problem taking the inspiration from a paper which formulates the MCF problem for AGV routing in container terminals [13]. In Figure 2 $G = (N, A)$, each initial AGV location can be considered as a source node. In addition, each job is represented with a couple of nodes and the corresponding arc between them. This representation permits only one visit to each main warehouse location, and also enables an AGV to visit multiple main warehouses. The arcs represent the different mobile resources jobs. All arc capacities must be limited by 1 for planning. Finally, a sink node has used for the satisfaction of the demands of all jobs. The arc costs are determined using the travelling times of the AGVs based on the travelling distances. The main objective of the problem is to minimize the total travelling distance of the AGVs calculated after all the requested jobs are performed. The described directed graph is illustrated in Figure 2 for two jobs.

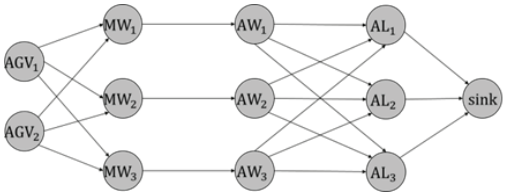


Figure 2. A Network Example for the MCF Formulation of AGV Routing Problem

The description and the nomenclature of the model parameters and the variables is as follows:

AGV : set of type 1 AGVs,
I : set of initial AGV location nodes,
M : set of main warehouse nodes,
A : set of assembly warehouse nodes,
A' : set of assembly line nodes,
s : the sink node,
$n = |AGV|$,
$A_1 = \{(i,j): i \in I, j \in M\}$,
$A_2 = \{(i,j): i \in M, j \in A\}$,
$A_3 = \{(i,j): i \in A, j \in A'\}$,
$A_4 = \{(i,s): i \in A'\}$,

$$c_{ij} = \begin{cases} d_{IM}, & if\ (i,j) \in A_1 \\ d_{MA}, & if\ (i,j) \in A_2 \\ d_{AA}, & if\ (i,j) \in A_3, \end{cases}$$

$$x_{ij} = \begin{cases} 1 & if\ arc\ (i,j) is\ traversed, \\ 0 & otherwise. \end{cases}$$

The complete model is as follows:

$$Min\left\{\sum_{(i,j)\in A} c_{ij}.x_{ij}\right\} \quad (1)$$

s.t.

$$\sum_{j\in N:\,(i,j)\in A_1} x_{ij} = 1, \qquad \forall i \in AGV \quad (2)$$

$$\sum_{i\in N:\,(i,j)\in A_4} x_{is} = n, \qquad \forall i \in A' \quad (3)$$

$$\sum_{i\in N:\,(i,j)\in A} x_{ij} - \sum_{i\in N:\,(j,i)\in A} x_{ji} = 0, \forall j \in A_1 \cup A_2 \cup A_3 \quad (4)$$

$$0 \le l_{ij} \le x_{ij} \le u_{ij}, \forall (i,j) \in A$$

where

$l_{ij} = 0, u_{ij} = 1\ if\ (i,j) \in A_1 \cup A_3$ and $l_{ij} = 1, u_{ij} = 1\ if\ (i,j) \in A_2 \cup A_4$.

The objective function (1) minimizes the total traversed distance. The constraint (2) satisfies that there is only one arc outgoing arc exists at type 1 AGV nodes. The constraint (3) satisfies the condition that the sink node s has only n much incoming arcs and no outgoing arcs. Finally (4) is the flow balance constraint and (5) corresponds to the flow capacity constraint.

The initial coordinates of the AGVs are generated from a uniform distribution between 0 and 90. Since the main objective is to obtain an efficient schedule, the distances between all locations are calculated as an Euclidean distance and we assumed that there is no occurrence of collusions, jamming or waiting times. All the methods start with the same initial AGV locations. Additionally, same target location parameters are also given as an input to all methods. Number of the emergency type 1 AGVs is equal to the number of the jobs that are targeted from the initial AGV locations to the main warehouses, namely MW-AW

jobs. Similarly, number of the emergency type 2 AGVs is equal to the number of AW-AL jobs.

Due to the sequencing constraints, the described problem is more complex than the multi travelling salesperson problem (MTSP) which is NP-complete [14]. Hence, being at least as hard as the MTSP, AGV routing problem is NP-hard. In order to find a grateful solution in a reasonable time, metaheuristic algorithms and/or their variations are introduced [15-18]. Chaotic-PSO is a variant of the previous PSO approach proposed for solving the unplanned AGV routing problem. [8] This is the main contribution of this paper which clearly exhibits the difference with PSO and the Chaotic-PSO approaches.

In this section special implementations of the PSO and Chaotic-PSO algorithms suited to the AGV routing problem are described. The famous PSO approach is presented first. Then, the Chaotic-PSO algorithm is discoursed together with the various chaotic functions.

PSO for Mobile Resource Routing

The modified PSO algorithm is a discrete solution for the dynamic routing of the mobile resources like emergency AGVs which can be changed during the operation according to the particle with the best-found travelling distance in whole preceding iterations and the particle with the best-found travelling distance in current the iteration. A particle represents a solution that includes the routes of the AGVs satisfying the all requested stock delivery jobs. Positions of the particles in iteration k, x^k form the population which is updated at each iteration using the velocity vector. Velocity vector at iteration k, v^k is calculated using the inertia weight w, learning factors c_1 and c_2, and the random numbers λ_1 and λ_2. The fitness of each particle is determined by considering the total traversed distances. The inertia weight in the kth iteration is calculated by the formula

$$\omega^k = \omega_{mzx} - (k/\, k_{mzx})\, (\omega_{mzx} - \omega_{min}). \quad (5)$$

where k_{mzx} is the maximum number of iterations, k is the current iteration number and ω_{min} and ω_{mzx} are the minimum and the maximum values for w, respectively.

Afterwards, v^k is calculated using the equation

$$v^{k+1} = \omega^k . v^k + c_1 . \lambda_1 . (p_{Best} - x^k) + c_2 . \lambda_2 . (g_{Best} - x^k) \quad (6)$$

where p_{Best} is the best-found travelling distance in whole preceding iterations and g_{Best} is the best-found travelling distance in current the iteration.

Since the problem has a discrete solution, addition operation of the velocity vector to the particle positions not only results with rational positions, but also results with deteriorating particle positions. Therefore, the update of the current position of the particles in the population is done by a swap operator. Several swap operators are considered in some PSO approaches to the TSP problem [15;19;20]. The proposed swap operator is such that the particles with the minimum and the maximum velocity values are swapped first. Together with this operation, the particles with the second minimum velocity and the second maximum velocity are also swapped. Since the swapping operations do not harm the completeness of the particles, the feasibility is sustained after the swap operations. Hence, the positions of the particles in the population are updated according to the following equation where the $\oplus$ sign is the swap operator.

$$x^{k+1} = x^k \oplus v^{k+1} \quad (7)$$

Finally, the general PSO algorithm used is as follows:

For each particle
    Initialize particle
End
While iteration number < maximum number of iterations **Do**
    For each particle
    Calculate fitness value
    If the fitness value is better than the best fitness value (p_{Best}) in history
    set current value as the new p_{Best}
    End
    Choose the particle with the best fitness value of all the particles as the g_{Best}
    For each particle
        Calculate particle velocity according to equations (5) and (6)
        Update particle position according to equation (7)
    End
End

PSO with Chaotic Randomness (Chaotic-PSO) for Mobile Resource Routing

To cope with the random calculation of λ_1 and λ_2 values at each iteration, selected chaotic functions are included. Moreover, combined with chaos optimization algorithm, the particles can go through all places in the solution space without repetition under a deterministic iteration formula.[15] The diversification of the search and also the time complexity is improved by embedding the chaotic functions instead of the random variables.

One dimensional and two dimensional chaotic maps are applied to solve test task scheduling problem (TTSP) to replace random sequences. [18] One dimensional chaotic maps with promising results are selected as chaotic functions to improve the PSO algorithm. Hence, the λ_1 and λ_2 variables in (6) are updated using the chaotic maps which are shown in Table 1. Besides, the positions of the particles are updated using (7) where the $\oplus$ sign is the swap operator defined previously.

Table 1. List of Chaotic Maps for Randomness

Chaotic map	Formula	Range
Circle map	$x^{t+1} = \{x^t + b - (a/2\pi)\sin(2\pi x^t)\} \bmod(1)$, $a = 0.5 \quad b = 0.2$	(0,1)
Cubic map	$x^{t+1} = \rho\, x^t\,(1-(x^t)^2)$,$\rho = 2.59$	(0,1)
Logistic map	$x^{t+1} = a\, x^t\,(1-x^t)$,$a = 4$	(0,1)
Sinusoidal map	$x^{t+1} = \sin(\pi x^t)$	(0,1)

Experimental Settings and Simulation Results

General experimental setting is shown in Table 2. Since the scheduling is applied only for the emergencies, there are less number of jobs than a daily or weekly delivery schedule. At most 20 jobs are considered at a single time interval in order to see the situation of the algorithms.

Table 2. Parameters for the Simulation Environment

Parameter	PSO	Chatic-PSO
c_1, c_2	0.5, 0.5	0.5, 0.5
λ_1, λ_2	$\epsilon\ U(0.1)$	Chaotic
Population size	150	150
w_{min}, w_{max}	0.5, 0.95	0.5, 0.95
Maximum # of iterations	300	300

Testing the suitability done for 16 problem instances based on job numbers. The instances are incremental such that each instance is a subset of the following large-sized instance in Table 3. The followings are the main observations after reaching the results in Table 3. When there are 5 jobs, both PSO and Chaotic-PSO succeeded to find the solution with same objective value. However, when we move forward to the larger instances, the solutions found by each method differ from each other which may be due to the increasing complexity of the problem. For all instances, Chaotic-PSO with logistic map gives the best scores. Second best results are obtained by the circle map implementation of Chaotic-PSO for several instances. When we check the score averages, third best approach is the cubic map integrated Chaotic-PSO. Between all Chaotic-PSO approaches, the worst results are obtained by using the sinusoidal map as a chaotic function. The averages tells us that the classical PSO algorithm performs not well when the competitor is circle map, logistic map or cubic map integrated Chaotic-PSO. Finally, it is worth-emphasizing that the inclusion of chaotic position updates prevents the early convergence of the PSO algorithm.

Table 3. Total distance travelled by mobile resources for jobs

#Jobs	PSO	Chaotic-PSO (circle map)	Chaotic-PSO (cubic map)	Chaotic-PSO (logistic-map)	Chaotic-PSO (sinusoidal map)
5	**2438,2**	**2438,2**	**2438,2**	**2438,2**	**2438,2**
6	2902,9	2904,3	2902,9	**2899,2**	2907,6
7	3198,1	3174,6	3187,7	**3164,1**	3198,1
8	3585,7	3584,1	3585,7	**3581,9**	3588,2
9	4042,8	4041,3	4041,3	**4030,3**	4045,4
10	4577,2	4530,1	4544,7	**4513,6**	4553,0
11	4956,0	4950,6	4951,2	**4920,9**	4957,6
12	5485,8	5437,8	5441,8	**5431,7**	5475,3
13	6085,8	6045,5	6034,6	**6028,7**	6048,5
14	6408,0	6401,4	6400,8	**6376,0**	6410,1
15	6866,1	6841,1	6848,0	**6834,2**	6861,5
16	7073,3	7073,4	7075,1	**7061,4**	7078,0
17	7600,1	7553,4	7585,8	**7530,0**	7590,1
18	7851,7	7788,3	7839,2	**7776,7**	7879,2
19	8223,8	8213,9	8223,2	**8149,9**	8291,0
20	8722,2	8693,3	8711,0	**8639,9**	8778,7
Avg.	5626,1	5604,4	5613,2	**5586,0**	5631,3

Conclusion and Future Work

Recently, use of particle swarm optimization for different scheduling and resource allocation problems has been broadly used and offered. In this paper, both general particle swarm optimization and a modified particle swarm optimization where the true random generator of the classical approach has been modified with a chaotic random number generation applied to mobile resource routing problem. Proposed algorithm and approach applied to an unexpected planning request generated within a JIT-Kanban operating manufacturing factory. Visual Studio and C# has been used for developing the simulation software.

According to the simulation results, Chaotic-PSO with a logistic-map function for randomness gives the optimum results by means of less distance travelled during the emergency operation of the mobile resources.

The future work for the researchers will be based on the variation of unexpected jobs and delivery problems by using a chaotic problem generator and a hybrid approach of C-PSO and GA and the performance measurements of the problem.

References

[1] Behagg, C., 1998, Mass Production without the Factory: Craft Producers, Guns and Small Firm Innovation, 1790-1815, *Business History*, 40, 1-15.
[2] Herer, Y. T., Shalom, L., 2000, The Kanban assignment problem "A non-integral approach", *European Journal of Operational Research*, 120, 260-276.
[3] Klei, C. M. ,Kim, J., 1996, AGV dispatching, *International Journal of Production Research*, 34, 95-110
[4] Lage Junior, M. & Godinho Filho, M., 2010, Variations of the kanban system: Literature review and classification, *International Journal of Production Economics*, 125, 13-21.
[5] Lu, H, Yin, L, Wang, X, Zhang, M, & Mao, K., 2014, Chaotic Multiobjective Evolutionary Algorithm Based on Decomposition for Test Task Scheduling Problem, *Mathematical Problems in Engineering*.
[6] Maughan, F. G. & Lewis, H. J., 2000, AGV controlled FMS. *International Journal of Production Research*, 38, 4445-4453.
[7] Musson, A. E., 1975, Joseph Whitworth and the Growth of Mass-Production Engineering, *Business History*, 17, 109-149.
[8] Ozpinar A., Kucukasci E., 2014, Particle Swarm Optimization for Unplanned AGV Routing in Kanban Systems, *15th EU/ME Workshop*,"*Metaheuristics and Engineering*".
[9] Rahman, N. A. A, Sharif, S. M., Esa, M.M., 2013, Lean Manufacturing Case Study with Kanban System Implementation, *Procedia Economics and Finance*, 7, 174-180.
[10] Rashidi, H. & Tsang, E. P. K. ,2011, A complete and an incomplete algorithm for automated guided vehicle scheduling in container terminals, *Computers.& Mathematics with Applications*, 61, 630-641.
[11] Samanlioglu, F, Ferrell, W. G, & Kurz, M. E., 2012, An interactive memetic algorithm for production and manufacturing problems modelled as a multi-objective travelling salesman problem, *International Journal of Production Research*, 50, 5671-5682.
[12] Shi, X. H, Liang, Y. C, Lee, H. P, Lu, C, & Wang, Q. X.,2007, Particle swarm optimization-based algorithms for TSP and generalized TSP, *Information Processing Letters*, 103, 169-176.
[13] Somhom, S., Modares, A., Enkawa, T., 1999, Competition-based neural network for the multiple travelling salesmen problem with minmax objective, *Computers & Operations.Research*, 26, 395-407.
[14] Sugimori, Y., Kusunoki, K., Cho, F., Uchikawa, S., 1977, Toyota production system and Kanban system Materialization of just-in-time and respect-for-human system, *International Journal of Production Research*, 15, 553-564.
[15] Wallace, A., 2001, Application of AI to AGV control agent control of AGVs. *International Journal of Production Research*, 39, 709-726.
[16] Wang, K. P, Huang, L, Zhou, C. G, & Pang, W., 2003, Particle swarm optimization for traveling salesman problem, *Machine Learning and Cybernetics*, 3,583-1585.
[17] Wilson, J. M., 2013, Henry Ford vs. assembly line balancing, *International Journal of Production Research*, 52, 757-765.
[18] Wilson, J. M. & McKinlay, A., 2010, Rethinking the assembly line: Organisation, performance and productivity in Ford Motor Company, c. 1908-27, *Business History*, 52, 760-778.
[19] Yuan, Z, Yang, L, Wu, Y, Liao, L, & Li, G. ,2007, Chaotic particle swarm optimization algorithm for traveling salesman problem, *IEEE International Conference on Automation and Logistics*, 1121-1124.
[20] Zhang, Q, Manier, H, & Manier, M. A., 2012, A genetic algorithm with tabu search procedure for flexible job shop scheduling with transportation constraints and bounded processing times, *Computers & Operations Research*, 39, 1713-1723.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

After Live Stage in Enterprise Software Implementations and Points to be Considered

Batuhan Kocaoglu [1]

Abstract

The term enterprise software describes the applications that large companies use to conduct line-of-business operations such as accounting, business intelligence), communication and collaboration, customer relationship management and human resources. These tools are traditionally deployed in on-premise data centers, often as multi-faceted ERP suite. ERP is an industry acronym for Enterprise Resource Planning refers to automation and integration of a company's core business to help them focus on effectiveness & simplified success. Traditionally the process of controlling an investment like an ERP system ends with the delivery of the system to the users. But the realization of system benefits is reported to significantly ***lag expectations.*** *The issue of successful implementations, as evaluated during the post-implementation process and the potential effects on the realization of potential system outcomes, provide a solid motivation for the present study. This kind of systems allows us lots of improvements. On the other hand, we must keep the system updated, regarding to business process changes. By using predefined indicators, we can measure the values in periods, and see the progress more easily and systematically. In this study we developed a framework for post-implementation studies and provided related indicators from the literature for a more effective management.*

Keywords: Enterprise Software, Post Implementation, Usage, Indicator, Stage, ERP, MIS

Introduction

Enterprise software, most known type as **enterprise resource planning (ERP)** systems, enable organizations to streamline operations, leverage common business processes, and manage multiple operations through an integrated suite of software modules and a centralized database [1], [2].

Although stories of ERP successes and failures are widely discussed in both academic and practitioner publications, surprisingly **little evidence** exists about how well ERP has actually been assimilated in adopting organizations **beyond the initial implementation**. Little is known about how extensively or faithfully organizations **use ERP functionalities** [3], [4] because much of the research to date **focuses** on data collected just prior to, **during, or just after ERP software implementation** [5] , [6], [7], [8], [2].

The primary purpose of this paper is to emphasize **how companies might facilitate usage of their installed ERP functionality**. This study addresses **maintenance activities** that take place **after an ERP system goes live**, classifies these activities into meaningful maintenance categories, then analyzes the indicators.

This study is relevant to both the **research and practitioner communities**. First, it contributes to knowledge on the **post-implementation stage** of ERP systems—an area where **little research** has been conducted. Second, the **findings** increase our understanding of **how maintenance** of software packages. Such understanding is **important and necessary for effective information systems management.** Third, with a **good understanding** of the indicators and sample alerts, usage of ERP systems can be better facilitated.

[1] Batuhan Kocaoglu, Okan University, Department of Logistics, Istanbul, Turkey, batuhan.kocaoglu@gmail.com

This paper covers a brief introduction to ERP software, after live activities, the methodology employed in this research, analysis of the results and findings.

Extent of ERP System Usage and ERP Systems Along Their Lifecycle

ERP like systems are designed around a process view of the business. It is widely reported in the literature that enterprise-wide applications promise seamless integration of all information flowing through a company: accounting and financial information, human resource information, supply chain information, and customer information [9], [10], [11].

Once the company successfully implements the ERP, the **attention moves forward** to the most efficient **use of the system**. Especially since considerable resources have been invested in the ERP implementation, the best possible **utilization** of the system is anticipated. Indeed, the value of an ERP system draws from its **effective and efficient usage** and not so much from the system itself [12].

It is estimated to take **12 to 18 months**, even up to **three years**, after implementation for an organization to re-stabilize its processes and to stabilize its use of the ERP in order for it to begin to realize benefits from the installed ERP [13], [14], [2]. It is not uncommon for a firm initially to require several days to perform processes in ERP that took only a few hours in the prior systems [15]. Even after the initial stabilization period, it often takes several years for firms to make a full transition to ERP [16], [17], [18]. One reason for this is the underlying cultural shift, in addition to the technical shift, that ERP often requires. For example, although ERP allows an organization to gain a more convergent view of its data and processes, this requires organizational members to understand a broader, more divergent set of activities within their own work processes [19], [2].

Several ERP **life cycle models** have been reported in the literature to emphasize important phases and related activities during an ERP project. These models have phases comprising processes of 1) **Pre-implementation** phase (denoted as Project chartering phase) comprising selection of vendor and system, and signing a contract, 2) **Implementation** phase (denoted as Project phase), including the installation and configuration of the ERP-system, and 3) **Post-implementation phase** (denoted as Shakedown phase and Onward and Upward phase) involving solving of bugs, stabilization, further adaption, training, support and maintenance after the system is rolled out [16], [20]. [21], [22].

In this study, we **utilized** the phases of an ERP life cycle to systemize our framework based on Esteves and Pastor [23]. This framework is structured in phases, which consist of the several stages that an ERP system goes through during its whole life within the hosting organization. The stages are: adoption decision, acquisition, implementation, **use and maintenance**, **evolution** and retirement phase. To simplify, we used the mentioned two sub-phases "use and maintenance", and "evolution" that correspond to "**post-implementation**" phase. In the following, we describe post phases.

The **post-implementation stage** in a system's life cycle encompasses a number of processes that are critical for a system's success. Following the implementation of the system, an organization would engage in a number of activities, such as post-implementation review, support and maintenance (e.g., [24]. **The focus of this paper** is on the factors that drive successful implementations during the post-implementation process of an ERP system. The two sub-phases are:

a) Use and maintenance phase: This phase consists of the use of the product in a way that returns expected benefits and minimizes disruption. During this phase, functionality, usability, and adequacy to the organizational and business processes are important. Once a system is implemented, it must be maintained, because malfunctions have to be corrected, special optimization requests must be met, and general systems improvements have to be implemented.

b) Evolution phase: In this phase, the system is upgraded by new technology insertion and additional capabilities are integrated into the ERP system to obtain improved benefits. The extensions can be classified in two types: 1) Evolution "upwards": Functionality is oriented to decision making with applications such as advanced planning and scheduling, data warehouses, and business intelligence systems; 2) Evolution "outward" to the system ' s environment, with applications such as customer

relationship management, supply chain management, inter-organizational workflow, and electronic commerce [25].

Research Method

This study has the objective to explore the process of post-implementation in ERP systems and **identify the factors** that lead to post-implementation. Such "why" questions can be answered using the case study method [26]. A qualitative approach was used to analyze a series of events exhibiting some theoretical principles.

The proposed framework is based on the assumptions listed below. These assumptions are drawn from (1) the body of literature, (2) the authors' experience by working in the field of enterprise information systems for small businesses. In this research, the **authors themselves were actively involved** as consultants to the ERP implementations. We focused to find an answer to these questions and develop a roadmap based on previous separate studies:
1. What kind of activities must be performed during the post-implementation phase of the system life cycle?
2. What tools can be used for their measurement, if any?

Framework

In ERP projects, companies try to build the picture of their desired business processes, named as TO-BE state. First step of this study is, to create a picture of the current situation, named as AS-IS state.

Developed framework in Figure 1 emphasizes the road to TO-BE state. First, we must define the indicators in AS-IS state and record the results, and when the time comes, we must compare the results of the indicators in post-implementation stage. In post implementation stage, we assume that the system becomes routine and the heavy work related with configuration settings and customization is minimized. We must consider and track, different indicators in this stage. And results of the indicators must be evaluated.

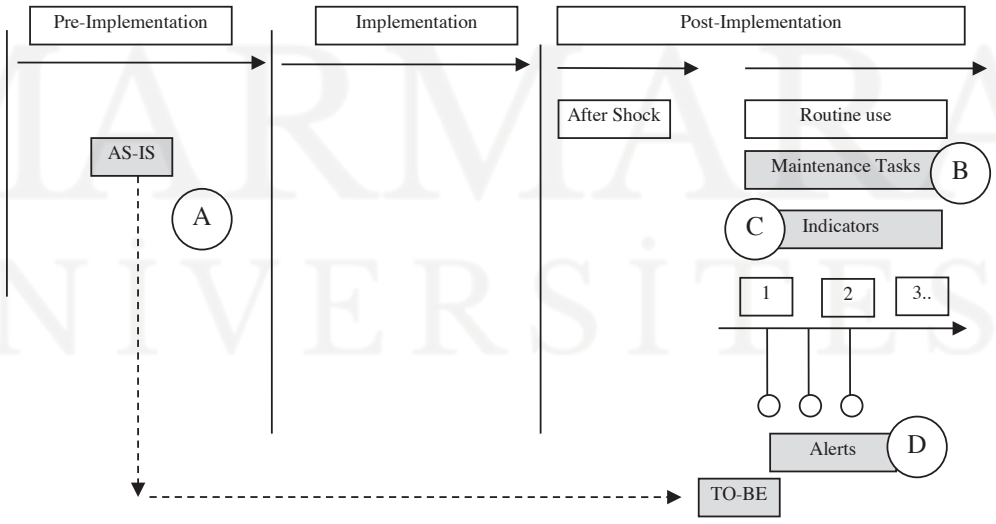


Figure 1. Developed Framework

As a result of the results of the indicators or audits, we may face some problems. In this study, we also emphasized some possible problems and their alerts, and their solutions. Using indicators, and alert-improvement cycles, companies can use their systems more efficient, and parallel with their business processes, up-to-dated.

Framework components namely A,B,C, and D will be discussed in following sections.

(A) Before (AS-IS) and After (TO-BE) Comparison

Companies must set some metrics in the pre-implementation stage, to **compare** with the desired state, and see if the targets have been reached. We must use the system for a period of time to see the results, for example after 1 year or 3 years. When the system comes **routine**, we can measure the new values of the indicators in the TO-BE situation, and compare with the values of the first AS-IS state.

Some sample metrics are given below. The following matrix is an example that sums up how the implementation to help companies to improve their operation in terms of intangibles. The number of metric can be increased.

Table 1. Indicators for AS-IS and TO-BE Comparison

Item	Before Current System (AS-IS)	After Proposed ERP System (TO-BE)	Resources
Quote to cash speed		Reduced	[27]
Offer realization time		Reduced	
Accurate cycle time	3 out of 4 (75%)	19 out of 20 (95%)	
Order processing speed in	in days	minutes	
Financial Close book data	> 9 days	few days / real time	
Paperwork		Less	[28]
Manual work		Less	
Paperwork associated with order processing		Less	
Time to process order and deliver		Less	

(B) After Activities (Maintenance)

In after live stage (post-implementations) systems is now routine. To make the system more sustainable, stable and updated, some task must be done. Some task must be executed periodically. In this study we mainly focused on list of Nah et. al (2001) [29].

Table 1 shows the two-tier classification of ERP maintenance. The first level comprises corrective, adaptive, perfective, and preventive maintenance as well as user support. External parties, such as the ERP vendor, third-party vendors, and consultants, may play a key role in ERP maintenance. Such activities may be sporadic or continuous and they take up a significant amount of time.

Table 2. Classification of Maintenance Tasks Into Maintenance Categories [29]

Maintenance categories	Maintenance tasks	Description of tasks
(1) Corrective maintenance	Application of hot packs	Incorporate system patches sent by ERP vendor (in cases where the problems could not be resolved by the IT department)
	Troubleshooting	Resolve anomalies reported by users
	Import new objects from ERP vendor	Incorporate objects (lines of code) sent by the vendor to solve problems (examples include new database structures, programs, and new reports)
(2) Adaptive	Transfers	Moving new features from development to test to production environment
	Testing	Integration testing after hot pack application and configuration changes
	Modifications and enhancements	In-house customization and modification performed by the IT personnel, and report development by the developer team
	Authorizations	System password maintenance, changes in access permissions as staff arrive, leave, or change positions
	Tuning of system interfaces	Tuning interfaces with other software
(3) Perfective maintenance	Version upgrade	Justification, planning, and actual implementation of new software versions
(4) Preventive maintenance	Routine administration	Monitoring average system response times and thresholds, file sizes, tape backups, and error logs

	Monitoring workflow	Tracking flow of maintenance work items
(5) User support	Training users	Training users on new or existing features
	Help desk	Answering user questions about the system
(6) External parties	Coordination and administration	Coordinating work and relations among ERP team members, vendors, contractors/consultants, and external user organizations
	Creation of Online Service System (OSS) notes	Online query or reporting of problems to the vendor, tracking vendor's progress towards resolution of problems reported

(C) After, Comparison Between Periods

The indicators are dedicated to an examination of the company's ability to effectively make use of the ERP system's functions as well as to enhance and improve it. Since that ability depends on the know-how of personnel, employee-centered measures covering both users and IT staff are called for. Table 3 lists the indicators that can be used in evaluating the system usage, among periods.

For example, a useful indicator is the level of training courses, measured by the amount of time or expenses spent. Specifically for system developers, their type of formal qualification can additionally be surveyed [30] In some cases, it may have feed-forward value - negative deviations of actual training costs versus budgeted costs may indicate that the system's functions are not efficiently used by staff members. By contrast, a continuous increase in external consulting expenses may point to deficiencies in the internal training staff's competence [30].

Table 3. Indicators for Comparison Of The Different Period Of The Current System

Goal	**Measure**	**Resource**
Compliance with budget	Maintenance – Hardware : Budget/Actual	[30]
	Maintenance – Software : Budget/Actual	
	Maintenance - Consulting : Budget/Actual	
	Training – Hardware : Budget/Actual	
	Training - Software : Budget/Actual	
	Training – Consulting : Budget/Actual	
Coverage of business processes	% of covered process types	[30]
	% of covered business transactions	
	Percent of critical processes monitored	[31]
	% of covered transactions valued good or fair	[30]
Operational problems	% of transaction not finished on schedule	[30]
	% of cancelled telephone order processes due to non-competitive system response time	
	# of problems with customer order processing	
	# of problems with warehouse processes	
	# of problems with standard reports	
	# of problems with reports on demand	
Technical-Availability of the ERP-system	average system availability	[30]
	average downtime	
	maximum downtime	
	average response time in order processing	
	average response time in order processing in the peak time	
	average # of OLTP-transactions	
	maximum # of OLTP-transactions	
Actuality of the system upgrade	average time to upgrade the system	[30]
	release levels behind the actual level	
Development support	punctuality index of system delivery	[30]
	quality index	
	average workload per developer	
	rate of sick leave per developer	
	% of modules covered by more than 2 developers	

	# of training hours per user	
	# of training hours per developer	
	qualification index of developer	
	# of consultant days per module in use > 2 years	
	# of consultant days per module in use < 2 years	
Reliability of software vendor	# releases per year	[30]
	# of functional additions	
	# of new customers	
Technical-Using ERP system	How many employees use the system daily?	[32]
	How much time per day do employees work with the system? (%)	
	reports generated per day? (%)	
	Amount of use/duration of use	[33]
	Charge for system use	
	Number of reports generated	
	Number of inquiries	
	Amount of connect time	
	Number of different computer systems	[28]
Process improvement	Number of changes to targets for key processes effectiveness and efficiency	[31]
	Amount of satisfaction of management and the governance entity with ERP system	
	Amount of reduction in the number of outstanding process deficiencies	
	Amount of stakeholder satisfaction with the measuring process	
	Number of improvement actions driven by ERP system	
	Number of performance targets met	
Request management	Requirements Stability Index (RSI)=No. Of requirement changed (added / deleted / modified) / Total No. initial requirements	[34]
	Arrival Rate of Problems (ARP)=No. of problems reported by the users per month	
	Closure Rate of Problems (CRP)=No. Of problems closed per month	
	Age of Open Problems (AOP)=Sum of time (days per month) that problems have been open / No. Of open problems per month	
	Age of Closed Problems (ACP)=Sum of time (days per month) that problems have been closed / No. Of closed problems per month	
	Frequency of requested for special functions	[35]

(D) Alerts and Actions

The information system cannot support company strategy without being mastered as a "tool". Certain situations are consequently impossible (control of the processes without mastery of the software). Alert criterias allowing recognising, and by the typical actions of improvement to be implemented at this level. These alert criteria and improvement actions are presented in Table 4.

Table 4. Alerts and actions (derived from [36])

Group	Level	Alerts	Actions
software maturity	Software mastery	Non-appropriation of the system by the users	Additional training of the users
		Unsatisfactory operational execution	Create a competence centre
		Insufficient speed/ability to react	Empowerment of the users on their role and on their duty (user's charter, quality indicators)
		Insufficient system response time	Stabilization of the execution

			(indicators with follow-up of objectives)
	software maturity	The users create parallel procedures	
		No documentation on parameters, data, data management procedures	
	Improvement	The full ERP potential is not used	Implement the functions that are not yet used
		Results not reached, expectations unsatisfied	Definition of performance indicators, business indicators
		The standard system installed does not fit all requirements	
	software maturity	The number of office automation utilities increases	Improvement and automation of the reporting
		The procedures are too heavy	Rethink the roles to simplify the procedures
	Evolution	Context "multi-activities", international firm	Standardization on several sites/activities
		Reorganizations, technological changes	Version upgrade
		Need of (analytics) reporting	Develop business intelligence systems
	software maturity	Outside integration: B to B	Address the ERP/environment technological evolution (EAI)
		Bar-code integration	Implementation of enterprise architecture (application mapping)
		Software maturity depreciation	Version upgrade
strategy deployment	**Master-data control**	Numerous erroneous technical data	Cleaning of the migrated data
		Messages of ERP not relevant (stock shortages, rescheduling in/out MRP, purchase proposals)	Maintain a business project team with a plan of action to master-data
		Numerous manual inventory corrections	Define responsibility for data
		Product lifecycle not improved, not integrated in the IS (revision …)	Indicators of data control
			Assert the **uniqueness of the data** in the whole company
	Process control	Conflicts between services on procedures	Revise management rules in the company
		Contradictions between local and global indicators	Verify the **appropriateness** of the tool to the organization
		Results not reached, needs unsatisfied	Rethink the **roles** to simplify the procedures
		Demands for improvement, for roles redefinition by the users	Define responsibility for processes
		Higher expectations of customers and top management	Strengthen the transverse responsibilities: indicators, communication
		No return on investment calculated	
	Strategy support	Business objectives not reached	Modeling and optimization of the supply chain
		Higher expectations of customers and top management	External integration: B to B
		Changes of markets, of customer expectations	Implementation of application mapping
		International extension	Business Process Management (modeling, process performance measure)
		Management expectation concerning follow-up consultancy	IT associated to business strategies

Findings and Recommendations

Problems associated with enterprise resource planning (ERP) implementations become more rampant during the post implementation phase because once users learn their way around the system, they can **test its limits,** setting off shockwaves that can devastate an otherwise successful control environment. While extensive integration and acceptance testing flushes programming errors and exercises pathways through the system, post implementation brings an explosion of **bug reports** that hit the maintenance team, along with a slew of frenzied requests for new functions. As a result, the post implementation phase requires an **ongoing process of improvement** and fine tuning. It is the greatest challenge to audit, because an audit is expected to unravel the root of problems in the ERP processes and provide effective solutions [37].

To be effective, there must be a strong, across -the-board commitment to technology **audits**, including upper management. The audit also should take into account how well employees interact with the software. Does it help them feel more empowered to accomplish key tasks? How quickly do they feel they've mastered the software? Implementing **user surveys** immediately following training and again six months later can be advised [38].

The areas that are **designed to automate processes**, such as printing shipping labels and notifying customers, should be relatively easy to measure, as long as you've established benchmarks. More difficult to measure are areas that reveal an employee's lack of familiarity with the software. For example, if your audit reveals little improvement in overall shipping errors despite the software's automation capabilities, you may need to go back again to key employees. Ask them to show you precisely how they use the software [38].

When employees fail to use all of the ERP features because of inadequate training or because of a natural resistance to change, the software benefits will erode over time, until you're only using a fraction of its capabilities. At some point, you have to return to base-level training to protect your technology investment. A **continuous feedback loop** is necessary. You can go back in and talk to end users to discover any knowledge gaps, so that you can take corrective action. If end users have the perception that software is the problem, that perception tends to become a reality [38].

Natural **disasters**, security failures, or even a change in business cycle can affect your servers and applications. Start by defining what constitutes a disaster. Then you can plan for those things you believe are beyond your control, such as weather or theft [38].

In the post-implementation stage, when a critical mass of users is fully using the system, bringing to it all their in genuity and creativity, when post-implementation aftershock strikes and bug reports start flooding the maintenance group. The bugs they report are rarely trivial and are difficult to track down. Many of these bugs result from users **doing tricky things** with the system in hopes of "faking it out". The records generated by these tricks cause problems of which the administrators are not aware in the subsystem. It takes **major detective work** to determine the source of these illegal records [37].

But this **slew of system** requests is **not a sign of bad design**; rather, it is a sign of the system's success. It shows that users have **accepted** the system and are putting it to use. It also demonstrates that the experienced users are confident enough to go beyond a cookbook approach to using the system and are becoming **creative** and innovative partners in the system's design [37]. Now, having digested the system that, these sophisticated users want to **push the system's limits further**.

It is essential to retain the services of the people who implemented the system, since it is at this stage that **users request** the **most useful** and, to them, necessary enhancements to the system.

The best way to track **aftershock** is to design a function into the new ERP system that monitors **system usage** in terms of transactions or function used and frequency of use, breaking that usage down by individuals. This information is usually available in the system already but is not presented in an accessible report format. This function should generate reports that go to ERP project management on a

weekly basis during the first months of the system's life, and it is a good idea to have a version of this information sent to user group management. These reports will give information that is helpful in several respects [37].

An **audit** can be performed for various reasons based upon the organization's needs. It might be a post-implementation **audit** or an ongoing audit performed to monitor system integrity or test controls based upon management's control objectives.

Some example issues to be checked in the audit process: Authorization Concept, Review the list of inactive users (An auditor can review user access logs and ensure that the user list contains only active users), Review the security of custom codes and tables (Check for users who have program execution access)

How often you measure will depend on the size of your organization and the depth of your software change [38]. Typically, an **audit** should occur halfway through the implementation, again at three-quarters of the way through the implementation, and when it's complete. Then, you should follow up at 3-, 6-, and 12-month intervals.

Due to the complexity and extremely technical aspect of the system, ERP reviews require a **person** who understands this environment and is trained to perform such reviews.

Conclusions

The implementation concerns of ERP do not end once the system becomes operational. As indicated by Davenport [39], 'an enterprise system is not a project; it's a way of life'. He argues against the traditional assumption of treating ERP as a project that has a termination date. Users need **on-going support and organizations** face a variety of issues such as fixing problems, upgrading to new versions of the software, and managing organizational performance with the system to achieve desired benefits [40]. Since ERP is continually evolving and is a fairly new phenomenon, little research has been done to study maintenance of these systems [29].

While many companies spend significant amounts of time and money researching, analyzing, and justifying an enterprise resource planning (ERP) purchase, they give only a token look (if any) at how well the application actually performs once it's installed. And that's a big mistake [38].

Realization of ERP system benefits is reported to significantly **lag expectations** [41], [42], [43]. As a result, the issue of successful implementations, as evaluated during the post-implementation process and the potential effects on the realization of potential system outcomes, provide a solid motivation for the present study.

Most of the companies focus on choosing the right product. To but if companies don't establish specific **performance metrics**, it will be very hard to gauge how well that product is working to meet their objectives, let alone correct any **performance gaps**.

All management and resources focus on going live. Most of the companies don't engage in a thorough, **after**-the-fact **audit**. Because there is not a roadmap, and no one agrees on what precisely constitutes a successful ERP program. Also it may be dangerous if the project fails for the responsible senior management.

In this study, we proposed a **roadmap** by a framework and related indicators. Identified metrics and activities can help companies.

Approaches that are related to the productive phase of the ERP system focus mainly on the financial effects in terms of costs. We also presented a set of interrelated **measures** that give a more complete insight into the **performance** of the ERP system **beyond financial key** performance indicators.

Limitations

We indicated these factors from literature and author's consulting experience. Although limited to few industries and companies, we believe these cases capture general information that would be expected to be found in many organizations. With better track of the indicators, ERP system management can be accomplished more successfully.

For Further Studies

For further studies, **number** of the indicators listed in tables may be increased. Developing a consensus on post-implementation and ERP usage metrics will help companies to analyze and benchmark using general accepted metrics. So, this study may help for generalization and standardization of the metrics, for measuring the ERP systems usage and maintenance.

Companies should calculate the values of these metrics in different periods and make evaluation. Results must be interpreted carefully to achieve useful results. Based on these results, it becomes possible to see some critical points and points to be improved. Also accepted metrics, can be measured using ERP logs and simple queries.

References

[1] Scott, J.E., and L. Kaindl. "Enhancing Functionality in an Enterprise Software Package." *Information and Management* , 2000: 37, 111-122.

[2] Clark Jr., Thomas D., Mary C. Jones, and Robert W. Zmud. "Post Adoptive ERP Use Behaviors: A Dynamic Conceptualization." *July 26-30, Proceedings of the 27th International Conference of the System Dynamics Society*. Albuquerque, New Mexico, USA, 2009.

[3] Sarkis, J., and R.P. Sundarraj. "A Decision Model for Strategic Evaluation of Enterprise Information Technologies." *Information Systems Management*, 2001: 18(3), 62-72.

[4] Sarkis, J., and R.P. Sundarraj. "A Decision Model for Strategic Evaluation of Enterprise Information Technologies." *Information Systems Management*, 2001: 18(3), 62-72.

[5] Hunton, J.E., B. Lippincott, and J.L. Reck. "Enterprise Resource Planning Systems: Comparing Firm Performance of Adopters and Nonadopters." *International Journal of Accounting Information Systems*, 2003: 4, 165-184.

[6] Jones., M.C., M. Cline, and S. Ryan. "Exploring Knowledge Sharing in ERP Implementation: An Organizational Culture Framework." *Decision Support Systems*, 2006: 41(2), 411-434.

[7] Ke, W., and K.K. Wei. "Organizational Culture and Leadership in ERP Implementation." *Decision Support Systems*, 2008: 45, 208-218.

[8] Zviran, M., N. Pliskin, and R. Levin. "Measuring User Satisfaction and Perceived Usefulness in the ERP Context." *Journal of Computer Systems*, 2005: Spring, 43-52.

[9] Davenport, T.H. "Putting the enterprise into the enterprise system." *Harvard Business Review*, 1998: 76 (July/August), 121-131.

[10] Kumar, K., and J. Van Hillegersberg. "ERP: Experiences and evolution." *Communications of the ACM*, 2000: 43 (April), 23-26.

[11] Nicolaou, Andreas I., and Bajor. "ERP Systems Implementation And Firm Performance." *The Review Of Business Information Systems*, 2004: 8(1), 53-60.

[12] Moon, Young B. "Enterprise Resource Planning (ERP): a review of the literature ." *Int. J. Management and Enterprise Development*, 2007: 4(3),235-264.

[13] Hitt, L. M., D.J. Wu, and X. Zhou. " Investment in Enterprise Resource Planning: Business Impact and Productivity Measures. ." *Journal of Management Information Systems,*, 2002: 19(1): 71-98.

[14] Poston, R., and S. Grabski. "Financial Impacts of Enterprise Resource Planning Implementations." *International Journal of Accounting Information Systems*, 2001: 2: 271-294.

[15] Jones, M.C., and R.L. Price. "Organizational knowledge sharing in ERP implementation: Lessons for industry." *Journal of End User Computing*, 2004: 16(1), 21-40.

[16] Markus, L.M., and C. Tanis. "The Enterprise Systems Experience - From Adoption to Success." In *Framing the Domains of IT Research: Glimpsing the Future Through the Past,* , by R.W. Zmud, 173-207. Cincinnati,

OH,: Pinnaflex Educational Resources, Inc., 2000.

[17] Nicolaou., Andreas I. "Quality of Post implementation Review for Enterprise Resource Planning Systems." *International Journal of Accounting Information Systems*, 2004: 5: 25-49.

[18] Ross, J. "Surprising Facts about Implementing ERP." *IT Pro*, 1999: July/August: 65-68.

[19] Robey, D., J. W. Ross, and M. Boudreau. "Learning to Implement Enterprise Systems: An Exploratory Study of the Dialectics of Change ." *Journal of Management Information Systems*, 2002: 19(1), 17-46.

[20] Hustad, Eli, and Aurilla A. Bechina. "A study of the ERP Project Life Cycles in Small-and-Medium–Sized Enterprises: Critical Issues and Lessons Learned ." *World Academy of Science, Engineering and Technology 60*. 2011. 110-116.

[21] Esteves, J.M., and J.A. Pastor. "An ERP Life-cycle-based Research Agenda." *Enterprise Management and Resource Planning: Methods, Tools and Architectures - EMRPS-99; in First International workshop* . Venice, Italy, 1999. 359-371.

[22] Aloini, D.,, R. Dulmin, and V. Mininno. "Risk management in ERP project introduction: Review of the literature." *Information and Management*, 2007: 44(6), 547-567.

[23] Esteves., J., and J. Pastor. "Towards the unification of critical success factors for ERP Implementations." *10th Annual BIT conference,*. Manchester, UK, November (2000), 2000. 1-9.

[24] Gelinas., U., and S. Sutton. *Accounting information systems*. Boston (MA): South Western, 2002.

[25] Nazemi, Eslam, Mohammad Jafar Tarokh, and & G. Reza Djavanshir. "ERP: a literature survey." *Int J Adv Manuf Technol*, 2012.

[26] Yin, R.K. *Case Study Research: Design and Methods*. Thousand Oaks: Sage, 1994.

[27] Chan, Xin, and Lau Yui-yip. "Evaluation Of Erp Implementation On Firm Performance: A Case Study Of A&T."

[28] Rajagopal, Palaniswamy, and Frank Tyler. "Enhancing Manufacturing Performance with Erp Systems." *Information Systems Management*, 2000: 17:3, 1-13.

[29] Nah, Fiona Fui-Hoon, Silvana Faja, and Teuta Cata. "Characteristics of ERP software maintenance: a multiple case study ." *Journal Of Software Maintenance And Evolution: Research And Practice*, 2001: (13) 399–414.

[30] Rosemann, Michael, and Jens Wiese. "Measuring the Performance of ERP Software – a Balanced Scorecard Approach." *10th Australasian Conference on Information Systems*. 1999. 773-784.

[31] Chen, Zhuang, and Taige Wang. "An IT governance framework of ERP system implementation for Chinese enterprises." *7th World Congress on Intelligent Control and Automation*. 25-27 June, WCICA 2008, 2008. 4929-4932.

[32] Ruivo, P., T. Oliveira, and M., Neto. "ERP post-adoption: Value impact on firm performance: A survey study on Portuguese SMEs." *Information Systems and Technologies (CISTI), 7th Iberian Conference*. 20-23 June, 2012 . 1-6.

[33] Tsai, W.-H., T.-S. Tsaur, Y.-W. Chou, J.-Y. Liu, and J.-L. Hsu. "Evaluating the information systems success of ERP implementation in Taiwan's industries." *IEEE International Conference on Industrial Engineering and Engineering Management*. 8-11 Dec, IEEM2009, 2009. 1815-1819.

[34] Parthasarathy, S, and N Anbazhagan. "Significance of Software Metrics in ERP Projects." *India Conference,* . Sept.,2006 Annual IEEE, 2006. 1-4.

[35] Wei, Chun-Chin. "Evaluating the performance of an ERP system based on the knowledge of ERP implementation objectives." *International Journal of Advanced Manufacturing Technology*, 2008: 39, 168-181.

[36] Botta-Genoulaz, Vale´rie, and Pierre-Alain Millet. "A classification for better use of ERP systems." *Computers in Industry* , 2005: 56, 573–587.

[37] Musaji, Yusuf. "ERP Postimplementation Problems ." *Information Systems Control Journal*, 2005: 4, 1-9.

[38] Saunders, Trish. *Measuring the Value of Your ERP System*. December 1, 2004.

[39] Davenport., T.H. *Living with ERP*. December 1, 1998. http://www.cio.com.au/article/108202/managing_-_living_erp/.

[40] Eriksen, L.B., S. Axline, and M.L. Markus. "What happens after 'going live' with ERP systems? Competence Centers can support effective institutionalization." *Proceedings of the Fifth Americas Conference on Information Systems. Association for Information Systems: Atl*. Atlanta GA, 1999. 776–778.

[41] Benchmarking_Partners. *ERP's Second Wave: Maximizing the Value of ERP-Enabled Processes*. Cambridge, MA, 1998.

[42] META_Group. *Enterprise Resource Management (ERM) Solutions and Their Value*. . Stamford, CT., 1999.

[43] Peterson, W.J., L. Gelman, and D.P. Cooke. *ERP Trends*. New York, NY: The Conference Board; Report 1292-01-RR, 2001.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

R&D Project Selection by Integrated Grey Analytic Network Process and Grey Relational Analysis: An Implementation for Home Appliances Company

Umut R. Tuzkaya[1], Ezgi Yolver[2]

Abstract

For many firms, the key to improve competitiveness is their ability of research and development (R&D); therefore the R&D project selection is an essential decision process for them. In this study, we worked on R&D Project Selection issue and performed an implementation for a home appliances company. We first discussed important criteria for R&D projects selection with R&D specialists in the company. In order to evaluate projects, many criteria, containing various sub-criteria were determined via extensive literature research. After reviewing multi criteria decision methods in order to handle the interdependencies among the criteria and the sub-criteria, Analytic Network Process (ANP) was chosen. Due to being conformed to characteristics of R&D projects, the ANP model generated basing on grey numbers. Also, ANP was used to get the weight of criteria. The experts filled the pairwise comparison matrices, which were built up for defining the importance and influences of the criteria/sub-criteria in the ANP model. According to these matrices, weights were determined. Then, determined alternative projects were ranked via Grey Relational Analysis (GRA) method. The model was applied on a real life refrigerator projects in a home appliances company.

Keywords: R&D Project Selection, Grey Analytic Network Process, Grey Relational Analysis

Introduction

R&D project management is one of the most difficult areas in projects management. In today's world, precondition of surviving of a company in highly competitive environment is conducting Research and Development (R&D) projects. Developed countries generally encourage the R&D activities of private sector and government to improve the overall competitive power of the country.

Companies that want to maintain their existence in competitive environment must continually change and develop their products, services and production processes. This is only possible through R&D activities and innovation. R&D activities generally involve scientific and technological uncertainties. Innovations are also unpredictable, and thus involve large uncertainties. Corporate R&D management, supporting the maximal use of new innovations and technologies, always tries to keep the company up with the pace of technological development. R&D projects are tools for the company's management to outpace competitors and obtain new information about promising technologies and methods. With such new information, companies aim to defend and build sustainable competitive advantages [1].

R&D Project Selection

Around the world advanced high-tech companies are investing R&D projects. R&D projects must be compatible with the company's vision and mission. Such projects should provide benefits for stakeholders, link with the company's expertise and have clear objectives in place along with built-in appropriate evaluation resources and have prospects of sustaining itself. The most challenging tasks are to choose the right projects in order to survive in the competitive environment. The projects that will lead to success should have a positive cost/benefit, provide the organization to improve the chance of success, have futuristic scope and strategic fit on stakeholder involvement [2].

[1] Assoc. Prof. Dr. Umut R. TUZKAYA, Yıldız Technical University, Mechanical Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, tuzkaya@yildiz.edu.tr

[2] Ezgi YOLVER, Yıldız Technical University, Mechanical Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, eyolver@gmail.com

The selection of R&D project is a complex decision-making problem encountered by most industrial firms. R&D project selection requires consideration of uncertain and/or subjective multiple criteria. The selecting and determining relative importance of criteria will differ according to the goals and objectives of the sponsoring organization and the nature of the R&D activity itself [3].

A wide range of criteria and sub-criteria such as strategic fit, capacity, technical success, funding, risks, considerations, opportunity costs, manpower, etc., are used for decision process [2]. Obviously, wrong decisions in project selection have two negative consequences: (1) resources are spent on unsuitable projects and, (2) the organization loses the benefits it could have gained if these resources had been spent on more suitable projects [4]-[5]. Therefore, most companies apply the scientific selection methods that are generally multi criteria decision methods for R&D projects.

An extensive literature review is carried out on the subject of R&D Project selection and evaluation criteria. R&D project selection criteria available in the literature are categorized into five factors; technical, marketing, financial, environmental and organizational factors. In this study, 12 sub-criteria, which are evaluated by the decision committee, are classified into these five factors. The sub-criteria that are grouped are shown in Figure 1.

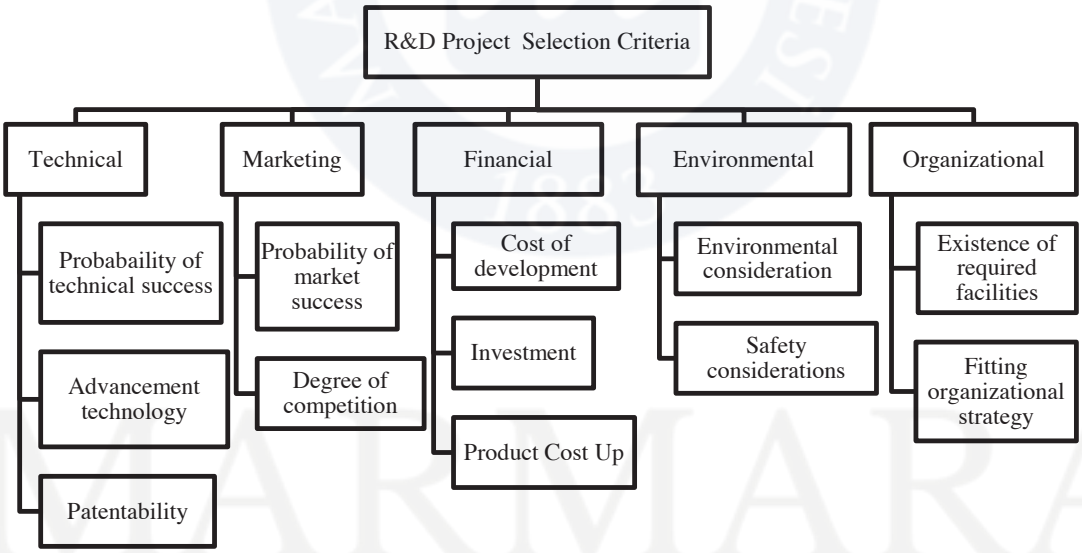


Figure 1. Project Selection Criteria

Multi Criteria Decision Making Methods

In this study, multi criteria decision-making methods are used on selecting of R&D projects. These methods can provide solutions to increasing complex management problems. Here, the background information about the used multi-criteria decision methods is provided. Firstly, Grey System approach is explained. Then, Grey Analytic Network Process (GANP) method and finally Grey Relational Analysis (GRA) method are described.

Grey System Theory

Grey theory, which was proposed by Chinese scholar Professor Deng Julong [6], is one of the new mathematical theories born out of the concept of the grey set. It is an effective method used to solve uncertainty problems with discrete data and incomplete information [7]. The concept of the Grey System, in its theory and successful application, is now well known in China [8]. The major advantage of grey

theory is that it can handle both incomplete information and unclear problems very precisely. It serves as an analysis tool especially in cases where there is insufficient data [9].

Grey Analytic Network Process (GANP)

GANP method is applied for weighting of criteria using ANP and grey system theory based on Saaty's ANP model. The ANP is coupling of two parts. The first consists of a control hierarchy or network of criteria and sub-criteria that control the interactions. The second is a network of influences among the elements and clusters. The network varies from criterion to criterion and a different super matrix of limiting influence is computed for each control criterion. Finally, each of these super matrices is weighted by the priority of its control criterion and the results are synthesized through addition for all the control criteria [10].

Pairwise Comparison and Local Weights Estimation: The ANP is based on deriving ratio scale measurements founded on pairwise comparisons to derive ratio scale priorities for the distribution of influence among the elements and clusters of the network [11]. In the study, grey numbers were applied. The parameters $\underline{G_1}$ and $\overline{G_1}$, denote the smallest possible value and the largest possible value that describe a fuzzy event. Grey number scale that used in this study is given in Table 1.

Table 1. Linguistic Scales For Difficulty And Importance [12]

Linguistic Scale For Importance	Grey Number Scale	Grey Number Reciprocal Scale
Just equal (E)	(1, 1)	(1, 1)
Equally important (EI)	(1/2, 3/2)	(2/3, 2)
Weakly more important (WMI)	(1, 2)	(1/2 ,1)
Strongly more important (SMI)	(3/2, 5/2)	(2/5, 2/3)
Very strongly more important (VSMI)	(2, 3)	(1/3, 1/2)
Absolutely more important (AMI)	(5/2, 7/2)	(2/7, 2/5)

Pairwise comparison matrices are formed by the decision committee by using the grey number scale.

Super Matrix Formation and Analysis: According to the ANP approach, we need to define interdependencies among factors and clusters. This is also possible with super matrix formation. The relative weights are aggregated into a super matrix based upon influence from one cluster to another, or from one factor to another within a cluster itself. The super matrix formation incorporates four elements: (1) relationships to the final objective; (2) comparisons among factors and clusters; (3) comparisons of alternative relationships with respect to the factors; and (4) an identity matrix for all alternatives (unless the alternatives influence each other) [13].

Calculate The Global Weight: Finally, to yield the cumulative influence of each element on every other element with which it interacts, the super matrix is raised to limiting Powers [14]. Before taking the limit of the matrix, it must first be reduced to a column stochastic matrix (i.e. weighted super matrix), each of whose column sums to unity. Then via normalization, the normalized weight vectors can be found in the relevant rows of the normalized limit super matrix. In this way, global weights for all elements will be achieved.

Grey Relational Analysis

GRA method is applied for ranking of alternative projects. GRA is a new analysis method, which has been proposed in the Grey system theory and it is founded by Professor Deng Julong from Huazhong University of Science and Technology, People's Republic of China [15].

GRA is used to determine the relationship between two series of data in a grey system. Its structure has uncertainty, therefore it handles the problems consisted of discrete data and partial information [16]. It operates the grey relational grade to determine the relational degree of factors. Grey relation analysis is also an effective means of analyzing the relationship between sequences with less data and can analyze

many factors that can overcome the disadvantages of statistical method [17]. GRA is based on geometrical mathematics, which compliance with the principles of normality, symmetry, entirety, and proximity. GRA is suitable for solving complicated interrelationships between multiple factors and variables. There are 3 main steps in GRA [15]. The first step is data pre-processing, the second step is locating the grey relational coefficient and the final step is calculating of grey relational grade.

Implementation

We have performed an implementation about R&D project selection issue for an R&D system development department in a home appliances company. Various projects on refrigerator production processes are considered for ranking. Some of these projects have already been actualized and some of them have not been actualized. Objective of this study is to rank the projects according to priority and to see whether the right projects have been actualized or not.

Firstly, we have analyzed the R&D project selection criteria that are used in literature with two R&D specialists and then we determined the convenient ones. Secondly, the ANP model formed by the criteria and sub-criteria determined in the first step. Criteria have been evaluated by two decision makers via linguistic variables that can be expressed in grey number. Then, a degree of grey possibility is proposed to calculate the weights. Thirdly, alternative projects have been evaluated by decision makers in the same way with GANP method's weighting. Finally the GRA model formed and alternative projects have been ranked. A detailed implementation steps are given below.

Data Gathering and Using the GANP Technique

Firstly, main factors are evaluated by using pairwise comparison matrices (assumed that there is no dependence among the factors). The decision committee has formed pairwise comparison matrices by using the scale given in Table 1. Linguistic scale is placed in the relevant cell against the grey number while evaluating. Then this scale will be transformed into whitened value by the whitening membership function and local weights are calculated using GANP method formulation.

Pairwise comparison matrix for the main factors is filled and the local weights for the main factors are calculated as shown in Table 2.

Table 2. Local Weights And Pairwise Comparison Matrix Of Main Factors

MAIN FACTORS	Technical	Marketing	Financial	Environmental	Organizational	**Local Weight**
Technical	(1, 1)	(2/5, 2/3)	(1/3, 1/2)	(3/2, 5/2)	(2/3, 2)	0,16
Marketing	(3/2, 5/2)	(1, 1)	(2/5, 2/3)	(2, 3)	(3/2, 5/2)	0,24
Financial	(2, 3)	(3/2, 5/2)	(1, 1)	(5/2, 7/2)	(2, 3)	0,35
Environmental	(2/5, 2/3)	(2/5, 2/3)	(1/3, 1/2)	(1, 1)	(2/5, 2/3)	0,10
Organizational	(1/2, 3/2)	(2/5, 2/3)	(1/3, 1/2)	(3/2, 5/2)	(1, 1)	0,15

Sub-factors are also evaluated and weighted in the same way with main factors. Pairwise comparison matrix for sub-factors of technical factors is filled and the local weights for their sub-factors are calculated in Table 3. Sub-factors of other main factors are also evaluated and weighted in the same way.

Table 3. Local Weights And Pairwise Comparison Matrix Of Sub-factors of Technical Factor

TECHNICAL FACTORS	Probability of technical success	Advancement technology	Patentability	**Local Weights**
Probability of technical success	(1, 1)	(2, 3)	(3/2, 5/2)	0,511
Advancement technology	(1/3, 1/2)	(1, 1)	(2/5, 2/3)	0,182
Patentability	(2/5, 2/3)	(3/2, 5/2)	(1, 1)	0,307

Afterwards, interdependent weights of the main factors are calculated and the dependencies among the

main factors are considered. Dependence among the factors is determined by analyzing the impact of each factor on every other factor using pairwise comparisons. Same linguistic variable scale is used again. All the grey evaluation matrices are produced in the same manner. Then this scale will be transformed into whitened value by the whitening membership function and local weights are calculated using GANP method formulation.

After pairwise comparisons for technical factors are completed, the resulting relative importance weights are presented in Table 4.

Table 4. The Inner Dependence Matrix of The Factors with Respect to ‘‘Technical Factors”

TECHNICAL FACTORS	Marketing	Financial	Environmental	Organizational	**Relative importance weight**
Marketing	(1, 1)	(2/3, 2)	(1, 2)	(3/2, 5/2)	0,32
Financial	(1/2, 3/2)	(1, 1)	(1, 2)	(3/2, 5/2)	0,30
Environmental	(1/2, 1)	(1/2, 1)	(1, 1)	(1, 2)	0,22
Organizational	(2/5, 2/3)	(2/5, 2/3)	(1/2, 1)	(1, 1)	0,16

Same operations are generated for the sub-factors of each main factor and inner dependence relative importance weights are obtained. Finally, to compute the interdependent weights of the factors, these inner dependence matrices are multiplied with the local weights of the factors. The result of the GANP, Table 5 is obtained.

Table 5. Computed Weights

Main Criteria (Factors)	Factors Local Weights	Sub-Criteria (Sub-Factors)	Local Weights
Technical Factors	0,19	Probability of technical success	0,511
		Advancement technology	0,182
		Patentability	0,307
Marketing Factors	0,20	Probability of market success	0,414
		Degree of competition	0,586
Financial factors	0,28	Cost of development	0,203
		Investment	0,353
		Product Cost Up	0,444
Environmental Factors	0,17	Environmental considerations	0,253
		Safety considerations	0,747
Organizational Factors	0,16	Existence of required facilities	0,290
		Fitting organizational strategy	0,710

Application of The GRA Technique

The weighting of project selection criteria are obtained by GANP. Then, according to criteria, alternative projects are evaluated by two decision makers as using the grey number scale. Linguistic values are transformed into grey numbers and these grey numbers are transformed into whitened value by the whitening membership function. The data that are formed by whitened value are studied for the purpose of applying GRA steps.

Then referential series are determined according to original data series. After that, in GRA objective model, data are normalized in the range between zero and one based on referential series. Subsequently, absolute data table is obtained and the grey relational coefficient is calculated from the normalized data to express the relationship between the referential series and original data series. At the end, the aggregated

grey relational grade vector is obtained by multiplying the resulting grey relational coefficient matrix by the weights of criteria that are shown in Table 5.

Table 6. Grey Relational Grades For Alternatives

Alternatives	AVERAGE	RANK
Project A	0,728	1
Project B	0,572	4
Project C	0,711	2
Project D	0,579	3

As illustrated in Table 6, the four alternative projects, that is Project A, Project B, Project C and Project D are ranked 1, 4, 2 and 3 respectively. When the results are compared with the common previous opinions, high-ranked alternatives are overlapped with the most expected project alternatives. However, previously unconsidered criteria decreased the importance level of two projects. Considering the results of this study, the company has chosen two projects to actualize instead of three projects.

Conclusions

The R&D project selection is a difficult multi-criteria decision making process to handle. The most crucial features of this process are complexity and especially uncertainty. As a novel approach for solution, GANP and GRA based on grey number, have been utilized to determine the best project to actualize. These methods have been used together at first time for R&D project selection issue. The proposed model constituted from two parts. The first part applies ANP based on grey number to determine the weights of the criteria. And the second part applies GRA to rank the alternative projects.

The refrigerator projects are convenient to demonstrate the effectiveness of the proposed methodology for selecting the best project. The method provides an objective and effective decision model for selecting the most appropriate project to develop. The analytical results of this approach show that it can help to deal with complex decision making processes and provide acceptable and reasonable results for administrators and decision makers. Furthermore, this approach may be used for other group of projects that considered in department of R&D system development in the home appliances company.

References

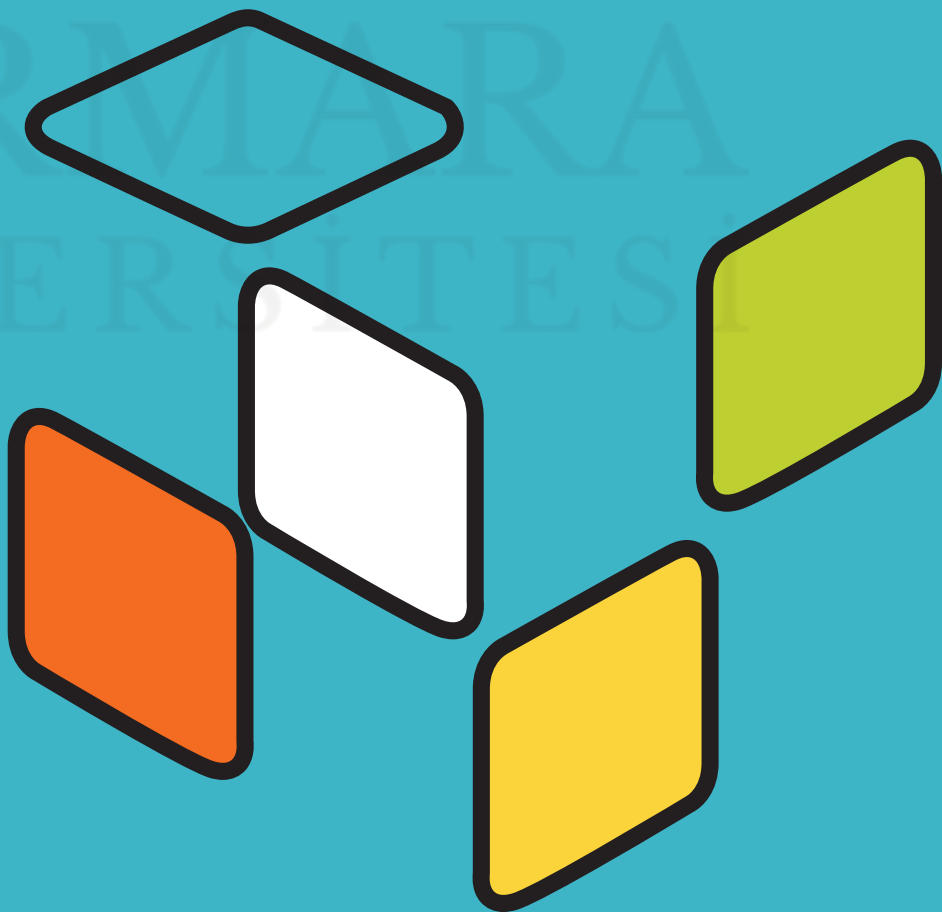
[1] Porter, M.E., 1985, "Competitive Strategy: Techniques for Analyzing Industries and Competitors", *The Free Press*.
[2] Mohanty, R. P., Agarwal, R., Choudhury A. K. And Tiwari, M. K., 2005, "A fuzzy ANP-based approach to R&D project selection: a case study" ,*International Journal of Production Research*, Vol. 43, No. 24, 5199–5216.
[3] Liberatore, M. J., 1988, "An Expert Support System For R&D Project Selectıon" , *Malhl Comput. Modelling*, Vol. I I, pp. 260-265, Great Britain.
[4] Martino J. P., 1995, "Research and development project selection", *Wiley Series in Engineering & Technology Management*, New York.
[5] Shakhsi-Niaei, M., Torabi, S. A. and Iranmanesh, S. H., 2011, "A comprehensive framework for project selection problem under uncertainty and real-world constraints", *Computers & Industrial Engineering*, Vol. 61, pp. 226–237.
[6] Duan, X., Huang, M., Yang, X., Wan, B. 2013, "A Method of Partner Selection for Supply Chain Based on Grey-ANP in Cloud Computing", *2013 10th Web Information System and Application Conference*.
[7] Li, G.D., Yamaguchi, D., Nagai, M. 2007, "A grey-based decision-making approach to the supplier selection problem", *Mathematical and Computer Modeling* 46, 573–581, Japan.
[8] Julong, D., 1989 "Introduction to Grey System Theory", *The Journal of Grey System* 1,1-24.
[9] Wen K. 2004, "The grey system analysis and its application in gas breakdown and var compensator finding(invited paper)", *Int. Journal of computational Cognition 2(1),* 21-44.
[10] Saaty, T.L., 1999 "Fundamentals of the Analytic Network Process", *ISAHP 1999*, August 12-14, Kobe, Japan.
[11] Carlucci, D. and Schiuma, G., 2010, "Determining key performance indicators – an analytical network approach", *Gunasekaran A. and Sandhu M. (Editors), Handbook on Business Information Systems*, World Scientific Publishing, ISBN 978-981-283-605-2, Chapter 21, pp. 515-536.

[12] Zhang, W., Zhang, X., Fu, X., Liu, Y., 2009, "A Grey Analytic Network Process (ANP) Model to Identify Storm Tide Risk", *Proceedings of 2009 IEEE International Conference on Grey Systems and Intelligent Services*, November 10-12, 2009, Nanjing, China.
[13] Dou, Y., Zhu, Q, Sarkis, J., 2014"Evaluating green supplier development programs with a grey-analytical network process-based methodology",*European Journal of Operational Research* 233, 420–431.
[14] Saaty, T. L., & Vargas, L. G. 1998. "Diagnosis with dependent symptoms: Bayes theorem and the analytic hierarchy process." *Operations Research*, 46(4), 491–502.
[15] Sallehuddin, R., Shamsuddin, S. M. H., Hashim, S. Z. M., 2008, "Grey Relational Analysis And Its Application On Multivariate Time Series", *Proceedings of IEEE International Conference on intelligent Systems Design and Applications*, vol:2.
[16] Deng, J. L., (1989) "Introduction to Grey System", *Journal of Grey System*, 1(1), 1-24.
[17] Sreenivasulu, R., SrinivasaR., Dr.Ch (2012), "Application Of Gray Relational Analysis For Surface Roughness And Roundness Error In Drilling Of Al 6061 Alloy", *International Journal of Lean Thinking* Vol. 3, Issue 2, December.

MARMARA ÜNİVERSİTESİ 1883

MARMARA ÜNİVERSİTESİ YAYINEVİ

FORECASTING TECHNIQUES



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

A Model for Predicting the Consumer Behavior Using Artificial Neural Networks (Case Study: Mobile Phone Subscribers)

Alireza Bafandeh Zendeh[1], Aida Meskarian[2], Davoud Norouzi[3]

Abstract

This study tries to develop a model to predict the consumer behavior using artificial neural networks in broadcasting industry. To do so, it should be identified all the variables that can determine the consumer behavior which were based on review of literature. Artificial neural network was used to estimate consumer behavior according to independent variables. Research's Statistical population is all mobile subscribers in Urmia (a city in northwest of Iran), in which 384 mobile subscribers have chosen to survey by sampling method. For modeling and analysis of multi-layer neural network with hyperbolic tangent function of education, training has been used by the Forward algorithm that results show the importance of independent variables in predicting the dependent variable (SIM card mobile phone) to arrange the variables of price, product, rank first and third in importance and the promotion of social class ranked fifth in importance. Gender, education and marital status have the least impact on selecting the type of SIM card. The overall extension of the model obtained, 65.7 percent of the SIM card used in the test samples correctly predicted.

Keywords: Artificial Neural Networks, Consumer Behavior, Mobile Phone Subscriber

Introduction

The rapid technological development in the field of telecommunication networks in recent years provided a wide range of services to private and institutional subscribers. In this context "macro-development planners" ,"telecommunications service providers" and "Equipment Manufacturers" are interested to know about scientific estimates of the demand and supply of equipment investment needed(K.T.Duffy & Deno,2001). There are many factors affecting the demand for mobile phones is one of the factors in improving the quality of mobile service is a mobile communications company. Another network modernization and upgrade it through the door to the next generation mobile technologies such as GPRS (General Packet Radio Service), EDGE (Exchanged Data rates for GSM (Global System for Mobile communications) Evolution), and 3G (Third Generation of mobile telecommunications technology). Also NGN (Next Generation Networks) and IN(Intelligent Network) issues can affect the amount of mobile applications. These factors all have the same features, and it is positive feedback. In other words, all of these factors are demand resonators and considered as "entrepreneurs". But there are other factors that impact, the negative feedback, it means, when they will escalate, decreases the demand for mobile and sales and services. However, these negative factors, and other factors should not stay away from experts that predict the demand for mobile.

[1] - Alireza Bafandeh Zendeh, Department of Management, Tabriz branch, **Islamic Azad University**, Tabriz, Iran
Bafandeh@iaut.ac.ir

[2] - Aida Meskarian, Department of Industrial Engineering, **Alghadir Institute**, Tabriz, Iran,
ali_baf2000@yahoo.com

[3] - Davoud Norouzi,, Young Researchers and Elite Club, Tabriz Branch, **Islamic Azad University,** Tabriz ،Iran
davood_tab@yahoo.com

Therefore, marketers should be aware of how marketing data and other data convert to buy reaction. Consumer behavior is influenced by personal characteristics and his decision-making process and followed this article is how mobile customers and users of its services decide to buy and how marketing affects their decision. Nowadays, with the development of predictive tools, formulas, by using the best models it is possible to predict consumer behavior in buying mobile phone. Recently, a technique known as "Artificial Neural Networks", along with the predicted structural models and time-series has been used. This model is in fact taken from Brain Learning Process, Using computational speed of computers, Learn relationships - though sophisticated –between variables and uses that for predicting future values. Neural networks have no common problem that is shown mostly in classical models such as reliability and non-reliability of time series and from this point, there is no need for preparation of time series of economic variables such as the classic models for solving problems of autocorrelation, and variances are clearly not linear. In contrast, the rates predicted by econometric methods toward neural networks have a stronger statistical justification, because it can be for each of the predictions made a confidence interval. Neural Networks actually learn how to predict the future. In general, the accuracy of the neural networks is superior to linear techniques. As a general principle that is expressed by Hornik, a well-trained neural network that is never be better than a linear classifier(Hornik,et al,1989). Although artificial neural networks have their own limitations, but they have special advantages, such as the ability to learn, flexibility, adaptability, and knowledge discovery (Goonatilake, 1995).

Theoretical Principles

Consumer behavior included all mental, emotional and physical activities that individuals use them when they buy, use and throw away products for their satisfaction (Wilkes, 2000, 118). Consumer behavior is influenced by personal characteristics and his decision making process. Lifestyle of people formed by the influence of two factors which include:
External factors include cultural factors (culture, subculture, social class), social factors (group, family, role and social status), personal factors (age and stage of life, occupation, social status, style or lifestyle personality and self-concept).The internal factors include psychological factors (perception, learning, memory, motivation, emotions, and attitudes and beliefs) (Hawkins et al, 2005). Including other factors that influence the consumer behavior is marketing mix in which the most common variables at formulation marketing mix are product, price, promotion and distribution. Products (goods and services) must be consistent with the expected benefits to the customer. Price should be commensurate with the ability of buyer. This product should be available to the customer so that he can buy easily and ultimately to promotional materials will also be alerted to potential consumers of such products. In fact the concept of marketing mix makes clear the direction of organization's performance by using a series of control variables in an environment where there are many uncontrollable factors (Bennett, 1997).

It is extremely difficult to predict consumer behavior. Marketers are always trying to predict the consumer behavior and provide activities and behaviors they are expected. Marketing researchers believe that behind every purchase is one important decision-making process that needs to be investigated. Steps that the buyer is going to decide what kind of products they buy is called buying decision process. In this area there are many models that this model of decision making show understandable buying behavior by consumer. The purpose of these models is to discipline and integrate components of a well-known extensive knowledge about consumer behavior, including stimulus - response model on which consumer behavior are formed on this basis that many stimulating and motivational factors with agents and marketing stimulus (means the marketing mix) enter to the consumer's black box and he shows a certain reactions from himself (kotler, 2003). In this model, in relation to marketing factors referred to marketing mix elements McCarthy's 4P model is used. But in this model in relation with non-marketing factors involved in consumer behavior is not mentioned what is the purpose of these and what is included yet. Other model in this context is comprehensive model of consumer behavior which is a mental model in which it is not included sufficient detail for predicting the behavior. According to this model, individuals form their theory of mind and life style based on effective factors like internal (mainly psychological and physical) and external (mainly social and sociological) (Hawkins et al, 2005). In the comprehensive model of

consumer behavior has been mentioned to all personal effective factors in the buying decision but has been not mentioned to the marketing factors that are the same as marketing mix as an effective factor on consumer behavior, so one of the weaknesses of this model is the lack of attention to this issue. Of the other models in relation to the consumer decision is the model of buying behavior by Howard and sheth (1969). In this model attempts to be explained how through learning, specific data in response to marketing stimuli are converted to stimulants such as buying or other behavioral responses. This is an edited version of the previous regular and systemic effort to build an attitude and a deep theory of the consumer decision making process. Howard believes the most important stimulus in determining consumer behavior is a set of information or awareness about the characteristics of goods or services (such as quality, price, having distinction, after sales service, availability). The data is transferred directly to the consumer by the product itself. The second group will include the same information that placed at the disposal of consumer through the Media (E.g. advertisements on TV). Third source of consumer information that is useful in his decision making process is information that transmitted by persons or groups that are associated with such as family, friends, social groups that he belongs or wish to belong and to which they are attached (Nabizadeh, 1996). This model also has some shortcomings but one of the most important criticisms of this theory believe that Howard knows the consumer as a reasonable being that before purchasing goods or services proceed to evaluate data within a conscious and rational process at their cognitive structures and their learning and then proceed to purchase goods. This model sees consumer as someone with the capacity to receive and applying plenty of information that have ability and comparability of different things, depending on the type, trademark, quality and other characteristics of the goods and can easily identify the data and able to select the fittest (Ibid). According to the model, we reach the conclusion that each model pointed to Part of the Factors influencing consumer behavior and they have some shortcomings. In order to compensate for these shortcomings, recent research seeks to answer a fundamental question that what important factors are influence the purchase of a SIM card. In this regard, the purpose of this study is examining and identifying effective and determinant factors on consumer behavior in determining the selected type of SIM card; obviously, the results of this research can help to the active operators in the field of mobile communication to do the necessary planning in the field of increasing their sales. In this regard, in proposed model has been tried to discuss all factors affecting the consumer behavior in four indexes of biographical features, demographic variables, psychological variables and organizational variables.

1. Biographical features: age of consumers itself has affect on the concept and lifestyle as we see it in community, young people tend to use MTN (type of SIM) while older people, prefer to use MCI (type of SIM). Men and women have unique personality traits, interests, knowledge, abilities, judgment, and social status. Therefore gender has effects in consumer behavior. Married couples and single people have different needs.
2. Demographic variables: Mobile phone use in high-income consumers, most of whom are low-income and then also social class that determined by using the individual information in relation to employment, education, income level, amount of assets, type of housing area of living, type of the vehicle and its model, has effect on using the SIM card so that people with moderate to high social class prefer to benefit from permanent MCI SIM card's services. Impact of groups in recommendations and benchmarking from friends, colleagues and family to choose the SIM card is effective, so that young and teen are highly influenced by groups in selecting the type of SIM card.
3. Psychological variables: Howsoever consumers should have more faith that specific product or service is more appropriate to satisfy him, he has more motivation to achieve it (Laroch, 2010). As a result, among the psychological variables, motivation including the need for security, the need for friendly relations, the need for acceptance, approval, and need to be modeled has been recognized effective in relation of selecting the SIM card.
4. Organizational variables: Including price that has direct impact on the buyer's decision whatever SIM card price is low demand for it increases. In relation to product whatever quality of the signal, communications and data services improved demand also increases. In relation to distribution whatever waiting time is reduced and SIM card sooner reach to the consumer will has a positive impact on purchase and about advertisement whatever operator's advertisement is more attractive in relation to their facilities and provide a useful information

about their facilities, they can attract more customers. Finally, the model has been derived as figure 1.

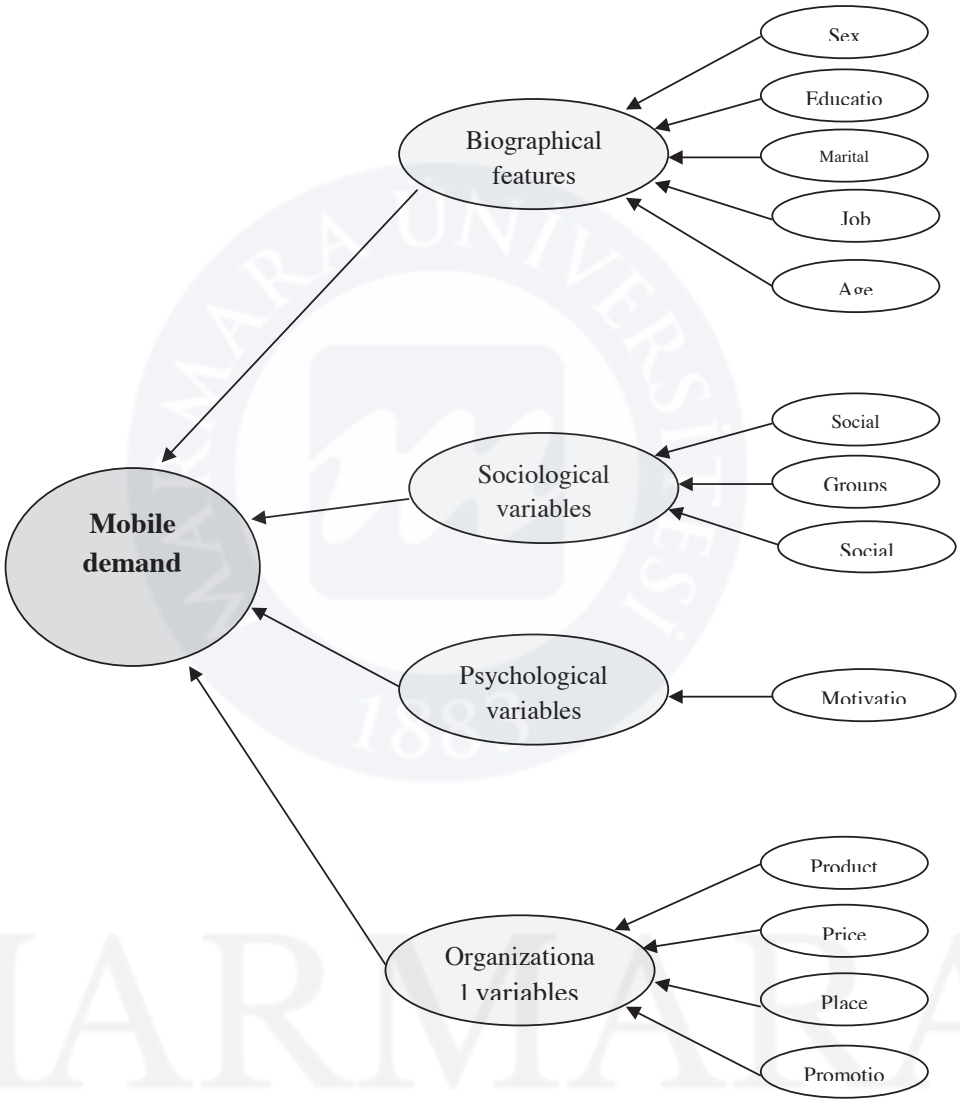


Figure 1. Research Model

MATERIALS AND METHODS

The research method used in this study from the view of objective is practical and due to study of cause and effect relationships it is a cause research. Statistical community of present research is all mobile phone subscribers are in Urmia. Sampling in this study is the available sampling. The size of sample considered unlimited, because the population is not clear. Since for determining the sample by using mentioned equation the variable trait variance is required, therefore with use an 30 semiconductor sample variance is calculated and the sample size has been determined.

To determine the sample the following formula is used: $n = (z^2 * \sigma^2) / ME^2$

Where:

Z = Z value (e.g. 1.96 for 95% confidence level)
σ = Population standard deviation
ME= Margin of Error (the margin of error expresses the maximum expected difference between the true population parameter and a sample estimate of that parameter)

In above formula by placing ε =0.08, σ = 0.8, $Z\alpha_{/2} = 1.96$ the sample size is obtained 384.

A questionnaire containing 46 questions was drafted that at the first three questions is determined the type of SIM card and the year of buying and proceed to Question 10 is determined the features of the person's biography who is responded to questions. Questions 11 to 29 are examined demographic and psychological variables and finally of questions 30 to 46 were evaluated the organizational variables. In order to obtaining validity of the questionnaire, in addition to obtaining opinion of experienced professors from universities in the field of management, marketing, research methods and statistics were consulted with manager of Mobile Communication province of Western Azarbyjan and five senior experts in the area of mobile communications and the validity of questionnaire also confirmed by them. Durability of questions is calculated by using Cronbach's alpha coefficient technique. In this study, Durability of Questions has been tested for each of the variables, according to Cronbach's alpha coefficient was calculated at 0.72, we conclude that the question have acceptable durability. According to scale of variables and their distribution, ANN toolbox is used to predict the consumer behavior on selecting the type of SIM card for mobile phon. Neural Networks are lacking common problems of classical modeling such as reliability and non reliability of time series. In this sense, it doesn't require preparation for time series of economic variables like the classic modeling for resolving the problems of autocorrelation, linear and variances. Neural Networks are superior to the linear techniques in terms of accuracy and are able to learn complex relationships between variables and used that for predicting future values. For predicting we have used multi-layer perception method, for this purpose initially we were divided the data into two groups of "training sample" and " testing sample " and were placed 70% of people the training samples (270 cases) and 30% of people in the tested samples (105 cases). Data recorded included the training of the neural network are used in education. Testing sample is an independent set of stored data that are used to find the error which occurred during the education and this will prevent the training too much. In this network, we have used a hidden layer of hyperbolic tangent activation function. Due to the small sample the type of training which is selected is batch.

RESULTS

In the output of the neural network weight of each independent variable is specified in predicting dependent variable that network data in the Table 1 and summarizes of the results from analysis of neural network models are shown in the Table 2.

Table 1. Network Information

Input Layer	Factors	1	sex
		2	Education
		3	Marital status
		4	job
		5	Place
	Covariates	1	age
		2	Social Base
		3	Social class
		4	Group
		5	motivation
		6	Product(service)
		7	price
		8	promotion
	Number of Unitsa		31
	Rescaling Method for Covariates		Standardized
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1a		4
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	Simkart
	Number of Units		3
	Activation Function		Softmax
	Error Function		Cross-entropy

Excluding the bias unit

Table 2. Model Summary

Training	Cross Entropy Error	202.965
	Percent Incorrect Predictions	31.5%
	Stopping Rule Used	1 consecutive step(s) with no decrease in error[a]
	Training Time	00:00:00.078
Testing	Cross Entropy Error	84.161
	Percent Incorrect Predictions	34.3%

Dependent Variable: Simkart
a. Error computations are based on the testing sample.

Also, table 3 shows the importance of each one of the independent variables for predicting the dependent variable.

Table 3: Independent Variable Importance

Independent Variable	Importance	Normalized Importance
Sex	.019	9.3%
Education	.046	22.6%
Marital Status	.047	23.1%
job	.058	28.7%
Place	.094	46.8%
Age	.056	27.9%
Social Base	.076	37.8%
Social Class	.092	45.5%
Groups	.060	29.5%
Motivation	.053	26.3%
Product	.119	58.9%
Price	.202	100.0%
Promotion	.079	39.1%

According to the weight given to the independent variables, resulting model from neural network analysis is capable in the training samples to correctly estimated 85.5% demand for permanent SIM1, 51.8% demand for credit SIM2 card and 57.4% demand for SIM3. In general, the training samples correctly predicted 68.5%.In testing sample is correctly estimated that 83.6% demand for permanent SIM1 card, 33.3% demand for credit SIM 2card and 65.7% demand for SIM3 card. The results are shown in Table 4.

Table4. Classification

Sample	Observed	Predicted			
		SIM1	SIM2	SIM3	Percent Correct
Training	SIM1	106	11	7	85.5%
	SIM2	25	44	16	51.8%
	SIM3	12	14	35	57.4%
	Overall Percent	53.0%	25.6%	21.5%	68.5%
Testing	SIM1	46	7	2	83.6%
	SIM2	9	6	3	33.3%
	SIM3	3	12	17	53.1%
	Overall Percent	55.2%	23.8%	26.0%	65.7%

Dependent Variable: Simkart

Conclusions

Assael and Xue believe that the decision to buy services and products is function of three factors, consumer, products and position. So the consumer according to goods and services (marketing mix) and a situation in which it is located (situational factors) gained information and evaluates product and then choose the goods by the influence of these two factors. On the other hand, Zajas and Crowley also described that the brand, recommendations of friends and experienced people in order to reflect the individual's personality is effective factors. Yu-Ho Cho also has declared that the reputation of brand and price can influenc consumer choice. According to the results of previous research, in this study also on buying a SIM card by consumer marketing mix has the greatest impact and biographical characteristics (gender, education, marital status, age, and occupation) has minimal impact. According to the importance of independent variables in predicting the dependent variable (type of mobile phone sim)respectively, price, product, distribution, rank first to the third in importance and the promotion

after the social class in the fifth grade are important. Sex, education and marital status have the least impact on the chosen SIM. Models of artificial neural networks are able to predict 65.7% of the samples to estimate correctly.

Among the independent variables, sex has minimal impact and the price has the greatest impact on the demand for mobile phones; in order to these results, it is suggested to the active operators of mobile communications that for increasing the demand for buying SIM cards, it is necessary to reduce the price of SIM cards. On the other hand, among other marketing mix variables promote has minimum impact on the demand for mobile phones. According to this theory, due to the impact of advertising on sales, we conclude that active operators in the field of mobile have a very weak advertising and it's essential to study this technically and take action to strengthen the publicity of their SIM till from this way increase sales of SIM cards and related services . Product Variable among the 13 independent variables that influence the demand for mobile located on the second place and it shows that the diversity of services, proper conversations quality, and affordable signal coverage and update data services provided by operators has a great importance in attracting the customers. After all what is recommended is that operators attempt to increase the quality of conversations, signal coverage and data services and be diligent to enhance their value in building services.

REFERENCES

[1] Assael, H., 2006, Consumer behavior and marketing action, in lian, Hong&lu. Duoc&tu, li (eds.), Kristianstad University the Department of Business Studies
[2] Bennett, Anthony, 1997, The five v,s - a buyer perspective of the marketing , Marketing Intelligence and Planning , volume 15 . Number 3, pp 151-156.
[3] Chou, YH. 2000, Classifying factors in fluencing purchase decisions of internet users, Aletheia University, Department of Information Management, p.12.
[4] Goonatilake, S., 1995, Intelligent Systems for Finance and Business: An Overview, Intelligent Systems for Finance and Business, Wiley, New York, pp. 1-28.
[5] Hornik, K., Stinchcombt, M. & White, H., 1989, Multilayer Feed Forward Networks are universal Approximators, Neural Networks, Vol.2, pp. 359-366.
[6] Howard, John A. and Sheth, Jagdish N.,1969,The Theory of Buyer Behavior, New York: John Wiley & Sons, Inc
[7] K.T. Duffy-D., 2010, Demand for Additional Telephone Lines: An Empirical Note, Information Economics and Policy, Vol. 13, pp. 283 – 299.
[8] Laroch, M., 2000, new development in modeling internet costumer behavior: Introduction to the special Journal of Business Research Vol. 63, Issues 9–10, Pages 915-1110
[9] Wilkes, M.S. and Bell, R.A., Kravitz & Richard L., 2000, Direct-to-consumer prescription drug advertising: trends, impact, and implications, Health Affairs, Volume 19, and Number 2
[10] Xue, F., 2008, the moderating effects of product involvement on situational brand choice, Journal of Consumer Marketing, Vol.25, pp.85-94.
[11] Zajas, J. and Crowley, E., 1995, Commentary: brand emergence in the marketing of computers and high technology products", Journal of product and Brand Management, vol.4, pp. 56-63.
[12] Kotler, P. and Armstrong, G., 2012, Principles of Marketing, Pearson Prentice Hall, 14th Edition.
[13] Hawkins, D. and Roger B. and minerals. K., 2005,consumer behavior, and the Common wealth 'Ahmad village planning, Sargl Publications, Tehran, first edition
[14] Nabizadeh, M.,1996, Models of consumer behavior, Tehran University (in Farsi)

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Economic Performance Measurement Proposal for Turkish Automotive Sector

Sinan Apak [1], *Fulya Taşel*[2] *Ebru Beyza Bayerçelik*[3]

Abstract

Automotive sector is one of the locomotive industries for many developed countries. To take an advantage is crucial for each player in this sector. So, performance measurement gets an important role for competitiveness on this market. Paper presents economic performance measurement proposal by using artificial neural network techniques. The study focuses on a comparison of automotive sector developments in Turkey by using both sale units and economic value data. Proposed analyzes would lead a comparable sectorial economic performance measurements. By the way, getting necessary performance comparisons eliminate problems will provide the automotive industry to expand and improve more than its capabilities.

Keywords: Automotive, Economic Performance Measurement, Forecasting, Neural Networks

Introduction

As it has been seen that automotive sector has an important potential when we compare with other emerging sectors. The sector closely linked with marketing, allowing raw materials, spare parts and final products to reach consumers, dealers, service, fuel, finance, and insurance with achieving most important support in the sector, the fact that automotive industry has an impact on other sectors. Today, there is a serious competition on an international scale in the automotive industry. In the past mainly price competition was concerned but today quality, product variety and competition elements are included to price in terms of future investment. As we consider when all type of motor vehicles is used in defense industry, agriculture, transport, infrastructure and construction sectors need are provided by that sector. Therefore, changes in the sector are related to the whole economy. In this content, R&D expenditures get a significant role and improve production rate in sector. Figure 1 represents the general view of sales numbers in sector. It can be seen that there is a clear increase in world automotive sales trend.

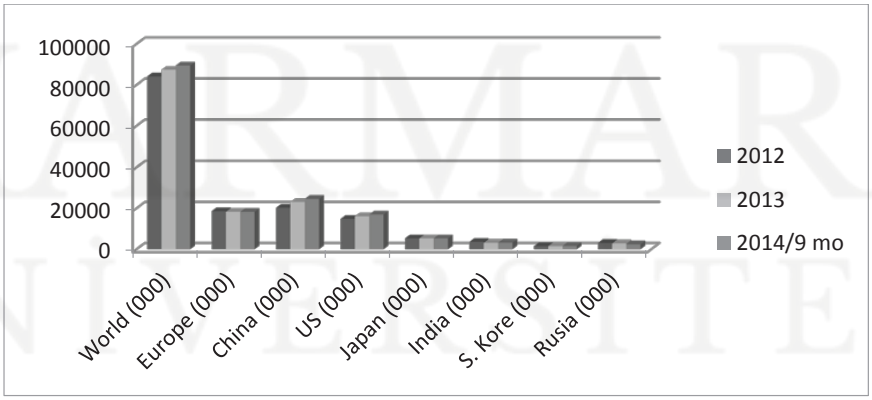


Figure 1. Automotive sector sales numbers

[1] Sinan Apak , Maltepe University, Engineering and Natural Sciences Faculty, Department of Industrial Engineering, Istanbul, Turkey, sinanapak@maltepe.edu.tr

[2] Fulya Taşel, Maltepe University, Department of International Trade and Logistics Management, Istanbul, Turkey, fulyatasel@maltepe.edu.tr

[3] Ebru Beyza Bayarçelik, Gelişim University, Department of International Logistics and Transportation, Istanbul, Turkey, ebbayarcelik@gelisim.edu.tr

Growth of export has been realized as a result of including of these facilities in Turkey to the global production plans by the leading manufacturers. In the aim of global and regional sales, a large number of models, which is getting increased day by day, are produced in Turkey while other vehicles which are not manufactured in Turkey are imported. Including of Turkey to the global production planning has been possible with Custom Union agreed with EU and in force since 1996 [1]. To understand the development Turkish automobile industry sales, we can compare sale numbers from 1996 to 2014/10 in Figure 2.

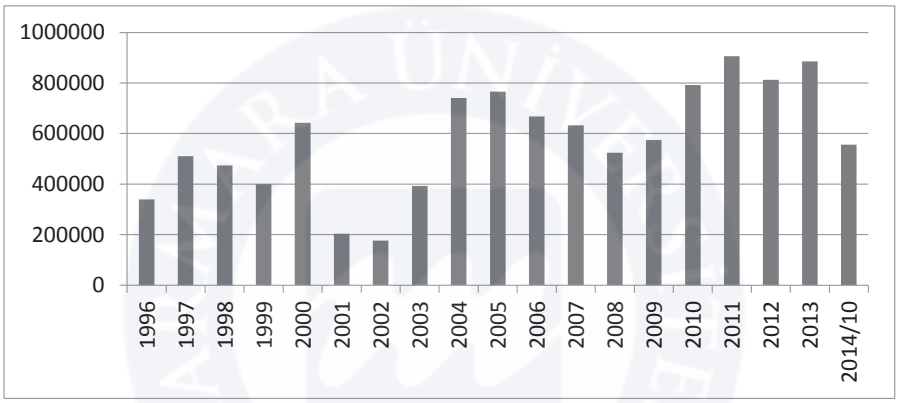


Figure 2. Automotive sector sales numbers, annually

Production index value of Turkish automotive manufacturing sector which had increased steadily until 2008, entered in a downward trend in 2008 and 2009 because of the global crisis, but it has been increasing since the early 2010 to 2014. The projection of the Turkish automotive sector for 2015 is [2];

- 2 Million unit production annually,
- Get a place in top ten in production in the World production,
- Get a place in top three in production in, European Union (EU),
- Get a place in top five in R&D in EU,

For those targets new investments would be needed. To understand reality of this targets this paper applies a comparative forecasting techniques with economic factors for future projections. With a systematic approach paper presents forecasting analysis while considering economic indicators that have effects on economy and automotive sale. A comparison presented base on five European leading automotive countries, sale numbers for last 2 years. (see in, Fig. 3).

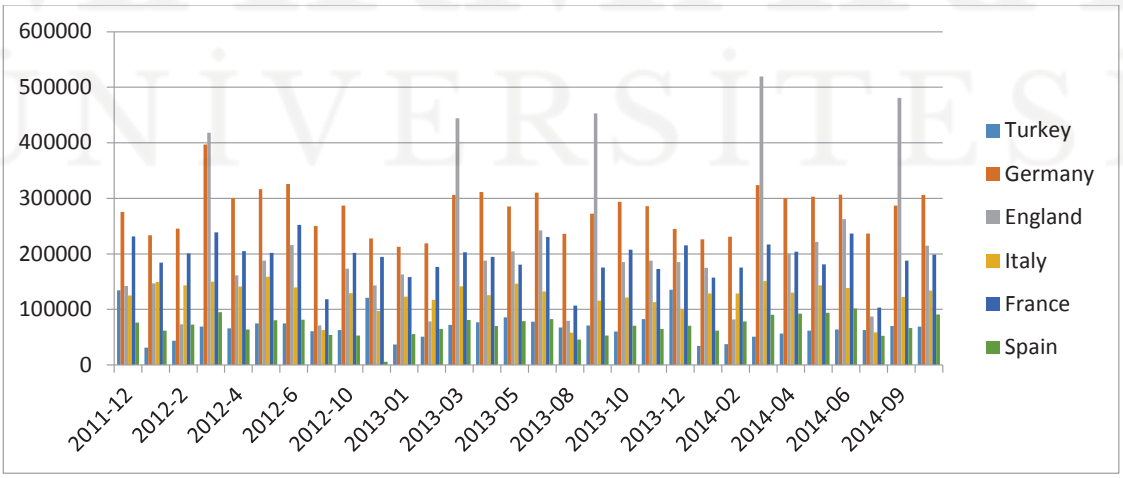


Figure 3. Comparative sale numbers, monthly

To determine future trends the study applies economic performance measurements by using artificial neural networks. Neural networks are a proven, widely used technology for such complex prediction problems. Study continues with literature review about studies on defining economic performance indicators and then next chapter study identifies artificial neural network methodology. At the application chapter we examined collected data to get a conclusion about future trend of Turkey. Finally, comparison and results are discussed in conclusion chapter.

Economic Performance Measurement Criteria

In many industrialized countries, developments in the automotive industry are key significance for overall economic activity. Because of this, there are many studies that have analyzed in depth the dynamics of car sales and make forecasting. In 1994, Jonsson and Agren [3] try to investigate determinates of expected expenditures on automobiles in Sweden. They find that combining car registrations with other economic indicators helps to forecast expenditures on automobile. Pierdzioch, Rulke and Stadtmann [4] accomplish detailed literature review about studies such as relation between automotive sales with economic variables. Those studies concentrate on growth of car ownership as a function of per-capita income and other variables. On the other hand some analyzes have been done about correlation between developments in the automotive industry and macroeconomic variables like exchange rates [4]. Also, Wang et al. [5] used an adaptive network-based fuzzy inference system to estimate new automobile sales in Taiwan with economic indicators.

In literature there are relatively small researches trying to find a link between economic indicators and automotive sales. Bruhl et al. [6] investigated the German automobile market and forecast the sales using economic variables. They used Gross Domestic Product, available personal income, consumer price index, interest rate, unemployment rate, industrial investment demand, petrol prices and private consumption as exogenous parameters. Shahabuddin [7] investigated the USA automotive industry and to forecast automobile sales in the USA, some demographic and economic variables were selected. Data on automobile sales and twelve independent variables such as durable industrial demand, durable personal consumption, population, discount rate, non-durable industrial goods, non-durable personal consumption, GNP,GDP, M1, M2 and M3 were analyzed.

Artificial neural networks

Artificial neural network (ANN) computational modeling technique was inspired by a biological nervous system as in the human brain. It can be employed to model complex physical systems and does not require an explicit mathematical representation. The fundamental processing element of the ANN is a neuron, while weighted connection serves as the synapse. Each neuron receives input through weighted connections (inputs) and these inputs are combined or summed in a specific manner. The formulation for the sum of the weighted inputs is given by

$$n = \sum_{i=1}^{R} w_i p_i + b \quad (1)$$

where p_i and w_i are the input vector and the connection weight from the input vector p_i, respectively and b is the bias of the neuron [8]. The sum of the weighted inputs with a bias is processed through an activation function, represented by a and the output that it evaluates is

$$a(n) = f\left(\sum_{i}^{R} w_i p_i + b\right) \quad (2)$$

The activation function can be defined in many ways such as threshold function, sigmoid function and hyperbolic tangent function [3]. Typically, the architecture of an ANN model is made up of three basic layers namely an input layer, a hidden layer and an output layer.

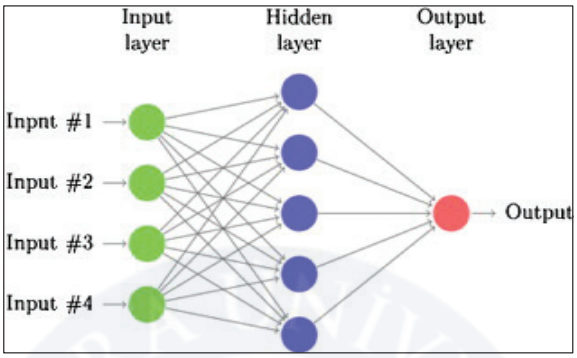


Figure 4. The architecture of the ANN model

The first layer is an input layer with four neurons, the middle layer is a hidden layer consisting of five neurons and the third layer is an output layer with three neurons. The accuracy of the ANN model prediction can be measured using a one-step ahead prediction technique in which the predicted output is compared with the previous input and output data. The one-step ahead prediction is defined as,

$$y_i(t) = f_i\left(x(t-1), \cdots, x\left(t-n_y\right), u(t-1), \cdots, u(t-n_u)\right) \quad (3)$$

where $f_i(t)$ is the predicted nonlinear function [3].

The inputs to the ANN model are consumer price index, consumer confidence index, production index, and harmonized unemployment rate. The ANN model is developed through 2 stages: training stage and testing stage. The network is trained to predict an output based on input data during the training stage. To validate the result, the model is tested using difference sets of input. In this study, the computer program was performed NeuroXL Predictor which is a neural network forecasting tool that quickly and accurately solves forecasting, classification and estimation problems in Microsoft Excel.

The ANN approach has applied in many sectors for planning, emulation and management of production processes. For example, Kamar et al., [8] developed ANN system for automotive air-conditioning system for a passenger car with a low error index, Cavalieri et al., [9] studied on estimation of the unitary manufacturing costs of a new type of brake disks produced by an Italian manufacturing firm, Zhang et al. [10] illustrated the use of a neural network-based model for the estimation of the packaging cost, based on the geometrical characteristics of the packaged product.

Economic Performance Measurement with ANN

The Neural model parameters have to be carefully adjusted to improve the accuracy of the predictor. In addition, it is necessary to accomplish a compromise between the accuracy needed and the computing time to suit each specific application. Based on the above parametric study, a suitable ANN model for economic performance measurement system was developed. The properties of the ANN model for the measurement system are tabulated in Table 1. F At the first run of data set gave us Fig. 5 and fourth run program gave us Fig. 6, respectively.

Table 1. Properties of the final ANN model

Structure	Feed forward neural network
Activation Function	Zero-based Log-Sigmoid
Initial weights	0.30
Learning rate	0.30
Momentum	0.60
Epoch	3000
Weight Delta	0.0003884
Minimum weight Delta	0.000001

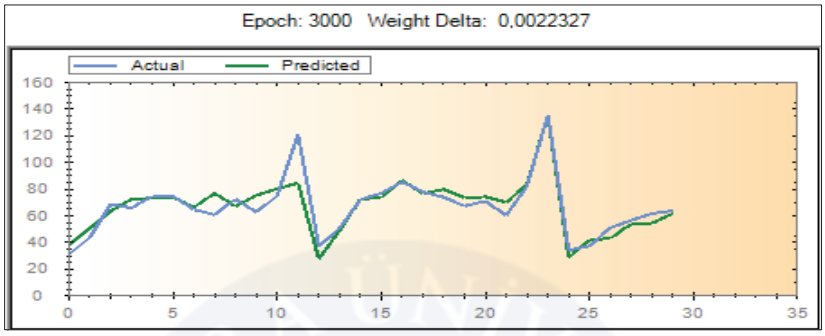


Figure 5. NeuroXL Predictor first learning process

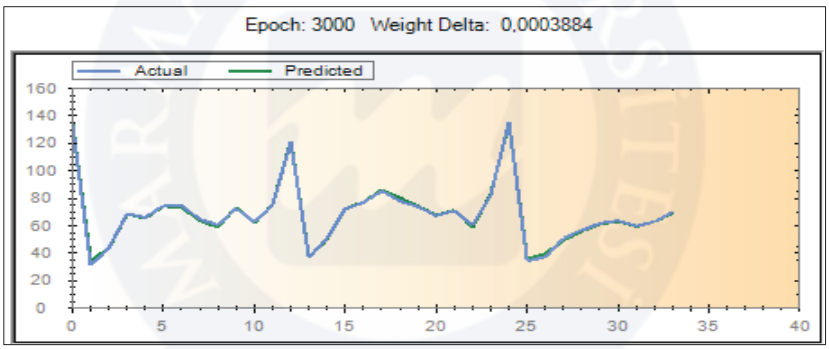


Figure 6. NeuroXL Predictor fourth learning process

Table 1. presents data that used to make a forecast and result of ANN model. As result shows that estimation of economic performance measurement of automotive sector for month November is 69488 automotive units and the real value for October is 69271 units. Model gives as a similar sale values when we compare with actual sale numbers.

Table 1. Data set

	Turkey				
	Mounty Sale Units	Consumer price index	Consumer confidence index	Production index	Harmonized unemployment rate
2011-12	134281	0,60	78,82	120,10	8,20
2012-1	31192	0,60	79,03	104,50	8,10
2012-2	43778	0,60	79,65	102,90	8,20
2012-3	68831	0,40	79,34	115,80	8,20
2012-4	66014	1,50	75,75	110,00	8,10
2012-5	74773	-0,20	78,11	118,20	8,00
2012-6	74781	-0,90	76,76	116,50	7,80
2012-7	64754	-0,20	77,01	116,10	8,00
2012-8	60871	0,60	74,33	103,40	8,00
2012-9	72620	1,00	72,12	116,40	8,20
2012-10	62699	2,00	69,34	112,30	8,10
2012-11	75039	0,40	72,60	121,40	8,30
2012-12	121113	0,40	73,59	116,70	8,50
2013-01	37139	1,60	75,79	106,80	8,50

2013-02	50885	0,30	76,66	104,40	8,40
2013-03	72380	0,70	74,91	116,00	8,50
2013-04	77038	0,40	75,62	115,30	8,60
2013-05	85421	0,10	77,46	120,50	8,70
2013-6	78105	0,80	76,23	120,00	8,70
2013-07	74007	0,30	78,47	122,90	9,00
2013-08	67412	-0,10	77,18	102,10	9,00
2013-09	71037	0,80	72,11	123,90	9,10
2013-10	60406	1,80	75,54	111,70	8,90
2013-11	82474	0,00	77,50	127,00	8,80
2013-12	135596	0,50	74,97	124,80	8,50
2014-01	34288	2,00	72,40	114,40	9,20
2014-02	37502	0,40	69,20	109,20	9,10
2014-03	51062	1,10	72,70	120,90	9,10
2014-04	56741	1,30	78,50	120,50	9,20
2014-05	61866	0,40	76,00	122,60	9,50
2014-06	63826	0,30	73,70	121,90	10,00
2014-07	59907	0,50	73,90	117,20	10,40
2014-08	62837	0,10	73,20	114,90	10,40
2014-09	70143	0,10	74,00	129,40	10,10
2014-10	69488	Forecast units			
2014-10	69271	Actual units			

Calculated October automotive sale value gives us a feedback about seasonal pattern that is followed by ANN model. Hereby, the result has only 217 unit error that could be easily tolerated. In analyze part we collected those economic performance indicators to show influences on economic performance measurement.

Conclusions

An ANN model has been developed in this study to forecast the October sale units of an economic performance measurement. The ANN model contains four nodes. Training and testing data set for the ANN model were obtained from tests. The performance of the ANN model was assessed using the comparison with actual sale units. The ANN model was found to be capable of accurately predicting the economic performance measurement parameters. ANN model can forecast the performance parameters of the model accurately.

Economic performance indicators which are consumer price index, consumer confidence index, production index, harmonized unemployment rate are capable of forecasting automotive sale units. As so, those performance measurement criteria would be used as a prediction data.

In future studies data set could be used more historical perspective and investigated as more indicators to find any correlation between sale units.

References

[1] General assessment of Turkish Industry Sectors, 2011. Availabe at: www.sanayi.gov.tr
[2] TurkStat NaceRev.2 K 29, 2014. Availabe at: www.tuik.gov.tr
[3] Jonsson, B., Agren, A., 1994. "Forecasting car expenditures using household survey data", *Journal of Forecasting* 13, 435–448.

[4] Pierdzioch, Rülke, Stadtmann, (2011). "Forecasting U.S. car sales and car registrations in Japan: Rationality,accuracy and herding", *Japan and the World Economy* , 23, 253–258.
[5] Wang, F.-K., Chang, K.-K., Tzeng, C.-W., (2011). "Using adaptive network-based fuzzy inference system to forecast automobile sales", *Expert Systems with Applications*,38, 10587–10593.
[6] Bruhl, B., H ulsmann, M., Borscheid, D., Friedrich, C., Reith, D., 2009. A sales forecast model for the German automobile market based on time series analysis and data mining methods. In: Perner, P. (Ed.), Advances in Data Mining. Applications and Theoretical Aspects. Springer, Berlin/ Heidelberg, pp. 146–160.
[7] Shahabuddin, S., 2009, Forecasting automobile sales. *Management Research News* 32, 670–672.
[8] Kamar H.M, Ahmad R., Kamsah N.B., Mustafa A.F.M., 2013 Artificial neural networks for automotive air-conditioning systems performance prediction, *Applied Thermal Engineering*, 50, 63-70.
[9] Cavalieria S., Maccarroneb, P., Pinto, R., 2004, Parametric vs. neural network models for the estimation of production costs: A case study in the automotive industry, *Int. J. Production Economics*, 91, 165–177.
[10] Zhang, Y.F., Fuh, J.Y., Chan, W.T., 1996, Feature-based cost estimation for packaging products using neural networks, *Computers in Industry*, 32, 95–113.

MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Forecasting Patient Length of Stay in an Emergency Department by Artificial Neural Networks

Muhammet Gül [1], *Ali Fuat Güneri* [2]

Abstract

Emergency departments (EDs) have faced with high patient demand during peak hours in comparison to the other departments of hospitals because of their complexity and uncertainty. Therefore, prolonged waiting times in EDs have caused dissatisfaction on patients. Patient length of stay (LOS), also known as patient throughput time, is generally considered to be the length of time that passes from the patient's time of arrival at the ED until time of discharge or transfer to another department of the hospital. Starting from patient admissions to the EDs, it becomes important have to be known the overall LOS in terms of right resource allocation and efficient utilize of the department. For this purpose, this paper aims to forecast patient LOS using Artificial Neural Network (ANN) within the input factors that are predictive such as patient age, gender, mode of arrival, treatment unit, medical tests and inspection in the ED. The method can be used to provide insights for ED medical staff (doctors, nurses etc.) determining patient LOS.

Keywords: Forecasting, Patient Length of Stay, Emergency Department, Artificial Neural Networks

Introduction

Emergency departments are the busiest departments in a hospital and their main purpose is to provide timely emergency care to patients [1,2]. The highest attribute of emergency departments is their uninterrupted serviceability. Providing this service to a lacker in a short time and giving priority to very urgent one is essential. However, patients without urgent cure may frequently visit to emergency departments. These visits cause patient overcrowding in many emergency departments. Thus waiting times and unsatisfaction of patients may increase, a general complex condition may occur in the ED [3]. Performance indicators that emergency departments use to evaluate their operations and service quality are used in the recent literature such as average waiting time, average LOS ED productivity, resource utilization and layout efficiency [4,5]. Prolonged waiting times have been a major cause of ED overcrowding, that is a main reason of supply–demand mismatch [1]. Prolonged waiting times are constituted by the long waits in triage, delays in testing or obtaining test results, waiting for the physician, and shortage of nursing staff [6]. [7] reveals several reasons that cause to increase long waiting times in emergency departments. These reasons include the inefficient utilization of ED resources, miscommunication between ED staff to ensure the smoothness of flow of patients in or out of the emergency department, delays in admitting patients from the emergency department, inefficient resource allocation in the hospital, and other external factors, such as an increase in demand of patients due to a reduction in the number primary care physicians in the neighboring area of the emergency department. LOS is used to assess hospital ED costs and effectiveness and is made use of several methods to forecast [8]. Accurate forecasting of patient LOS enables ED management right resource allocation and efficient utilization of the department resources. In [9], it is emphasized that forecasting and determining LOS in hospitals can be very useful for hospital management, particularly for prioritizing health care policies and promoting health services, comprising the appropriate allocation of health care resources according to differences in patients' LOS along with considering patients' health status and social-demographic features. Therefore, we aim to forecast patient LOS using Artificial Neural Network (ANN) within the input factors that are predictive such as patient age, gender, mode of arrival, treatment unit, medical tests and inspection in an emergency department.

[1] Muhammet Gul, Yıldız Technical University, Mechanical Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, mgul@yildiz.edu.tr
[2] Ali Fuat Guneri, Yıldız Technical University, Mechanical Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, guneri@yildiz.edu.tr

Literature Review

Limited number of studies related to the forecasting of LOS is available in the literature. The studies use various methods to forecast including such as ANNs, linear regression and logistic regression. [8] propose a data mining approach based on Back-Propagation (BP) neural net-works to construct a LOS prediction model. They analyze 921 cholecystitis patients data of a Chinese hospital treated between 2003 and 2007. The model constructed provides approximately 80% accuracy and reveal 5 LOS predictors: days before operation, wound grade, operation approach, charge type and number of admissions. [10] estimate patient's length of stay in the ED with an ANN. They develop an ANN using the software Stuttgart Neural Network Simulator using patient variables such as age, acuity level, coded ICD-9 chief complaint, language, order for a consult service, presence of at least one laboratory exam, and presence of at least one radiology exam. They also use operational variables. By the conclusion of the study they point out that ANNs have the potential to be a powerful tool for the analysis of complex medical system data like EDs. [1] use a data-driven method to identify variables correlated with the daily arrivals of the non-critical patients and model this association using ANNs. They compare the ANN modeling with the least square regression (NLLSR) and multiple linear regression (MLR) in terms of mean average percentage error (MAPE). In this study, we apply a data mining approach *ANN* to forecast ED patient LOS. The constructed model can be used to provide insights for ED medical staff (doctors, nurses etc.) determining patient LOS.

Material and Method

In this section, the model data, ANNs as the modeling technique and constructed ANN model considering ED LOS forecasts are introduced as sub-sections, respectively.

Data

The data is obtained from a regional university hospital emergency department in eastern part of Turkey that serves approximately an average of 40.000 patients per year. We collect a total data of 1500 ED patients who were treated in the department in October and November, 2010. We provide the related data by the aid of hospital information management system, medical staff opinion and manual data collecting forms. The variables used for generating ANN model are categorical and numeric. The statistical results for numeric and categorical variable types are presented in Tables 1-2.

Table 1. Statistical results of numeric variables

Numeric variables affecting patient ED LOS	*Variable type*	*Description*				
		Detail	*Min*	*Max*	*Mean*	*SD*
Number of tests	Input	Ranges from 0 to 8	0 time	8 times	1.12 times	1.53
Door-to-doctor time	Input	Starts with a patient registered and ends after seen by a doctor initially	0 min	65 mins	3.96 mins	4.01
ED LOS	Output	Average total length of stay in ED per patient	5 mins	600 mins	72.15 mins	59.42

"Number of tests" represents the number of tests that patients take during their hospitalization in the emergency department. Most of the patients take one test. "Door-to-doctor time" represents the time between registration and first treatment area by a doctor. It especially takes 4 minutes. "ED LOS" is our output variable (dependent variable). It is generally considered as the time that passes from the patient's time of arrival at the emergency department until time of discharge or transfer to another department of the hospital. In Table 2, patient mode of arrival refers to the patient type of arrival at the emergency department. A patient who comes on foot, by his/her special car or on a stretcher refers to walk-in patient. A patient who moves into the ED via an ambulance vehicle (car, helicopter etc.) refers to ambulance patient.

Table 2. Statistical results of categorical variables

Categorical variables affecting	*Variable*	*Detail*	*Occurrence*	*Number of*
Gender	Input	(1) Male	51%	770
		(0) Female	49%	730
Mode of Arrival	Input	(1) Walk-in	93%	1396
		(0) Ambulance	7%	104
On-call physician	Input	Practitioner physician (1)	11%	160
		Practitioner physician (2)	2%	28
		Practitioner physician (3)	13%	189
		Practitioner physician (4)	9%	133
		Practitioner physician (5)	8%	118
		Practitioner physician (6)	11%	158
		Practitioner physician (7)	14%	206
		Practitioner physician (8)	9%	131
		Practitioner physician (9)	11%	167
		Practitioner physician (10)	14%	210
Judicial case	Input	(1) Judicial case	2%	28
		(0) Not judicial	98%	1472
Treatment area	Input	(1) Monitor beds area	53%	799
		(2) Emergency-1	25%	375
		(3) Emergency-2	17%	262
		(4) Emergency response room	4%	57
		(5) Resuscitation	0.5%	7
Immediate treatment	Input	(1) Need immediate treatment	12%	184
		(0) Do not need	88%	1316
X-ray	Input	(1) Taking desired test	22%	329
		(0) Not need to take	78%	1171
ECG (Electrocardiogram)	Input	(1) Taking desired test	16%	238
		(0) Not need to take	84%	1262
Hemogram	Input	(1) Taking desired test	27%	401
		(0) Not need to take	73%	1099
Medical biochemistry	Input	(1) Taking desired test	26%	384
		(0) Not need to take	74%	1116
Exact urine analysis	Input	(1) Taking desired test	2%	34
		(0) Not need to take	98%	1466
Tomography	Input	(1) Taking desired test	6%	84
		(0) Not need to take	94%	1416
Arterial blood gas test	Input	(1) Taking desired test	0.3%	4
		(0) Not need to take	100%	1496
Ultrasonography	Input	(1) Taking desired test	5%	71
		(0) Not need to take	95%	1429
Urine test	Input	(1) Taking desired test	6%	96
		(0) Not need to take	94%	1404
Prothrombin time test	Input	(1) Taking desired test	0.1%	1
		(0) Not need to take	100%	1499
Blood center	Input	(1) Taking desired test	0.1%	2
		(0) Not need to take	100%	1498

Treatment areas consist of five different areas where patients are sent by their acuity level. While, critical patients are sent to the beds with monitors (monitor beds area), non-critical patients who have minor injuries, headache, stomach ache etc. are sent to the Emergency-1 and Emergency-2 rooms. Patients who had an accident and had major injures are rapidly placed under observation in resuscitation area. Patients who have infectious diseases are placed in a room called emergency response room.

Artificial Neural Networks

Artificial Neural Networks (ANNs), which are generally called as "neural networks" or "neural nets", attempt to reproduce the computational processes taking place in the central nervous system (CNS) by using a set of highly interconnected processing elements [11]. An ANN model, which is formed of n layers, presents a different number of computational elements that function like biological neurons and intensive connections between these computational elements among layers. The computational elements used in various ANN models are named as artificial neurons or process elements [12, 13]. The first layer which is called as the "input" layer and the last one which is called as the "output" layer are used to get information from inside and outside the network, respectively. The middle layers which are generally called as "hidden" layers are essential to the network in order to be able to convert certain input patterns into appropriate output patterns [11]. ANNs are applied to several practices such as forecasting. For ED operations, ANNs are frequently applied to forecasting ED patient arrivals [1], ED length of stay (LOS) [8,10], ED patient admission process [7], etc [14].

Empirical Study

We prefer to use professional neural network-based software Alyuda NeurolntelligenceⓇ. We follow a study process including the steps as here: (1) data collection, (2) data preparation, (3) correlation analysis on the variables and (4) modelling by ANN. After the data entry to the software, the system randomly selects 68% of the data as training sets, 16% of the data as validation sets and 16% of the data as test sets. The software has an automatic architecture search module which selects [33-27-1] architecture for training (see Figure 1). This means that the system select a single hidden layer as well as 27 hidden neurons. We make a correlation analysis before developing an alternative ANN model. The alternative model includes factors that have a strong correlation with the independent variable *LOS*. The correlation analysis is performed by Minitab® 17.1.0 with a significance level (α) of 0.05. We calculate the correlation coefficient for every variable (numeric and categorical) with LOS. The results are given in Table 3. We divide the significance into three correlation strengths as in [8]: strong (1-p>0.95), medium (0.90<1-p<0.95) and weak (1-p<0.90), where p is the test probability value.

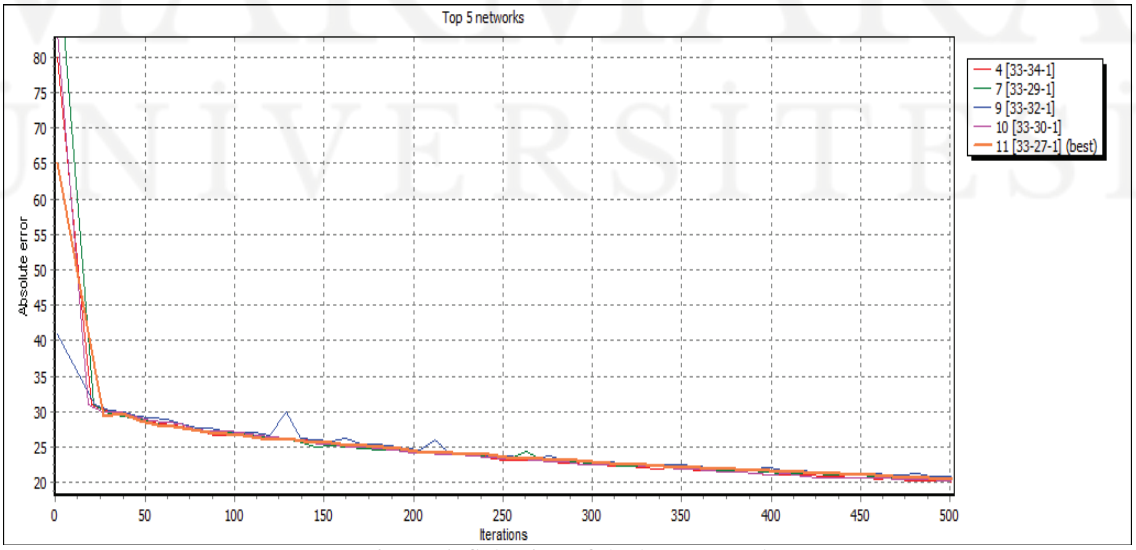


Figure 1. Selection of the best network

Table 3. Correlation of all the variables

Variables	*Correlation coefficient*	*P-value*	*Correlation*
Gender	0.014	0.583	Weak
Mode of Arrival	-0.249	0.000	Strong
On-call physician	-0.034	0.185	Weak
Judicial case	0.160	0.000	Strong
Treatment area	-0.163	0.000	Strong
Immediate treatment	0.123	0.000	Strong
X-ray	0.279	0.000	Strong
ECG (Electrocardiogram)	0.239	0.000	Strong
Hemogram	0.539	0.000	Strong
Medical biochemistry	0.544	0.000	Strong
Exact urine analysis	0.138	0.000	Strong
Tomography	0.309	0.000	Strong
Arterial blood gas test	0.089	0.001	Strong
Ultrasonography	0.288	0.000	Strong
Urine test	0.271	0.000	Strong
Prothrombin time test	0.014	0.576	Weak
Blood center	0.123	0.000	Strong
Number of tests	0.601	0.000	Strong
Door-to-doctor time	-0.005	0.844	Weak

Results and Discussion

We use an initial learning rate of 0.1 and a momentum of 0.1. We try alternative values for both the learning rate and momentums of (0.1), (0.2), (0.4) and (0.6) along with various learning algorithms such as Quick Propagation, Quasi-Newton, Online-Back Propagation and Levenberg-Marquardt. We run all the models within a cycle of 500 iterations. We try 64 various models in total and obtain the optimum value with the lowest absolute error (Table 4). The scatter plot related to the target, output values of the ANN model and a comparison of actual and output values of the model have been acquired by means of the software (as shown in figure 2).

Table 4. The best network and parameters

Summary of the ANN model	
Network Architecture	[33-16-1]
Training Algorithm	Levenberg-Marquardt
Hidden FX	Logistic
Output FX	Logistic
Number of Iterations	501
Avg. Training Error	25.769552
Avg. Validation Error	33.430944
Avg. Test Error	34.287008
R-Squared	0.63
Learning Rate	0.4
Momentum	0.4

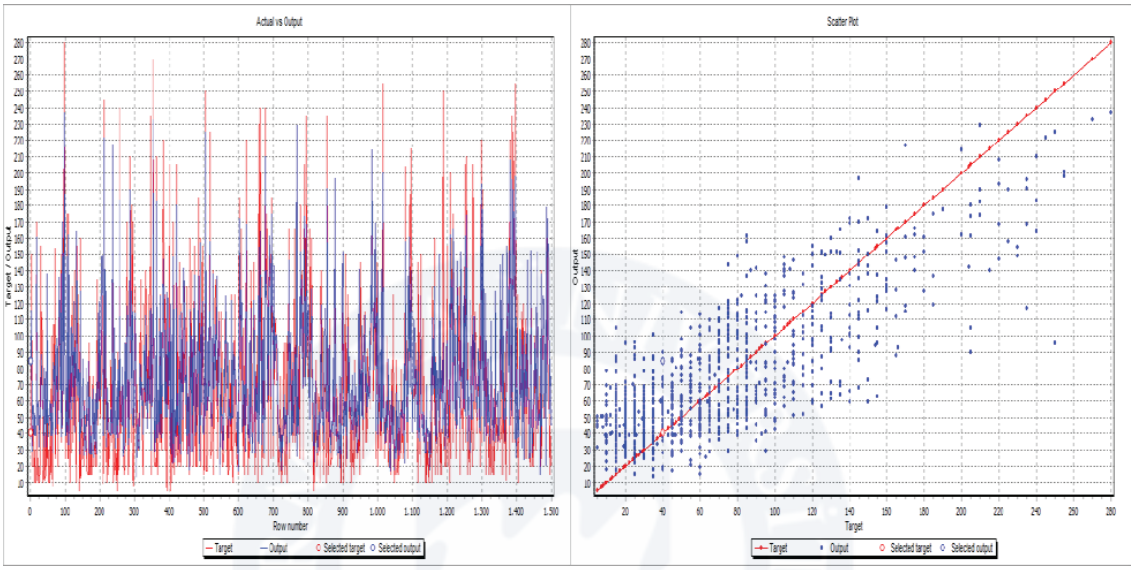


Figure 2. Visualization of actual vs. output and scatter plot of the ANN model

For our alternative ANN model, we exclude the variables that have little affects (variables with weak or medium correlation) on LOS. Therefore we run the new model with all the variables except gender, on-call physician, prothrombin time test and door-to-doctor time. The performance of the new model is shown in Table 5. We could see that the accuracy of the models has close values.

Table 5. The best network and parameters

Summary of the ANN model	
Network Architecture	[31-15-1]
Training Algorithm	Levenberg-Marquardt
Hidden FX	Logistic
Output FX	Logistic
Number of Iterations	501
Avg. Training Error	25.629
Avg. Validation Error	31.319
Avg. Test Error	34.492
R-Squared	0.61
Learning Rate	0.4
Momentum	0.4

Conclusion

This study presents an ED LOS forecasting model using ANNs. We benefit a collected data of 1500 ED patients and identify several variables. While some of them are categorical variables such as gender, mode of arrival, on-call physician, treatment area and taking some tests, the remaining are numerical variables such as number of tests and door-to-doctor time. In the study, we propose two ANN-based models as a base model that includes all variables and an alternative model that takes into consider all the variables except variables with weak or medium correlation on LOS. Each of the models did not give an ideal prediction accuracy that is generally expected to be better than 80% in forecasting. The reason of this is considered to be originated from the selection of sufficient and accurate input variables. Neural network models can include some hidden relations between the variables. This hidden ability is very important when forecasting of medical data such as ED LOS. The little difference between two proposed models can be stemmed from this. Other forecasting methods multiple linear regression, logistic regression, support vector machine and so on can be applied to build ED LOS forecasting models for future researches.

Acknowledgement

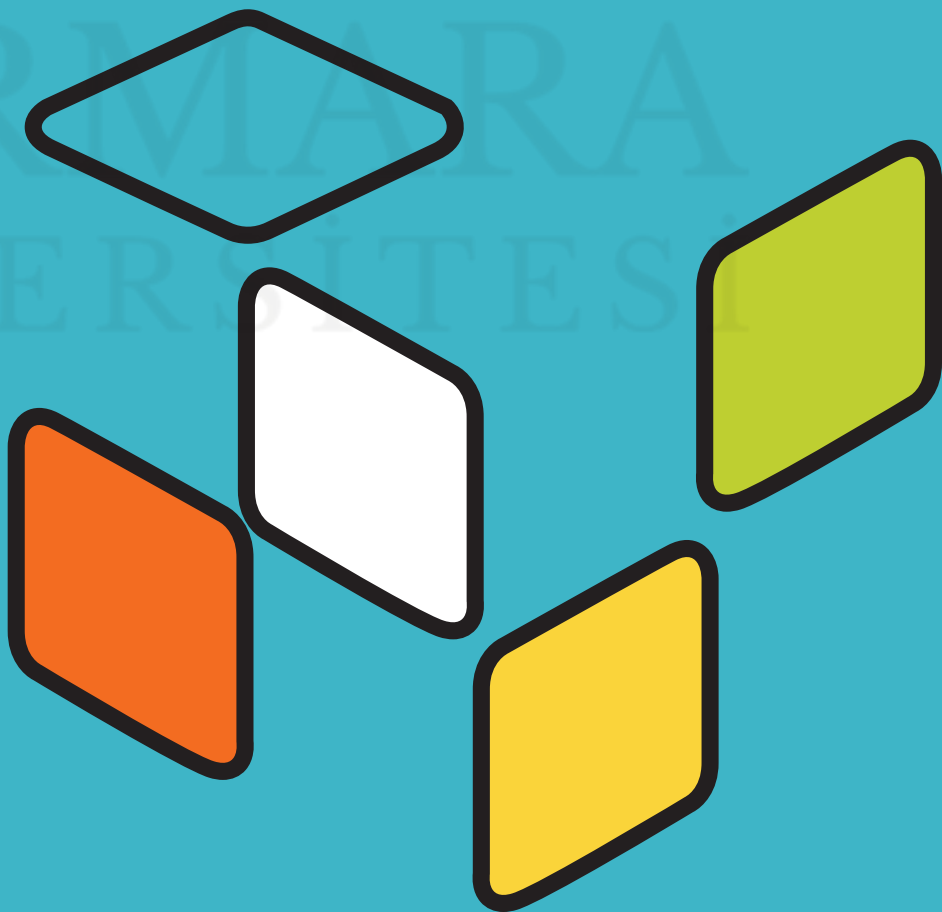
We thank to Dr. Mustafa Yıldız, the head of the department of the emergency medicine at Fırat University Hospital. And we also owe doctors and nurses work by all three shifts a debt of gratitude for helps on getting access data.

References

[1] Xu, M., Wong, T.C., Chin, K.S., 2013, Modeling daily patient arrivals at Emergency Department and quantifying the relative importance of contributing variables using artificial neural network, *Decision Support System*, 54, 1488-1498.
[2] Gul, M., Guneri, A.F., 2012, A computer simulation model to reduce patient length of stay and to improve resource utilization rate in an emergency department service system, *International Journal of Industrial Engineering: Theory, Applications and Practice*, 19(5), 221-231.
[3] Ersel, M., Karcıoğlu, Ö., Yanturalı, S., Yürüktümen, A., Sever, M., Tunç, M.A., 2006, Emergency Department utilization characteristics and evaluation for patient visit appropriateness from the patients' and physicians' point of view, *Turkisj Journal of Emergency Medicine*, 6(1), 25-35 (In Turkish).
[4] Gul, M., Guneri, A.F., 2014, A comprehensive review of emergency department simulation applications for normal and disaster conditions, *Computers & Industrial Engineering*, Submitted Manuscript.
[5] Gül, M., Güneri, A.F., Tozlu, Ş., 2014, Prioritization of emergency department key performance indicators by using fuzzy AHP, *15th International Symposium on Econometrics, Operations Research and Statistics*, Isparta, Turkey.
[6] Paul, J.A., Lin, L., 2012, Models for Improving Patient Throughput and Waiting at Hospital Emergency Departments, *The Journal of Emergency Medicine*, 43(6), 1119-1126.
[7] El-Sharo, M.R.A., 2002, Predicting hospital admissions from emergency department using artificial neural networks and time series analysis, *MSc Thesis*, Yarmouk University, Jordan.
[8] Li, J-S., Tian, Y., Liu, Y-F., Shu, T., Liang, M-H., 2013, Applying a BP neural network model to predict the length of hospital stay, In *Health Information Science* (pp. 18-29). Springer Berlin Heidelberg.
[9] Hachesu, P.R., Ahmadi, M., Alizadeh, S., Sadoughi, F., 2013, Use of data mining techniques to determine and predict length of stay of cardiac patients, *Health Informatics Research*, 19(2), 121-129.
[10] Wrenn, J., Jones, I., Lanaghan, K., Congdon, C.B., Aronsky, D., 2005, Estimating Patient's Length of Stay in the Emergency Department with an Artificial Neural Network. In *AMIA Annual Symposium Proceedings* (Vol. 2005, p. 1155). American Medical Informatics Association.
[11] Somoza, E., Somoza, J.R., 1993, A neural-network approach to predicting admission decisions in a psychiatric emergency room, *Medical Decision Making*, 13(4), 273-280.
[12] Guneri, A.F., Gumus, A.T., 2008, The usage of artificial neural networks for finite capacity planning, *International Journal of Industrial Engineering: Theory, Applications and Practice*, 15(1), 16-25.
[13] Guneri, A.F., Gumus, A.T., 2009, Artificial Neural Networks for Finite Capacity Scheduling: A Comparative Study, *International Journal of Industrial Engineering: Theory, Applications and Practice*, 15(4), 349-359.
[14] Kilmer, R.A., Smith, A.E., Shuman, L.J., 1997, An emergency department simulation and a neural network metamodel, *Journal of the society for health systems*, 5(3), 63-79.

MARMARA ÜNİVERSİTESİ YAYINEVİ

SUSTAINABILITY II



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Money Creation Mechanism Produces Unbridled Debt: Pseudo Relationship between Production of Goods and Services and the Production of Money

Mete Gündoğan [1], *B. Gültekin Çetiner* [2]

Abstract

Systemic approach requires processes to be analysed in a unified whole. Once context boundary of a system is identified, remainings are expected to be in a balanced cycle hence satisfying user requirements. A bottom-up view reveals that many products constitute a project. Many projects constitute a business. Many businesses constitute an industry. Many industries may constitute a socio economic system. From a top-down approach, a socio economic system is an integrated and unified system. One part of it is dealing with the production of goods and services and counter part of it is dealing with the prodution of money. Production of goods and services is a well-studied and well-defined scope. On the other hand, production of money is having many ambiguities to be studied. Having the concept of reciprocity in mind, production of money is creating significant problems that cannot be underestimated. Initial scarcity of money is resulting in a continuous debt scheme. That can be identified as Debt Based Monetary System (DBMS) which is behaving irrespective of the production of goods and services. This article is explaining the fabricated scarcity of money and how that is covered by the DBMS. Thus this situation let the reason of existence of money be away of production of goods and services.

Keywords: Debt Based Monetary System, Systems Engineering, Fractional Reserve System, Fractional Reserve Banking

Introduction

Systems engineering is an important discipline to create a unified whole that is called the system of systems. It brings together in some way of a number of independent enterprises or businesses. Current problems of environmental, political, cultural, social, economic, technological and psychological issues are multi faceted problems facing humanity. Systems engineering approach gives a good basis to handle these problems in a unified whole.

Within this context, there are two ways of approaches to handle problems i.e. mechanistic approach and systems approach. In a mechanistic approach, the idea is to decompose parts to more basic components then reassemble them and hence explain how things worked. In a system approach, on the other hand, the behaviour or properties of the containing whole is firstly explained. Then the behaviour of the thing to be explained in terms of its roles and functions is explained within its containing whole. The containing whole in some way is greater than the sum of its parts.

One of the systems engineering model is the five layer model [1]. The first layer is product/subsystem engineering. This is to make artifacts, products or goods and services which is also at the core of all systems. The systematisation starts with some problem and ends with a proven solution to the problem. The solution proves the symptoms of the problem to be neutralised and as well as to be effective, compatible with and adapted to its environment [2].

The second layer is the project systems engineering which is related to the corporate wealth creation. This

[1] Prof. Dr. Mete Gündoğan, Yıldırım Beyazıt University, Faculty of Engineering and Natural Sciences, Department of Industrial Engineering, Ankara, Türkiye, metegundogan@ybu.edu.tr

[2] Prof. Dr. B. Gültekin Çetiner, Marmara University, Faculty of Engineering, Department of Industrial Engineering, Istanbul, Türkiye, gultekin.cetiner@marmara.edu.tr

again starts with some problem and conceives solution options which are traded against the criteria as effectiveness, reliability, affordability and so on. The unified whole system i.e. product and process, may be partitioned into manageable parts. Then each part may be separately developed before being brought together. The model contains subsytem design which would be a layer 1 activity and customers' and users' requirements as well.

The third layer is the business/enterprise systems engineering that is to create industrial wealth. Many businesses make an industry. At this level, there are two integrated views. One is to design the process that is to be used to design, develop, create, test, integrate and prove the whole solution system. The second is to design the project that is done in conjunction with project management and takes into account business factors and the business environment in which the work is to be done.

The fourth layer is the industrial systems engineering which is about the national wealth creation. This layer models and characterises the nesting of the various layers of systems engineering. It also includes end users, suppliers and markets as well. The industrial systems engineering are not seen as having a life cycle. Because they are able to recreate themselves using the financial return on sales to undertake research, identify, design and make innovative new products and continually replace and update their equipment and facilities. In this respect, they are similar to biological organism like the human body.

The fifth layer is the socio-economic systems engineering that is related to government regulations and control. This is also including legal and political influences. For instance, the former USSR developed five year economic plans. In contrast, free market economies do not plan ahead in that manner. It is soundly based on financial motivation.

From this perspective, money which is created, circulated and accumulated in a country is the solely financial base of the fifth layer systems engineering i.e. socio-economic systems engineering. There should be some reasonable relationship between the two parts, namely amount of money and amount of production.

Natural Economic Cycle (NEC)

It is essential to know, at this step, the nature of manufacturing/production and its economic and social significance. Production is to transform raw materials and ideas into marketable goods and services which are known as economic goods and services. Economic goods and services cannot be obtained without expenditures. Expenditures can be made with money. In other terms, production is to transform raw materials into goods to transfer money from a set of holders to another.

In developed countries, manufacturing industries may be viewed as the backbone of the nation's economy where the real wealth is created. It has been estimated that in such a country on average about a quarter of the population is involved in some form of manufacturing activity, and the rest of the population benefits from the products (Harrington, 1984) [3]. According to 2013 Turkish Statistics Institution [4], in Turkey, manufacturing industries (agriculture, hunting, forestry, fishing, mining, quarrying, manufacturing, and construction) generate approximately 28.6 percent of the nation's wealth and employ 49.1 percent of the working population. Remaining 50.9 percent of the working population is in the service industries. Interestingly, the jobs of half of those employed in non-manufacturing sectors depend on the close links that exist between service systems and the manufacturing industries.

The strength of production determines the strength and scale of socio-economic systems engineering. With this respect, it is not surprising for over two centuries many studies have stressed the importance of production especially manufacturing. Many people attempted to evaluate effects of manufacturing on the nation's macroeconomy. However, it is surprising that very few people from the production area are working on the financial counterpart of the production that is money and its creation and accumulation.

The socio-economic systems engineering of a country requires us to study the unified whole system in two parts. Producing goods and services on one part and producing money on the other. This concept can be depicted as Natural Economic Cycle (NEC) in the Figure 1 as shown below [5].

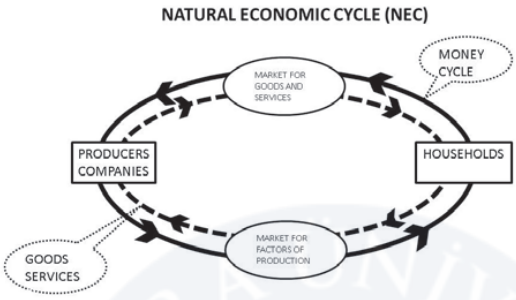


Figure 1. Natural Economic Cycle (NEC)

The most essential thing in the NEC is the production of goods and services. Existence of money is to support the production cycle of goods and services. The production part of the NEC is well-studied. Various methods of optimisations are employed to reduce costs and to maximise profits. But, how the other part of the NEC is worked and how money is created is kept beyond the scope of production studies. In fact, it is too important to leave it to economists only [6]. With the help of systems engineering approach, money creation can be studied from a different and unconventional perspective. Here, we avoid using common financial jargon i.e. terms and definitions. We rather used general terms and definitions to work out the systematic deficiencies of the money creation mechanism.

Requirement of Purchasing Power

The internal significance factors of manufacturing are continued employment, quality of life, and the creation and preservation of skills. The external factors of manufacturing are national defence, and the nation's position and strength in world affairs.

Interestingly, an industrial system is expected to create more and more employment. But on the other hand, we are optimising any industrial system with the object of cost minimisation and profit maximisation. That means we are studying to obtain a given output with a minimum of employment. In the same way, we are continuing to study in the area of energy and technology to replace human power. Similarly, great majority of people who are engaged in industry want goods. But those who owns industrial establishments want simply money.

Money creation has nothing to do with the industrial system but represents the effective demand upon the goods and services produced. Now, as explained by Douglas [7], money distributed in the production of goods and services consists of wages and salaries i.e. labour costs. Since labour costs are not the only cost of production, then we can say it is less then prices. Then,

$$\frac{Costs}{Prices} < 1 \quad (1)$$

If wages (labour costs) are reduced by an amount of x, the ratio of purchasing power to prices is lessened,

$$\frac{Costs-x}{Prices-x} < \frac{Costs}{Prices} \quad (2)$$

Lessening the labour costs reduces the population's ability to buy goods and services produced. Although we are expected to minimise costs to maximise profit.

In general, we can divide all production payments in two groups. Payments made to individuals as wages, salaries, divdents etc. can be denoted as A. Other payments as raw materials, repayment of bank loans and

other non-personal costs can be denoted as B. Prices in this case should be,

$$Prices \geq A + B \tag{3}$$

Therefore, A will never cover the A+B which are Prices. There should then be some intermediate producer to cover the deficiency in the Equation (3). This is currently covered by an unjust mechanism which will be explained in the next section.

If delivering goods and services is the objective of the industrial systems then rate of flow of purchasing power should be equal to the rate of generation of prices. There is a gap between these two rates. This gap is filled in by the Debt Based Monetary System (DBMS) which is issuing purchasing power in the form of loans [8]. In other words, the system is increasingly mortgaging the future in order to sell the goods and services existing at present.

In fact, the true cost of a given programme of production is the consumption of all production over an equivalent period of time.

Let us denote P for production, C for consumption and M for money distributed for a given programme of production. Then,

$$M \times \frac{\int_{T1}^{T2} \frac{dC}{dt}\, dt}{\int_{T1}^{T2} \frac{dP}{dt}\, dt} = M \times \frac{\frac{Mean\ consuption\ rate}{for\ selected\ period}}{\frac{Mean\ production\ rate}{for\ selected\ period}} \tag{4}$$

The real cost of a programme of production is not the money cost, but considerably less than the money cost [7]. How to fill in the difference is not studied well because of the current monetary system which is creating purchasing power out of nothing.

Debt Based Monetary System

Banks are creating money out of nothing. The deficiency between the cost of production and the power to buy produced goods and services is closed by banking system with the power of creating money. That power is not given to the banking mechanism but de facto assumed by them. Whenever a bank loans a credit that creates a deposit. Whenever that loan is paid back the the deposit is destroyed. This can be explained mathematically as follows [7],

Let Deposits = D
Loans = L
Cash in hand = C
Capital = K

Then Assets = L+C
Liabilities = D+K

So that

L+C = D+K

Differentiating with respect to time, we have,

$$\frac{dL}{dt} + \frac{dC}{dt} = \frac{dD}{dt} + \frac{dK}{dt}$$

Capital K is constant and assume we have cash to be kept fixed then,

$$\frac{dK}{dt} = 0 \text{ and } \frac{dC}{dt} = 0$$

Hence

$$\frac{dL}{dt} = \frac{dD}{dt} \tag{5}$$

This shows us the rate of increase or decrease of loans is equal to the rate of increase or decrease of deposits. How is that implemented in the modern mechanism of money creation is shown in Figure 2 below.

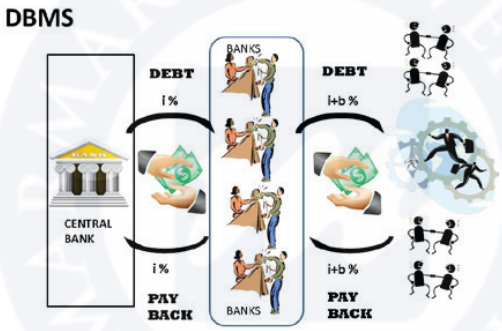


Figure 2. Money Creation Mechanism of The DBMS

Parliaments pass a decree indicating that the money created by the central bank is the only legal tender to be used in the country. Central Banks then create money based on empirical and theoretical estimations. The money is given to banks with interest rate i. Banks sell that money with a reasonable profit (i+b) to people for production or consumption. People pay money (credit) back to bank with an interest (i+b) on due date. Bank pays money back to central bank with an interest i.

Furthermore, if we take a closer look at the mechanism, we see it drifts the system to an unstoppable chaos. Now, suppose the system is at the state of nature and first lot of money M created is lent to a bunch of banks with an interest rate i for a maturity date T. Suppose, the central bank will not create any more money until the date T+1. Then how the banks will pay their debts back to central bank with interest rate i? This is not possible because the total amount of money in the system is M and the total amount of money the central bank is demanding is M+M*i%. M is always less than M+M*i%.

$$M < M(1+i)$$

Therefore, banks will compulsorily ask more money to pay their debts and will naturally get deeper into debt. Additionally, the compound interest embedded into money creation process makes the growth of debts in an exponential manner. This is a deathly recursive mechanism drifting all of the system into a chaos.

As understood from the Figure 2 and its explanation, money comes to existence (created) as a debt. The whole mechanism is based on that debt. This is why the system is to be called as a Debt Based Monetary System.

From this mechanism, one can think that the whole money is created by central bank with an interest rate i and then is distributed by banks with an interest rate (i+b). In Turkey, for instance, the amount of money created by the central bank is approx. 80 billion Turkish Lira [9]. On the other hand, if we look at the total money sold by banks, either as consumption or production credit, is about 1060 billion Turkish Lira [10].

Now, we have a good question to be answered here. If the central bank is creating 80 billion TL, how come the banks are giving 1060 billion TL money to their customers? Who creates the remaining 980 billion TL (as much as 12 fold of 80) money and how? Who gives the authority to create such amount of money as 980

billion TL to the banks?

In order to understand how that money is created we should look at the Fractional Reserve System (FRS) [11,12]. This is the term used for modern banking system practiced in almost all countries today. Figure 3 depicts the FRS mechanism shown below.

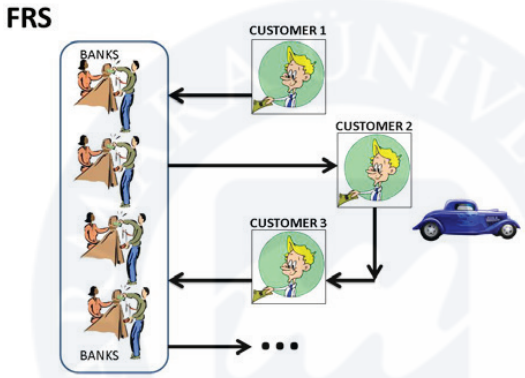


Figure 3. Money Creation Mechanism of The FRS

As shown in Figure 3, suppose, a bank Customer-1 brought to a bank a banknote (money) to deposit. Bank gives a receipt for the money. S/he then leaves the bank confident that s/he can spend her/his money in the marketplace with security. Suppose next that Customer-2 comes to the bank because s/he wants to purchase Customer-3's car and s/he is short of money. S/he would like borrow a certain amount of money. The bank finds her/him credit-worthy and, therefore, lends her/him the money asked. Customer-2 pays the money to Customer-3 and then Customer-3 becomes the bank's second depositor, leaving his money to the bank. The bank gives her/him a receipt and customer-3 leaves also the bank confident that s/he, too, can spend her/his money in the marketplace with security.

What is now the bank's position? The bank has one amount of money deposited in the bank and have issued two receipts against it. What is the collateral? By issuing two claims against the same amount of money, the bank would also have misled the marketplace into believing that one more amount of money exists than actually exists. This practice of banks can go on as much as they want. They can create as much money as they want with a stroke of a pen i.e. giving credit! Do they have the right of creating new ownership out of nothing? With the current FRS mechanism, de facto, yes [13].

This mechanism of money lending makes money appear to reproduce itself. But money does not reproduce itself, nor can it. Bankers are also aware of the risks they are taking. From time to time, depositors at particular banks became worried about whether there was sufficient amount of money available to meet their claims and went to those banks to remove their deposits. If too many arrived at the same time the bank could not honour them all and the business of that bank was disrupted. Depositors who had not succeeded in withdrawing their deposits before the disruption lost their deposits and the owners of the banks lost their own investments.

The FRS mechanism motors on relentlessly, increasing simultaneously both the money supply and the burden of debt. In the DBMS, each new claim represents a new debt. As the number of claims grew, so too did the amount of personal, business and government debt.

Citizens elect a parliament. The parliament charges central bank with the responsibility of creating and maintaining a stock of money for their use. The government then licenses banks to lend money created for them. With the FRS practice, banks create more money out of nothing with a stroke of a pen. One of the most

curious aspects of this arrangement is that the banks do not pay a cent piece by way of royalty or license fee to the government for the use of the money which they create for the government and then use for themselves. To say the least, this is not a commercial arrangement. Worse of all, when the government needs to spend more money on citizens behalf than it has raised in taxes, instead of creating it as citizens have authorised them to do and which would have a one-off cost but no further running costs, it borrows money from the pool created by the banking system. Then citizens have to pay both the one-off cost and the running cost of annual interest on it. This is neither a commercial nor a reasonable arrangement and to be studied in a unified whole from a systems engineering perspective to fix it.

Conclusion

In production of goods and services, there is a lack of purchasing power. It has also shown that the amount of purchasing power is less than the amount of money representing goods and services produced. The deficiency between these two terms is overfilled in by the DBMS. In the industry, every manufacturer has to buy raw materials. On the other hand in banking business, bankers receive the raw material for creating money every time a customer deposits money. As is understood that under the DBMS with FRS, the government is a minor player in money creation process.

Worse, if the government had itself printed hundreds of billions of liras that the banks produced, it could have paid off the entire national debt. Nor would it have had to pay tens of billions of interest yearly. We could now have the finest infrastructure, the finest public transportation system, the finest national health facilities, the finest education facilities, and the finest energy supply that can be obtained. Nor can there be equality of opportunity according to merit under the DBMS. A person with a sound idea and not assets finds it extremely difficult to get his idea financed. A person, on the other hand, with an unsound idea and assets will have little difficulty getting his idea financed.

Furthemore, DBMS together with FRS has not compatible with the production of goods and services in a unified whole. At the layer-5 systems engineering view, national stock of money should have been in some relation with the production of goods and services. But in fact, it is the other way round. Money reproduces itself out of nothing but owns goods and services. DBMS together with FRS represents the largest redistribution of wealth by bankers. Through this mechanism, bankers exercise a power which is not given to them by the people.

Certainly, modern economy cannot function without some kind of medium of exchange which must be created by human beings. At the moment, society uses the FRS expansion method to create money. Money is increased in numbers but decreases as purchasing power to buy goods and services produced. The investment of the funds means the reappearance of the same sum of money in a fresh set of prices. That means, a fresh set of price values is created without the creation of fresh purchasing power. These processes are at the core of the problem. The mechanism creates more money out of nothing and reduces the power to produce goods and services produced. At the same time, the money demands interest. We are then in a vicious circle. The production system requires purchasing power. The DBMS_FRS creates money which results in a further requirements of purchasing power. This is continuously increasing the amount of debt and becoming never ending circle. This problem should be fixed in the money creation mechanism by answering three questions following. First of all, who owns (should own) the money that we are using? Secondly, who decides (should decide) how much money is to be created? Lastly, who decides (should decide) the level of debt burden on the government?

References

[1] Hitchins, D.K. 2007. Systems Engineering: A 21st Century Systems Methodology, Wiley.

[2] Gundogan, M. 1996. System Analysis and Design Methods for Cumputer Integrated Manufacturing, Proceeding of the UMTIK 96, Ankara, Turkey, September 13.

[3] Wu, B. 1994. *Manufacturing Systems Design and Analysis*, 2nd Edition, Chapman & Hall.

[4] www.tuik.gov.tr

[5] Gundogan, M. Cetiner, B.G. 2014. Debt Based Monetary System. Joint Symposium on IMSS'14 and CIE'44. www.imss14-cie44.org 14-16 October 2014. Istanbul Turkey.

[6] Gundogan, M. 1997. Refah Toplumu, Vadi Yayınları.

[7] Douglas, C.H. 1979, The Monopoly of Credit, 4th Edition, Bloomfield Books, England.

[8] Gundogan, M. 2002. *Borca Dayalı Para Sistemi Türkiye'nin Sosyo-Ekonomik Analizi,* Keşif Yayınları.

[9] www.tcmb.gov.tr para verileri.

[10] www.tbb.org.tr kredi verileri.

[11] Dornbusch, R. Fischer, S. Startz, R. 2008. *Macroeconomics, 10th Edition,* McGraw-Hill International Edition.

[12] Cachanosky, N. 2014. Hayek's Rule, NGDP Targeting and the Productivity Norm: Theory and Application, *Journal of Stock and Forex Trading*, 3:121.

[13] Thoren, T.R. and Warner, R.F. 1994, The Truth in Money Book, 4th Edition, Truth in Money Publication.

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

A Review on Social Sustainability and Corporate Social Responsibility

Mahmure Övül Arıoğlu Akan [1], *Ayşe Ayçim Selam* [2]

Abstract

Over the last century, world population has tripled with an accompanying massive economic development and vast environmental degradation. Thus, the concepts of "sustainability" and "sustainable development", which have first formally been introduced by World Commission on Environment and Development (WECD) in 1987 as "meeting the needs of the present without compromising the ability of future generations to meet their own needs", have become the most significant concepts at all levels of decision-making. Sustainability has three pillars, namely environmental, economic and social, the latter gaining attention relatively later than the others. There are various definitions of social sustainability in the literature, some of which have approached to the concept as being synonymous with Corporate Social Responsibility (CSR) and some considering it separately, with "creating value for the society" at the intersection. Consequently, the aim of this study is to elaborate on the existing definitions of social sustainability and its relationship with CSR through the investigation of the respective objective indicators used to measure the social sustainability performance in different mediums (i.e. supply chain, cities, organizations etc.).

Keywords: Corporate Social Responsibility, Social Sustainability, Social Sustainability Indicators, Sustainability

Introduction

In the past 100 years, world population has tripled, and the world economy has grown 20 times with an increased fossil fuel consumption by a factor of 30 and industrial expansion by a factor of 50 [1]. The accompanying massive economic development and vast environmental degradation have placed "sustainability" and "sustainable development" at the center of decision-making in all mediums including product/service production, management, marketing and urban planning. As such, in order to generate environmentally conscious products/services, companies have integrated sustainability into their supply chains through systematic approaches such as "green supply chain management" and "sustainable supply chain management". In doing this, they have gained significant competitive advantages including decreased system costs and resource use together with increased productivity and profitability [2].

World Commission on Environment and Development (WCED) [3] defines sustainable development as "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Dehghanian and Mansour [4] state that the following objectives should be met for a sustainable development:

- Maintain a high and stable level of economic growth and employment;
- Effective protection of the environment; and
- Provide social progress, which recognizes the needs of everyone.

[1] Mahmure Övül Arıoğlu Akan, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, ovul.akan@gmail.com

[2] Ayşe Ayçim Selam, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, aselam@marmara.edu.tr

"Sustainability" differs from "Sustainable Development" in that it describes a stage (or state of being), while the latter points at processes towards or within that state [5][6]. Sustainability, with its many interacting factors and processes, is a complex system [7]. The connections and interactions among the above-mentioned pillars of sustainability, namely society, the environment, and economic/industrial development, should clearly be defined in order to achieve sustainable development in both industrialized and developing nations [8]. On the other hand, one major criticism of sustainable development research, which covers a wide range of issues including public policies, political systems, corporate citizenship, international trade, social equity/justice, economic growth/development, is the lack of clarity regarding its definition and its applicability [9]. This is mostly due to the fact that, besides the critical benefits it provides, sustainability is a challenging concept to systematically integrate because it spans through the whole organization including product development, procurement, manufacturing, maintenance, sales, distribution and customer services. Thus, different perceptions are formed in different departments even within the same company, making sustainability a complex concept to holistically define and apply [10][11]. This challenge has led academicians and practitioners to a more systematic, robust and trans-disciplinary systems perspective, integrating all three dimensions of sustainability [12][13][6]. Consequently, the social aspect of sustainability has recently been acknowledged as significant alongside the environmental and economic dimensions and emerged as a field of research, policy and practice over the past decade [14]. Companies have started to place more emphasis on creating social values along with profit generation and environmental protection [15][9].

As being a relatively new addition to the academic literature about the theory, policy and practice of sustainable development [14], there is no consensus on the definitions and boundaries of social sustainability. The concept is "undertheorized", with the related literature being described as "fragmented" and "conceptually chaotic" [14]. Missimer et al. [6] stress the inherent challenges of studying social sustainability with the following statement: "The social world is much too complex and far too interwoven with value statements, morals, and other intangible, non-measurable aspects to be studied as one would study an ecological system with traditional scientific methodologies."

In the light of the above-stated facts, the aim of this study is to investigate the existing definitions of social sustainability and its relationship with Corporate Social Responsibility (CSR), a concept associated with the social aspects of sustainability in the corporate context. To this end, the second part of the study provides a brief review on social sustainability definitions and indicators. The definitions and concepts of CSR are provided in the third part. The fourth part focuses on the different perspectives regarding the relationship between social sustainability and CSR. Finally, the fourth part elaborates the conclusions of the study and possible areas of future research.

Social Sustainability: Definitions and Indicators

The cross-disciplinary nature of social sustainability has resulted in multiple, often conflicting, interpretations based on a wide array of philosophical, political and practical issues [14]. Vallance et al. [16] have grouped these under three main categories. According to their perspective, some studies focus on meeting basic needs and address underdevelopment, while others are equally concerned about the promotion of stronger environmental ethics. There are also those studies, where social sustainability has been considered in terms of maintaining or preserving preferred ways of living or protecting particular socio-cultural traditions. Consequently, they provide a threefold schema of social sustainability including the following (see Figure 1):

- *development sustainability* addressing basic needs, the creation of social capital, justice, equity etc.;
- *bridge sustainability* concerning changes in behavior so as to achieve bio-physical environmental goals; and
- *maintenance sustainability* referring to the preservation – or what can be sustained – of socio-cultural characteristics in the face of change, and the ways in which people actively embrace or resist those changes.

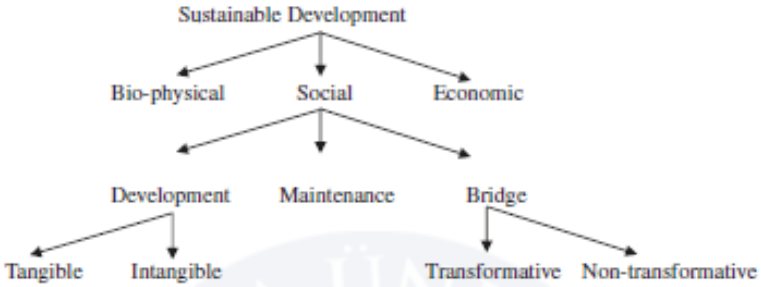


Figure 1. Three Strands of Social Sustainability [16]

McKenzie [17] defines social sustainability as "a life-enhancing condition within communities, and a process within communities that can achieve that condition" and lists the following issues as indicators:

- equity of access to key services (including health, education, transport, housing and recreation);
- equity between generations, meaning that future generations will not be disadvantaged by the activities of the current generation;
- a system of cultural relations in which the positive aspects of disparate cultures are valued and protected, and in which cultural integration is supported and promoted when it is desired by individuals and groups;
- the widespread political participation of citizens not only in electoral procedures but also in other areas of political activity, particularly at a local level;
- a system for transmitting awareness of social sustainability from one generation to the next;
- a sense of community responsibility for maintaining that system of transmission;
- mechanisms for a community to collectively identify its strengths and needs;
- mechanisms for a community to fulfil its own needs where possible through community action;
- mechanisms for political advocacy to meet needs that cannot be met by community action.

Social sustainability, as an emerging area of urban planning policy and practice, is increasingly used by governments, public agencies, policy makers, non-governmental organizations (NGOs) and corporations to frame decisions about urban development, regeneration and housing [14]. Dempsey et al. [18] list the urban social sustainability factors as depicted in Table 1. Table 2 presents the classification of social sustainability indicators within the general context (i.e. not limited to urban planning and design). As it has previously been stated, social sustainability, in the corporate sense is associated with CSR, which is introduced in the next section.

Table 1. The Social Dimension of Sustainable Development: Defining Urban Social Sustainability [18]

Non-physical factors	Predominantly physical factors
✓ Education and training	✓ Urbanity
✓ Social justice: inter- and intra-generational	✓ Attractive public realm
✓ Participation and local democracy	✓ Decent housing
✓ Health, quality of life and well-being	✓ Local environment quality and amenity
✓ Social inclusion (and eradication of social exclusion)	✓ Accessibility (e.g. to local services and facilities/employment/green space)
✓ Social capital	✓ Sustainable urban design
✓ Community	✓ Neighborhood
✓ Safety	✓ Walkable neighborhood: pedestrian friendly
✓ Mixed tenure	
✓ Fair distribution of income	
✓ Social order	
✓ Social cohesion	
✓ Community cohesion (i.e. cohesion between and among different groups)	

- ✓ Social networks
- ✓ Social interaction
- ✓ Sense of community and belonging
- ✓ Employment
- ✓ Residential stability (vs turnover)
- ✓ Active community organizations
- ✓ Cultural traditions

Table 2. United Nations Division of Sustainable Development (UNDSD) theme/sub-theme framework for social dimension of sustainability as cited in [8]

Theme	Sub-theme	Indicator
Equity	Poverty	Percent of population living below poverty line
		Gini index of income inequality
		Unemployment rate
	Gender Equality	Ratio of average female wage to male wage
Health	Nutritional Status	Nutritional status of children
	Mortality	Mortality rate under 5 years old
		Life expectancy at birth
	Sanitation	Percent of population with adequate sewage disposal facilities
	Drinking water	Population with access to safe drinking water
	Healthcare delivery	Percent of population with access to primary healthcare facilities
		Immunization against infectious childhood diseases
		Contraceptive prevalence rate
Education	Education level	Children reaching grade 5 of primary education
		Adult secondary education achievement level
	Literacy	Adult literacy rate
Housing security	Living conditions	Floor area per person
	Crime	Number of recorded crimes per 100,000 population
Population	Population change	Population growth rate
		Population of urban formal and informal settlements

Corporate Social Responsibility: Definitions and Basic Concepts

There has been an increasing focus both by companies and by society on the actions and outcomes of business [20]. Consequently, the concept of CSR has evolved since the 1970's [20], and it has become a significant corporate agenda around the world [21]. By the year 2004, almost 90% of the US-American Fortune 500 companies already had explicit CSR initiatives [22]. Parallel to this development, researchers have paid considerable attention to this topic, and it has become a prominent concept in management literature over the past two decades [23]. However, despite the large body of literature on CSR, there is still no unified and precise definition [23], and Armstrong and Green [24] argue that no such thing is possible because social responsibility to some people is irresponsible to others. They also state that views on what is socially responsible change over time. On the other hand, despite the lack of a clear definition, all opposing definitions of CSR agree on one thing, which is that firms must meet the expectations of society when planning their environmental management strategies [25]. According to Van Beurden and Gössling [26], CSR answers the uncertainties that business corporations have to cope with in terms of the social context of the dynamic, global, and technological business arena that we witness today. A similar perspective is provided by [27], who state that CSR is a component of a corporate policy to undertake the sustainability imperative.

Aguinis and Glavas [28], in a comprehensive review of the CSR literature based on 588 journal articles and 102 books and book chapters, elaborate on the its highly fragmented nature, pointing out that CSR has been studied through different disciplinary and conceptual lenses (e.g. [29]-[31]). While stating that CSR, in the general sense, is the ethical behavior of a company towards society, the World Business Council for Sustainable Development (WBCSD) defines it as ''the continuing commitment by business to behave ethically and contribute to economic development while improving the quality of life of the workforce and their families as well as of the local community and society at large'' [32]. Furthermore, they argue that CSR is an integral part of sustainable development and consequently, provide the context depicted in Figure 2.

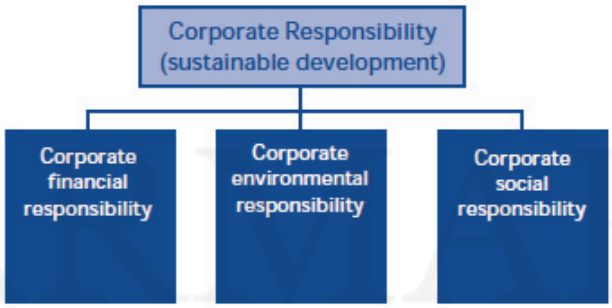


Figure 2. CSR in the Context of Sustainable Development [32]

Aguinis [33] defines CSR as "context-specific organizational actions and policies that take into account stakeholders' expectations and the triple bottom line of economic, social, and environmental performance." Aguinis and Glavas [28] emphasize the fact that such policies and actions are influenced and implemented by actors at all levels of analysis, i.e. institutional, organizational, and individual. Consequently, they offer a multilevel and multidisciplinary theoretical framework that synthesizes and integrates the literature at these three levels (see Figure 3). The framework includes reactive and proactive predictors of CSR actions and policies and the outcomes of such actions and policies, which they classify as primarily affecting internal (i.e., internal outcomes) or external (i.e., external outcomes) stakeholders. The framework also includes variables that explain underlying mechanisms (i.e., relationship- and value-based mediator variables) of CSR – outcomes relationships and contingency effects (i.e., people, place, price, and profile-based moderator variables) that explain conditions under which the relationship between CSR and its outcomes change.

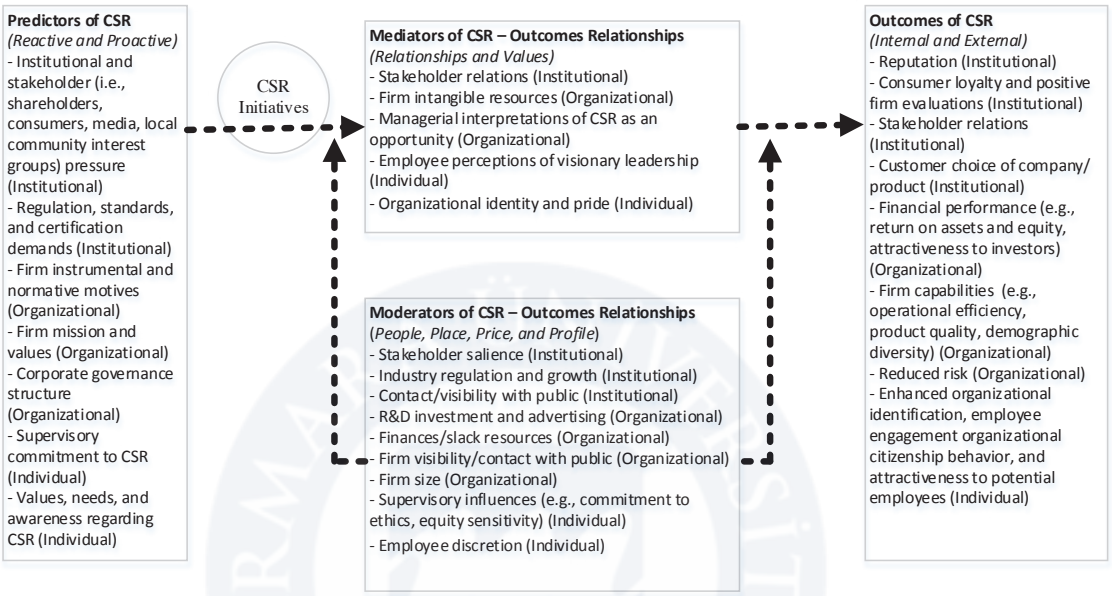


Figure 3. Multilevel and Multidisciplinary Model of CSR: Predictors, Outcomes, Mediators, and Moderators [28]

However, CSR is defined, it is clear that it has become a necessity for many firms in today's highly competitive business environment due to its significant impacts on major stakeholder outcomes, which can be summarized as follows [34]:

- increase customer trust, loyalty, positive word-of-mouth, and purchase intention;
- attract potential employees and enhance the existing employees' satisfaction and commitment by improving their identification with the firm; and
- positive influence on investor decisions and preferences through increasing the trustworthiness of the firm.

The ideal-type of CSR, which provides the above-listed competitive advantages, must incorporate the practices and activities depicted in Figure 4.



Figure 4. Characteristics of the ideal-type of strategic CSR [35]

CSR and Social Sustainability: How Do They Relate?

There are different perceptions in the literature regarding the relationship between social sustainability and CSR. Vachon and Mao [9] use the terms interchangeably, when they state, "the influence on social sustainability from an organization should extend beyond its boundaries to include not just fair labor practices but also social improvement of local communities and equity in the society within which they are operating". Despite certain arguments against its practice, even sustainability and CSR are often used as synonyms in a corporate context [36][37]. Hediger [38] state that CSR is different from the concept of sustainable development, but they can contribute to achieving the objective of sustainable development. The author points out to the fact that CSR refers to the way companies manage their internal resources (including shareholders' expectations) and at the same time contribute to the welfare of other stakeholders (society). Hutchins and Sutherland [8] share a similar view, stating that there are strong linkages between the concepts of sustainability and that the concept of CSR acknowledges the importance of the social dimension of sustainability. They also share their views on how the majority of the CSR definitions include references to ethical behavior related to the environment, society, and the economy. Morimoto et al. [39] strengthen this perspective by saying "CSR seems to be perceived by many as the social strand of sustainable development." In a comprehensive study, where 37 different definitions of CSR have been analyzed, Dahlsrud [40] has concluded that the definitions of CSR consistently refer to the five dimensions listed as the following:

- The stakeholder dimension,
- The social dimension,
- The economic dimension,
- The voluntariness dimension,
- The environmental dimension.

When the above-listed dimensions are considered, it can be stated that CSR is indeed the perception and adoption of sustainability in the corporate context. However, it is evident in the definitions provided by Dahlsrud [40] that the social, voluntariness, and environmental dimensions became more dominant with time, while the stakeholder and economic dimensions have been considered more within the newly emerging concept of "corporate sustainability". This view can be supported by Hediger's [38] statement on corporate sustainability referring to "…an internal objective of maintaining the capital stock and corporate value, rather than fulfilling some arbitrarily determined sustainability criteria. It indirectly serves the objective of sustainable development by its objective of sustainable asset management."

Conclusions

The aim of this study was to point out to the discrepancies in the "social sustainability" and CSR definitions to ultimately shed some light to the "chaos" observed in the respective literature. As a result of this study, the authors have come to the conclusion that the term "social sustainability" is more commonly used in urban sustainability while CSR relates solely to the corporate arena. In other words, CSR is how social sustainability is managed in the corporate context. However, with the development of the "corporate sustainability management", it can be stated that CSR has become more about voluntary acts and less concerned with the economic dimension. This particular area, namely the relationship between corporate sustainability, CSR and social sustainability stands out as a new area of research in the literature. The authors share the same view with Dahlsrud [40] in that no matter how they are defined, there is an urgent need for models and approaches regarding the management associated with the challenges within these concepts. Dahlsrud [40] verbalizes this, as "…the challenge for business is not so much to define CSR, as it is to understand how CSR is socially constructed in a specific context and how to take this into account when business strategies are developed." As such, the authors believe that more studies are needed as the one conducted by Cruz [41], where a decision support framework for modeling and analysis of supply chain networks with CSR, has been developed.

References

[1] Stanners, D., Bourdeau, P., 1995, Europe's Environment: The Dobris Assessment, *State of the Environment Report No 1*, EEA (European Environment Agency), http://www.eea.europa.eu/publications/92-826-5409-5, Accession Date:12.03.2010.
[2] Arıoğlu Akan, M.Ö., 2013, Kurumsal Sürdürülebilirlik Yönetimi: Bütünsel Bir Yaklaşım, *13. Üretim Araştırmaları Sempozyumu*, 25-27 Eylül, Sakarya, Türkiye.
[3] WCED (World Commission on Environment and Development), 1987, *Report of the World Commission on Environment and Development: Our Common Future*, http://www.un-documents.net/ocf-02.htm, Accession Date: 08.07.2010.
[4] Dehghanian, F., Mansour, S., 2009, Designing sustainable recovery network of end-of-life products using genetic algorithm, *Resources, Conservation and Recycling*, 53, 559–570.
[5] Holmberg, J., Robèrt, K.-H., 2000, Backcasting from non-overlapping sustainability Principles - a framework for strategic planning, *International Journal of Sustainable Development and World Ecology*, 7, 291-308.
[6] Missimer, M., Robèrt, K.H., Broman, G., Sverdrup, H., 2010, Exploring the possibility of a systematic and generic approach to social sustainability, *Journal of Cleaner Production*, 18, 1107-1112.
[7] Buys, L., Mengersen, K., Johnson, S., van Buuren, N., Chauvin, A, 2014, Creating a Sustainability Scorecard as a predictive tool for measuring the complex social, economic and environmental impacts of industries, a case study: assessing the viability and sustainability of the dairy industry, *Journal of Environmental Management*, 133, 184-192.
[8] Hutchins, M.J., Sutherland, J.W., 2008, An exploration of measures of social sustainability and their application to supply chain decisions, *Journal of Cleaner Production*, 16, 1688-1698.
[9] Vachon, S., Mao, Z., 2008, Linking supply chain strength to sustainable development: a country-level analysis, *Journal of Cleaner Production*, 16, 1552-1560.
[10] Littlefield, M., Roberts, M., 2012, Enterprise Sustainability Management: A New Paradigm Emerges, http://www.lnsresearch.com, Accession Date: 27.02.2013.
[11] Lozano, R., 2012, Towards better embedding sustainability into companies' systems: An analysis of voluntary corporate initiatives, *Journal of Cleaner Production*, 25, 14–26.
[12] Srivastava, S.K., 2007, Green supply-chain management: A state-of-the-art literature review, *International Journal of Management Reviews*, 9, 53-80.
[13] Arioglu Salmona, M.O., Selam, A.A., Vayvay, O., 2010, Sustainable Supply Chain Management: A Literature Review, *ICOVACS 2010 – International Conference on Value Chain Sustainability*, November 15-17, Valencia, Spain.
[14] Woodcraft, S., 2012, Social Sustainability and New Communities: Moving from concept to practice in the UK, *Procedia - Social and Behavioral Sciences*, 68, 29 – 42.
[15] Carter, C.R., Jennings, M.M., 2004, The role of purchasing in corporate social responsibility: a structural equation analysis, *Journal of Business Logistics*, 25, 145–86.
[16] Vallance, S., Perkins, H.C., Dixon, J.E., 2011, What is social sustainability? A clarification of concepts, Geoforum, 42, 342-348.
[17] McKenzie, S., 2004, Social Sustainability: Towards Some Definitions, *Hawke Research Institute Working Paper Series 27*, http://w3.unisa.edu.au/hawkeinstitute/publications/downloads/wp27.pdf, Accession Date: 12.01.2015.
[18] Dempsey, N., Bramley, G., Power, S., Brown, C., 2011, The social dimension of sustainable development: Defining urban social sustainability, *Sustainable Development*, 19, 289–300.
[19] Moir, L., 2001, What do we mean by corporate social responsibility? *Corporate Governance: The international journal of business in society*, 1, 16 – 22.
[20] Dincer, C., Dincer, B., 2007, Corporate Social Responsibility: Future Prospects in the Turkish Context, *Social Responsibility Journal*, 3, 44 – 49.
[21] Chen, C.H., 2011, The major components of corporate social responsibility, *Journal of Global Responsibility*, 2, 85 – 99.
[22] Málovics, G., Csigéné, N.N., Kraus, S., 2008, The role of corporate social responsibility in strong sustainability *The Journal of Socio-Economics*, 37, 907–918.
[23] Saeidi, S.P., Sofian, S., Saeidi, P., Saeidi, S.P., Saaeidi, S.A., 2015, How does corporate social responsibility contribute to firm financial performance? The mediating role of competitive advantage, reputation, and customer satisfaction, *Journal of Business Research*, 68, 341–350.
[24] Armstrong, J.S., Green, K.C., 2013, Effects of corporate social responsibility and irresponsibility policies, *Journal of Business Research*, 66, 1922–1927.
[25] Gossling, T., Vocht, C., 2007, Social role conceptions and CSR policy success. *Journal of Business Ethics*, 47, 363–372.
[26] Van Beurden, P., Gössling, T., 2008, The worth of values — A literature review on the relation between corporate social and financial performance, *Journal of Business Ethics*, 82, 407–424.

[27] Nicolăescu, E., Alpopi, C., Zaharia, C., 2015, Measuring Corporate Sustainability Performance, *Sustainability*, 7, 851-865.
[28] Aguinis, H., Glavas, A., 2012, What We Know and Don't Know About Corporate Social Responsibility: A Review and Research Agenda, *Journal of Management*, 38, 932-968.
[29] Carroll, A.B., 1999, Corporate social responsibility, *Business & Society*, 38, 268-295.
[30] Garriga, E., Melé, D., 2004, Corporate social responsibility theories: Mapping the territory, *Journal of Business Ethics*, 53, 51-71.
[31] Waddock, S.A., 2004, Parallel universes: Companies, academics, and the progress of corporate citizenship. *Business and Society Review*, 109, 5-42.
[32] Watts, P., Holme, L., 1999, *Corporate social responsibility: meeting changing expectations*. World Business Council for Sustainable Development, Geneva.
[33] Aguinis, H., 2011, Organizational responsibility: Doing good and doing well. In S. Zedeck (Ed.), *APA handbook of industrial and organizational psychology* (Vol. 3), 855-879, Washington, DC: American Psychological Association.
[34] Arikan, E., Kantur, D., Maden, C., Telci, E. E., 2014, Investigating the mediating role of corporate reputation on the relationship between corporate social responsibility and multiple stakeholder outcomes, *Quality & Quantity*, 1-21, DOI: 10.1007/s11135-014-0141-5.
[35] Caulfield, P.A., 2013, The evolution of strategic corporate social responsibility, *EuroMed Journal of Business*, 8, 220 – 242.
[36] Ahi, P., Searcy, C., 2013, A comparative literature analysis of definitions for green and to supply chain decisions, *Journal of Cleaner Production*, 52, 329-341.
[37] Van Marrewijk, M., 2003, Concepts and definitions of CSR and corporate sustainability: between agency and communion, *Journal of Business Ethics*, 44, 95-105.
[38] Hediger, W., 2010, Welfare and capital-theoretic foundations of corporate social responsibility and corporate sustainability, *The Journal of Socio-Economics*, 39, 518–526.
[39] Morimoto, R., Ash, J., Hope, C., 2005, Corporate social responsibility audit: from theory to practice, *Journal of Business Ethics*, 2005, 62, 315–25.
[40] Dahlsrud, A., 2008, How corporate social responsibility is defined: an analysis of 37 definitions, *Corporate Social Responsibility and Environmental Management*, 15, 1-13.
[41] Cruz, J.M., 2009, The impact of corporate social responsibility in supply chain management: Multicriteria decision-making approach, Decision Support Systems, 48, 224–236.

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Sustainable Project Management and Sustainability-Focused Projects: A Brief Summary

Ayşe Ayçim Selam[1], Mahmure Övül Arıoğlu Akan[2]

Abstract

Life cycle management and its contribution with sustainability evaluate the projects with the environmental, economic and social effects of a project's life. In other words, with the sustainability aspect in project management, a project is organized with measurable sustainable standards and the consequences caused by the project contain sustainable attributes. Even though this sustainability point of view has a rising significance in project management literature another important approach is managing sustainability focused projects around the world. "Without endangering the next generation's needs" is the main concept of sustainability. From this point of view, in order to inherit a habitable world for the next generations, sustainability projects are being conducted in a variety of areas. Having gained attention by the public, sustainability projects developed special assessment tools, instruments, processes, and methodologies to evaluate and apply sustainability around the world. However, each type of project revealed its own methodologies and the projects can be classified according to these techniques. As well as methodologies, evaluation criteria and indicators are also established for sustainability projects literature. In this study, sustainable project management is summarized and the sustainability focused projects around the world is researched.

Keywords: Sustainability, Project Management

Introduction

Today, sustainability concept is being integrated in many areas as well as project management domain. This term is being handled in two different aspects in project management. The former one is sustainable project management which balances environmental, economic, and social areas of sustainability with life cycle management. Here, the projects are designed by taking into consideration the effects to the global society. The projects are organized with measurable sustainable standards so that the consequences caused by the project contain sustainable attributes. This approach provides a basis for sustainable development where the natural resources are being protected for next generations and their needs are not endangered as defined in Brundtland Report, 1987 [1].

Even though this sustainability point of view has a rising significance in project management literature another important approach is managing sustainability focused projects around the world. In order to inherit a habitable world for the next generations, sustainability projects are being conducted in a variety of areas. Some examples of these projects are; sustainability of drinking water, wetland, drainage, forest areas, fisheries, waste management and agriculture areas.

[1] Ayşe Ayçim Selam, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, aselam@marmara.edu.tr
[2] Mahmure Övül Arıoğlu Akan, Marmara University, Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, ovul@marmara.edu.tr

Having gained attention by the public, sustainability projects developed special assessment tools, instruments, processes, and methodologies to evaluate and apply sustainability around the world. However, each type of project revealed its own methodologies and the projects can be classified according to these techniques. As well as methodologies, evaluation criteria and indicators are also established for sustainability projects literature. In this study, sustainable project management is summarized and sustainability focused projects around the world is researched.

Sustainable Project Management

The three well-known concepts of sustainability are environmental, economic and social aspects. A sustainable atmosphere is provided by balancing and harmonizing these three aspects [2]. In Figure 1, the intersection of the three components can be found.

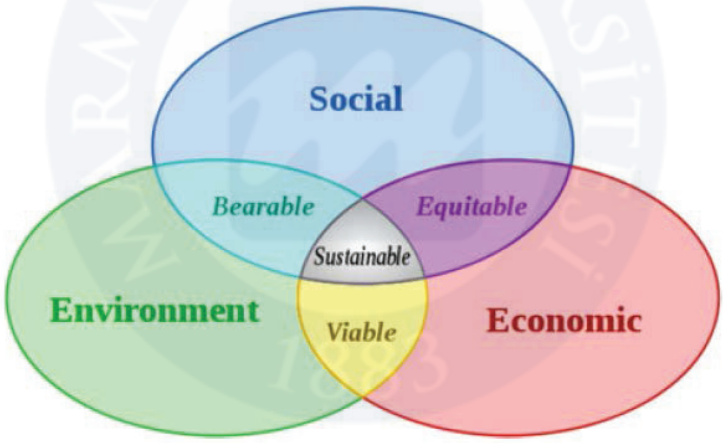


Figure 1. The three components of sustainability [3]

In order to integrate sustainability and project management Silvius (2012) defined the 6 principal of sustainability [3]:

1. Sustainability is about balancing or harmonizing social, environmental and economical interests.
2. Sustainability is about both short term and long term orientation.
3. Sustainability is about local and global orientation.
4. Sustainability is about consuming income, not capital.
5. Sustainability is about transparency and accountability.
6. Sustainability is also about personal values and ethics.

Projects are jobs which have a start and finish point in other words temporary, however sustainable development must provide permanent effects [4]. The contrast between these two is given in Table 1.

Table 1. The contrast between the concepts of sustainable development and projects [3]

Sustainable Development		Project Management
Long term + short term oriented	⟷	Short term oriented
In the interest of this generation and future generations	⟷	In the interest of sponsor/ stakeholders
Life cycle oriented	⟷	Deliverable/result oriented
People, planet, profit	⟷	Scope, time, budget
Increasing complexity	⟷	Reduces complexity

Sustainability Projects

Governments, municipalities and special organizations perform a variety of projects in order to protect the environment and inherit to the next generations. These projects are conducted on environmentally protected areas to make a living for today's population and sustain it for the future population. Most popular sustainability oriented projects:

- Agriculture Projects
- Fisheries Projects
- Water & Wetland Management Projects
- Waste Management Projects

In this study, examples of these projects are investigated and a literature survey for each type is provided below. Finally, a summary of the literature is given in Table 2.

Sustainable Agriculture Projects

On the livelihoods of rural people the degradation of natural resources leads to desperate and poor agricultural practices [4]. Sustainable agriculture works with natural processes to conserve all resources and minimize waste and environmental damage, while maintaining or improving farm profitability [5]. Principles of sustainable agriculture are defined by Gerber (1992), and the sustainable agriculture projects aim to provide these goals [6].

- A sustainable agricultural system is based on the prudent use of renewable and/or recyclable resources.
- A sustainable agricultural system protects the integrity of natural systems so that natural resources are continually regenerated.
- A sustainable agricultural system improves the quality of life of individuals and communities.
- A sustainable agricultural system is profitable.
- A sustainable agricultural system is guided by a land ethic that considers the long-term good of all members of the land community.

It is foreseen that in the next four decades food production will have to be increased 70% at least, by using the same area of land, with increasing costs of energy and other inputs, and under evident climate change [7]. For this reason, sustainable agriculture gains importance around the world and maintaining the agriculture lands to the next generations is vital for human existence.

Sustainable Fisheries Projects

Once believed to be inexhaustible resources, many of the world's commercially harvested fish populations have now reached a point of crisis [8]. Over the last two decades, demands by fish harvesters for greater input into policy-making, combined with government cutbacks to fisheries management agencies, have resulted in a proliferation of community-based fisheries co-management projects in many countries [9]. However, mono-disciplinary research and scientific paradigms have approached their limits in fisheries, both in terms of costs and utility, now it is apparent that the future for policy related research lies in an interdisciplinary approach incorporating the natural, economic and social sciences centralizing ecosystem integrity, economic viability and social equity [10]. This approach indicates sustainability and the importance of sustainable fisheries for managing fisheries policy.

Sustainable Water & Wetland Management Projects

Water management, sustainable agriculture, and food security are the key issues that dominate current policy debates in most developing countries of Asia and Africa [11]. The quality of the marine environments and coasts has a big role in the ecological integrity of the environment as well as in the economy with the fishing, tourism, transport, trade and industrial activities [12]. Because of this, academicians and government officials have advocated incorporating ecosystem services into

environmental policy-making processes [13]. For instance, marine protected areas are often recommended as tools for meeting management objectives for the marine environment and, in some cases, the creation of marine protected areas has become a management objective [14]. Similarly, sustainable management of wetlands as a part of water resources and a major component of water resources, are crucial to life-support functions, human health and the natural environment is especially important [15]. Therefore, wetlands are vital to the functioning of any economy in the world, providing the necessary inputs to production in several economic sectors such as agriculture, industry, tourism and household consumption [16].

Sustainable Waste Management Projects

Waste is often the result of inefficient use of natural resources or a potential product in the wrong place [17]. Government policy and development of sustainable waste management programs is becoming increasingly important to local authorities. For a waste management system to be sustainable, it needs to be environmentally effective, economically affordable and socially acceptable [17]. An extensive review of waste management practices across Africa has concluded that the most sustainable way to manage waste in the majority of urban communities is to [18]:

- remove dry recyclables by scavenging, through door to door collection, and/or a dirty materials recovery facility;
- compost the remaining biogenic waste in windrows, using the maturated compost as a substitute fertilizer; and
- dispose reject fossil carbon (plastics, synthetic textiles, metals) and inert waste in sanitary landfills.

Conclusions

In this study, a summary of sustainable project management is provided and how sustainability is integrated into project management is defined. Furthermore, the conflict between project management and sustainability is described. Afterwards the sustainability focused projects is researched and a brief summary of the types for these are given.

It is seen in the literature that sustainability focused projects has rising importance around the world. The projects are analyzed and evaluated by different methods. However, a management tool is not defined to assess projects and their success. So, it is thought that a methodology for assessing sustainability-focused projects will contribute improvement to the literature. This methodology can be constituted for each type of project separately, as each type has different variables and success factor. Another contribution can be provided by defining variables according to sustainability components (environmental, economic, and social). Especially, social factors are less indicated, than the other two in literature. As a future study, a project management methodology for sustainability-focused projects is planned to be formed for social issues and social success evaluation.

Table 2. Examples of Sustainability-Focused Projects from Literature

Author & Year	Sustainability Project Type	Area (if provided)	Method	Major Findings
Mölsa et al. (2002) [20]	Fisheries	Finland, Lake Tanganyika	Ecosystem Monitoring	• The institutional sustainability is required to harmonise legal arrangements and establish regional organization. • The project results show the lake fisheries are best managed for the whole lake rather than separately by each country.
Morissey (2005) [17]	Waste	Ireland	Survey	• In order to enhance the understanding of the social issues associated with the implementation of waste management policy in Ireland, a project is underway which examines participation in, perceptions of, and attitudes and responsibilities towards recycling. • The results of a pilot study are presented in the paper and social indicators are determined for waste management.
Shi & Gill (2005) [21]	Agriculture	China, Jinshan County	A system dynamics model	• A system dynamics model is developed to explore the potential long-term ecological, economic, institutional and social interactions of ecological agricultural development through a case study of Jinshan County in China. • Model is a feasible integrated tool to provide insight into the policy analysis of ecological agriculture, and sets a solid basis for effective policy making to facilitate sustainable development on a regional scale.
Davis et al. (2006) [9]	Fisheries	Bonavista Bay, Newfoundland, Eastport Project	Interviews	• By developing partnerships with government, researchers, public schools, and media outlets, the Eastport Peninsula Lobster Protection Committee has been successful in developing and promoting a unique approach to lobster conservation based on exclusive harvesting rights and a diverse array of conservation initiatives, including closed areas.
Mulder & Brent (2006) [4]	Agriculture	South Africa, LandCare Programme	Analytical Hierarchy Process	• The development of a new set of project selection criteria for the evaluation of project proposals in order to compile an effective LandCare programme portfolio is summarized.
Birol et al. (2008) [15]	Wetland	Cyprus, Akrotiri Wetland	A Contingent Valuation Study	• The results of the contingent valuation case study indicate that the public, both users and non-users of the resource, derive positive and significant economic values from sustainable management of the Akrotiri wetland.
Can & Alp (2012) [12]	Water	Turkey, Gocek Bay	Choice Experiment Method	• The environmental benefits can be obtained with improved water quality and restored marine ecosystem
Couth & Trois (2012) [19]	Waste	South Africa, Clean Development Projects	Sustainability Assessment	• The sustainability analysis shows that waste recycling and composting is beneficial over controlled landfilling, although uncontrolled dumping of waste as practiced across sub-Saharan Africa is cheaper in the short term.

Table 2. Examples of Sustainability-Focused Projects from Literature (continued)

Author & Year	Sustainability Project Type	Area (if provided)	Method	Major Findings
Mapedza et al. (2012) [22]	Wetland	Zambia, Lukanga	Qualitative Study	• In Lukanga, proposed developments in the name of poverty alleviation are more likely to result in the exclusion of poor local communities from the wetlands. • Any poverty alleviation strategy must take into account unequal power interests and ensure that developments made in the name of the poor really do benefit the poor.
Bobojonov et al. (2013) [23]	Agriculture	Khorezm, Uzbekistan, Aral Sea basin	A Mathematical Simulation Model	• Greater crop diversity can increase water use efficiency, • Secure farm income in dryland areas prone to water scarcity and soil salinity, • Crop diversification could secure income of downstream farmers during the climate-driven decline in water availability, and • Greater crop diversity and improved access to markets can lead to a sustainable development path in the region.
Phillipson & Symes (2013) [10]	Fisheries	-	Review	• The case for interdisciplinary research and call for renewed and deliberate efforts to build capacity for interdisciplinary working within research projects, programmes and institutions is reviewed.

MARMARA ÜNİVERSİTESİ

References

[1] Our Common Future: Report of the World Congress on Environment and Development, 1987, (Brundtland Report), A/42/427, United Nations Documents, http://www.un-documents.net/ocf-02.htm#I.
[2] Elkington, J., 1997, *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*, Capstone Publishing Ltc, Oxford.
[3] Silvius, G., 2012, Change the Game: Sustainability in Projects and Project Management, *Business Process Management – Towards the Environmentally Sustainable Enterprise*, 161-177.
[4] Mulder, J, Brent, A. C., 2006, Selection of Sustainable Rural Agriculture Projects in South Africa: Case Studies in the LandCare Programme, *Journal of Sustainable Agriculture*, 28:2, 55-84.
[5] Chel, A., Kaushik, G., 2011, Renewable Energy for Sustainable Agriculture, *Agronomy for Sustainable Development*, 31, 91-118.
[6] Gerber J.M., 1992, Farmer Participation in Research: A Model for Adaptive Research and Education, *American Journal of Alternative Agriculture*, 7, 118-121.
[7] Lobell, D.B., Cassman, K.G., Field, C.B., 2009. Crop Yield Gaps: Their Importance, Magnitudes, and Causes, *Annual Review of Environment and Resources*, 34, 179-204.
[8] United Nations Environment Program, (2002), *Global Environmental Outlook-3 (GEO-3)*, Earthscan, London.
[9] Davis, R., Whalen, J., Neis, B., 2006, From Orders to Borders: Toward a Sustainable Co-managed Lobster Fishery in Bonavista Bay, Newfoundland, Human Ecology, 34, 851-867.
[10] Phillipson, J., Symes, D., 2013, Science for Sustainable Fisheries Management: An interdisciplinary approach, Fisheries Research, 141, 13-23.
[11] Saleth, R.M., 2013, Water Management, Food Security and Sustainable Agriculture in Developing Economies, *International Journal of Water Resources Development*, 29/4, 678-683.
[12] Can, Ö., Alp, E., 2012, Valuation of environmental improvements in a specially protected marine area: A choice experiment approach in Göcek Bay, Turkey, *Science of the Total Environment*, 439, 291-298
[13] Ko, J.-Y., Day, J. W., Lane, R. L., Hunter R., Sabins D., Pintado, K. L., Franklin, J., 2012, Policy adoption of ecosystem services for a sustainable community: A Case Study of Wetland Assimilation Using Natural Wetlands in Breaux Bridge, Louisiana, *Ecological Engineering*, 38, 114-118.
[14] Jennings, S., 2009, The Role of Marine Protected Areas in Environmental Management, *ICES Journal of Marine Science*, 66, 16– 21.
[15] Birol, E., Koundouri, P., Kountouris, Y., 2008, Integrating Wetland Management into Sustainable Water Resources Allocation: The Case of Akrotiri Wetland in Cyprus, *Journal of Environmental Planning and Management*, 51/1, 37-53.
[16] United Nations Environment Program (UNEP), 2005, *Vital Water Statistics*.
Available at: http://www.unep.org/vitalwater/
[17] Morrissey, A., 2005, Indicators for Sustainable Waste Management, *Waste: The Social Context 2005 Conference Proceedings*, 488-496.
[18] Couth, R., Trois, C., 2010, Carbon Reduction Strategies in Africa for Improved Waste Management: A Review, Waste Management, 32, 2115-2125.
[19] Couth, R., Trois, C., 2012, Sustainable Waste Management in Africa through CDM Projects, Waste Management, 32, 2115-2125.
[20] Mölsa, H., Sarvala, J., Badende, S., Chitamwebwa, D., Kanyaru, R., Mulimbwa, M., Mwape, L., 2002, Ecosystem Monitoring in the Development of Sustainable Fisheries in Lake Tanganyika, *Aquatic Ecosystem Health & Management*, 5(3), 267-281.
[21] Shi, T., Gill, R., 2005, Developing Effective Policies for The Sustainable Development of Ecological Agriculture in China: The Case Study of Jinshan County With A Systems Dynamics Model, *Ecological Economics*, 53, 223-246.
[22] Mapedza, E., Geheb, K., van Koppen, B., Chisaka, J., 2012, Narratives from a Wetland: Sustainable Management in Lukanga, Zambia, *Development Southern Africa*, 29 (3), 379-390.
[23] Bobojonov, I., Lamers, J. P. A., Bekchanov, M., Djanibekov, N., Franz-Vasdeki, J., Ruzimov, J., Martius, C., 2013, Options and Constraints for Crop Diversification: A Case Study in Sustainable Agriculture in Uzbekistan, *Agroecology and Sustainable Food Systems*, 37, 788-811.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Business Processes as a Source of Competitive Advantage

Rıfat Kamaşak[1], *Meltem Yavuz*[2]

Abstract

Consistent with resource-based theory (RBV), business processes have had significant effects on firm performance. An examination of the resource-based view literature leads to the identification of business processes that are associated with the systems (e.g., intranet, EDI, and ERP) which support inter-functional coordination of activities for acquiring supplies and other raw materials along with optimising logistics and warehousing activities (e.g., supply chain systems), and other IT-based activities that help information processing about customers and markets (e.g., CRM). Business processes are internal in nature unlike other intangible resources (i.e., reputational resources such as corporate reputation and brand). Resources that are internal in nature can be difficult for competitors to replicate since it possesses the conditions of asset specificity and time compression diseconomies. Therefore, they may provide greater contribution to firm performance compared to other resources that are developed externally. This study aims to analyse the relative impact of business processes on firm performance compared to reputational resources. Hence, a self-administrated questionnaire was conducted on a sample of 161 Turkish firms which operate in different industries. The regression analysis results showed that whilst business processes provided greater contributions to the profitability and market share figures compared to reputational resources, no greater contribution was found on the sales turnover figures.

Keywords: Business Processes, Firm Performance, Reputational Resources, Regression Analysis

Introduction

RBV suggests that firm-specific intangible resources which provide important advantages to firms are the most desirable resources in sustaining competitive advantage [1, 2]. Wernerfelt [1] theorised that resources were leveraged inside the firm and that each firm had a unique resource endowment [3]. These identified firm-specific intangible resources can be described as employee know-how [4, 5], firm-specific tacit knowledge [6, 7], human capital [8, 9], innovation [10], customer relationships [11, 9], firm reputation and organisational culture [12, 13], social capital [14], entrepreneurial skills [15], business processes [16, 17] and information technology [18, 17]. In the past, several researchers [19] conducted research activities in order to offer practical contributions to executives and managers about their resource investment decisions by revealing the key determinants of firm success and their relative importance on performance. Some [18, 16, 17] suggest that the resources that are developed internally may provide greater contribution to firm success since they address the isolating mechanisms; *historical uniqueness*, *causal ambiguity*, *social complexity*, *time compression diseconomies* and *interconnectedness* which make resources inimitable [20].

Business processes as internally developed capabilities and their relationship with firm performance was searched in strategic management literature. Whilst Ray *et al.* [16] found a strong relationship between the customer services process and performance figures, in a more recent study, Weigelt [21] who examined the effects of suppliers' IT capabilities on the performance of client firms on market arrangements along with financial performance by using the archival data on 964 U.S. credit unions contracting with 22 technology solution providers indicated a strong relationship between suppliers' IT capabilities and client firms' performance. However, other researchers [22, 23, 24] claim that reputational resources that are external in nature and derived mostly from the perception of external constituents (the only exception can be employees) such as shareholders, customers, suppliers, distributors, and even competitors and governments may provide the same contribution to firm success. Roberts and Dowling [12], and Boyd *et al.* [24] tested the relationship between the reputation constructs (*e.g.*, brand reputation, corporate image) and firm performance. Their studies yielded results that prove a positive correlation between reputation and firm performance.

[1] Rıfat Kamaşak, Yeditepe University, Faculty of Commerce, Istanbul, Turkey, rkamasak@yeditepe.edu.tr
[2] Meltem Yavuz, Istanbul University, School of Transportation and Logistics, Istanbul, Turkey, meltem.yavuz@istanbul.edu.tr

The following section provides the details with regard to business processes along with reputational resources that contribute to firm performance.

Business Processes that are Developed Internally versus Reputational Resources that are Developed Externally

Business processes are "actions that firms engage in to accomplish some business purpose or objective" [16]. Business processes such as intranet and ERP software that support inter-functional coordination of activities, processes for acquiring supplies and other raw materials along with optimising logistics and warehousing activities [supply chain systems], and other IT systems that help information processing about customers and markets [CRM] provide firms agility and enable them to respond market demands quickly [17]. Furthermore, effective IT and SCM systems help firms to address market needs (*i.e.*, changing product ranges and/or accelerating product logistics) rapidly. Supply chain refers to a number of "value adding relations of partially discrete, yet inter-reliant, units that cooperatively transform raw materials into finished products through sequential, parallel, and/or network structures" [25]. As a business process, an effective supply chain system enables a firm to transmit its raw materials, finished goods, and services in a seamless way [25, 26]. Supply chain management is implemented through specific IT skills and ERP software that are produced by the firms like SAP and Oracle and integrates the whole business functions in the most effective and optimised manner. As a consequence, the firms that embark on supply chain management find substantial improvements in production costs and order fulfilment cycling times (the length of time between taking an order and delivery of the needed product to the customer) that are directly linked to firm performance [16, 25].

According to Ray *et al.* [17], ERP systems do not only help firms to integrate their production related functions but they also "enable firms to replicate and propagate administrative innovations *(e.g.*, organisational resources) and deploy their brand and customer base – relational capital – across a wide variety of markets" [17] by providing enterprise-wide platforms (*e.g.*, B2B). Hence, ERP systems *reconfigure* the resource base of firms by deploying and extending valuable organisational and relational resources broadly through a number of tools and infrastructures. An ERP system can be acquired in factor markets by other competitors as well and this prevents a supply chain management system be considered as a dynamic capability that addresses the strategic resources criteria of Barney [27] and asset stock accumulation ideas of Dierickx and Cool [20]. However, Barney [26] states that "home grown purchasing and supply chain management capabilities — that is, capabilities built organically, within the boundaries of a firm — are more likely to be sources of advantage". Given the explanations about the relationship between business processes and firm performance, it is likely to conclude that business processes are among the determinants of firm success.

Reputational resources refer to the intangible assets that develop positive feelings such as high-esteem, regard, and confidence across stakeholders of the firm by influencing their perceptions [22, 12, 13]. The impact of reputational resources comprised of brand name, corporate image/reputation, customer service reputation, product/service reputation on firm performance was frequently emphasised in management literature. Reputational resources positively influence impressions, perceptions, and beliefs of the customers, suppliers, competitors and other stakeholders by providing a good deal of information about firms [13]. Because reputational resources inform consumers and other stakeholders about the trustworthiness, credibility, and quality of the firm, they give occasion to the valuable repercussions on firm performance such as maintaining long-lasting relationships with customers and suppliers, creating brand loyalty, and attracting new customers that, in turn, lead firms to achieve superior financial [12, 13]. Although reputation is not legally protected by property rights, may not be acknowledged as a path-dependent asset which is characterised by specificity and social complexity, and create a resource position barrier, Porter [28] argues that competitors can be deterred from entering markets through a strong reputation and erosion of firm performance can be protected. In order to reveal the unique nature of reputational resources, Dierickx and Cool [20] stress the non-tradable and economic benefits provision features of reputation.

Business processes are internal in nature unlike reputational resources that were developed externally. Resources that are internal in nature can be difficult for competitors to replicate since it possesses the conditions of asset specificity and time compression diseconomies. A number of researchers [27, 29, 30]

linked the conditions under which resources are valuable to context dependency. Priem and Butler [30] suggest that level of the interaction of a resource with the organisational strategy and external environment is the main determinant of the value of a certain resource. Value can be attributed to a resource as long as it enables a firm to exploit market opportunities or neutralise threats from competitors. In other words, a resource can be deemed as valuable when it improves the market efficiency and effectiveness of the owner firm. Business processes were used by firms to create unique strategies and particular business models became socially complex and causally ambiguous resources over time that were difficult to be duplicated for rivals and cannot be purchased in the factor markets.

A similar and good example to the creation of competitive advantage through this kind of a business process ownership is "the cross-docking system of retail giant Wal-Mart" [31]. In the early years of Wal-Mart, whilst supply chain system of the firm contained commodity-type of information technologies that can be obtained easily in the factor markets, the system underwent such a complex customisation over years that none of the competitors could afford to imitate it. Given their unique nature that stems from social complexity, causal ambiguity, path-dependency, and asset specificity, business processes that offer economic benefits to firms which cannot be easily acquired and replicated seemed to have a higher impact on firm success than reputational resources that were developed externally. Therefore, this study offers the following hypothesis:

H_1: Business processes will make a larger contribution to firm performance than that of reputational resources.

Methods

In order to analyse the relative impact of business processes on firm performance compared to reputational resources, a self-administrated questionnaire was conducted on a sample of Turkish firms which operate in different industries. The sample was selected from the database of Istanbul Chamber of Industry (ISO) that announced the largest 1,000 firms of Turkey (ISO-1000). A total of 161 useable questionnaires were obtained from 1000 firms which yield a response rate of 16.1%. Three construct categories that are, business processes, reputational resources and firm performance constructs along with an additional control variable category was used as the measurement instrument. The questionnaire was consisted of a total number of 27 items: 9 items to measure the effects of business processes that include the questions with regard to intranet, EDI, ERP, SCM, and CRM [25, 16, 17], 8 items to measure the effects of reputational resources that include the questions with regard to brand name, corporate image, customer service reputation, and product/service reputation [12, 32, 13], 5 questions to control the effects of industry structure factors [33], 3 questions to measure market and financial performance [34], and 2 questions for the demographics (age and size).

Analysis and Results

Regression analysis (specifically, multiple hierarchical regression analysis) was used as the quantitative analysis technique to test the established hypotheses. In hierarchical regression method, each set of independent variables is entered into separate blocks for analysis and the incremental changes of the R^2 statistic which are assessed "as an indicator of the fraction of the variance explained by each independent variable" [31] are calculated. Hence, the explanatory power or in other words, the unique contribution of each independent variable in explaining dependent variable is explored. According to the results, the established hypothesis was accepted (Table 1). Mathematical explanation for the hypothesis is:

(Model 1) $FP = \beta_0 + \beta_1 AGE + \beta_2 SIZE + \beta_3 IND + \beta_4 REPT$
(Model 2) = (Model 1) + $\beta_5 BPROC$

FP = Firm performance, including sales turnover, market share, and profitability
β_0 = Constant
AGE = Firm age
SIZE = Firm size
IND = Industry structure factors
REPT = Reputational resources
BPROC = Business processes

Table 1. Results of the Statistical Analysis

	Sales turnover		Market share		Profitability	
Variables	*β*	*t*	*β*	*t*	*β*	*t*
Constant	–	5.104**	–	4.963***	–	6.757*
AGE	.021	.298	-.059	-.271	-.053	-.267
SIZE	.006	.643	.038	.732	-.036	-.712
IND	.063	1.101***	.148	1.549**	-.022	-1.668
REPT	.298	2.099*	.112	1.306**	.315	2.629**
BPROC	.203	1.086*	.184	1.997*	.549	3.998*
Model 1 (w/out BPROC)						
R^2	.165		.123		.216	
F	1.987**		1.632***		3.864**	
Model 2 (with BPROC)						
R^2	.169		.177		.319	
ΔR^2 (Change in R^2)	.004		.054		.103	
F	1.633		3.028*		5.752***	

*$p<0.05$; **$p<0.01$; ***$p<0.001$

Model 1 shows the separate effects of control variables (age, size and industry factors) along with the reputational resources (REPT) and their explanatory power in firm performance (see table 1). Namely, without other variables, age, size, industry factors and REPT explained 16.5% [($R2$ = .165); (F = 1.987, p<0.01)] of sales turnover, 12.3% [($R2$ = .123); (F = 1.632, p<0.001)] of market share, and 21.6% [($R2$ = .216); (F = 3.864, p<0.01)] of profitability. Having entered the business processes variable (BPROC) to model 2, the variations in market share, and profitability increased to 17.7% [($R2$ = .177); (F = 3.028, p<0.05)], and 31.9% [($R2$ = .319); (F = 5.752, p<0.001)], respectively. Therefore, entrance of the BPROC variable provided an additional and significant explanation power 5.4% ($\Delta R2$ = .054) for market share, and 10.3% ($\Delta R2$ = .103) for profitability in model 2. However, entrance of the BPROC variable yielded a tiny and insignificant ($\Delta R2$ = .004) increase in sales turnover. Given the analysis results, whilst business processes provided greater contributions to the profitability and market share figures compared to reputational resources, no significant and greater contribution was found on the sales turnover figures. Thus, Hypothesis 1 (H_1) is only partially supported.

Conclusion

The findings of this study emphasise the vital role of business processes on the way of increasing financial performance within the context of dynamic Turkish business environment. However, the insignificant effect on sales turnover figures may be evaluated that business processes can contribute to financial performance through creating business effectiveness, and efficiency in production and operation functions of the firms. So, the effect may occur in the form of decreasing costs of manufacturing, delivery, and logistics. The effect of reputational resources on the way of increasing turnover was evident in the research. It is certainly true to say that Turkish consumers enjoy western-oriented richer consumption experiences and higher levels of convenience than most of the developed country consumers would aspire to [35]. Western and other global brands (including famous Turkish brands) are highly esteemed in the country. Hence, whilst Turkish firms should execute effective strategies and make necessary investments to create unique global brands, foreign firms that operate in Turkey should manipulate adequate marketing mixes which highlight western orientation of the product and deliver "good enough" quality at a lower price compared to developed economies. Besides, given the effects of reputational assets on performance, management should consider crafting, nurturing, and leveraging a positive corporate image and reputation as well as creating unique brands to achieve a high level of customer loyalty. Consequently, although allocation of resources in favour of business process development such as strengthening IT infrastructure, SCM and logistics systems should be a concern for managers and priority should be given to the business processes, importance of reputational resources should not be omitted to stimulate the sales turnover figures of the firms.

References

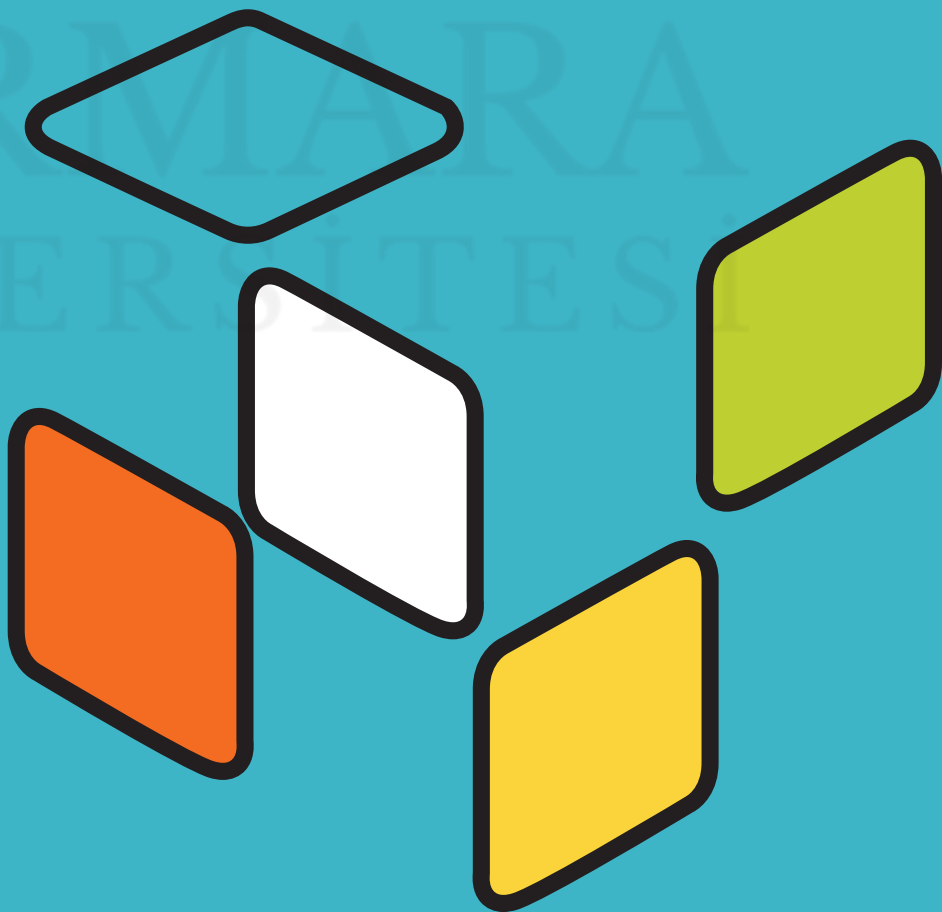
[1] Wernerfelt, B., 1984, A resource-based view of the firm, *Strategic Management Journal,* 5, 171–180.
[2] Peteraf, M., Barney, J.B., 2003, Unravelling the resource-based tangle, *Managerial and Decision Economics,* 24, 309–323.
[3] Lockett, A., O'Shea, R.P., Wright, M., 2008, The development of the resource-based view: Reflections form Birger Wernerfelt, *Organization Studies,* 29, 1125–1141.
[4] Hall, R., 1993, A framework linking intangible resources and capabilities to sustainable competitive advantage, *Strategic Management Journal,* 14, 607–618.
[5] Coff, R.W., 1999, When competitive advantage doesn't lead to performance: The resource-based view and stakeholder bargaining power, *Organization Science,* 10, 119–133.
[6] Wiklund, J., Shepherd, D., 2003, Knowledge-based resources, entrepreneurial orientation, and the performance of small and medium sized businesses, *Strategic Management Journal,* 24, 1307–1314.
[7] Wang, H.C., He, J., Mahoney, J.T., 2009, Firm-specific knowledge resources and competitive advantage: The roles of economic and relationship based employee governance mechanisms, *Strategic Management Journal,* 30, 1265–1285.
[8] Hitt, M.A., Bierman, L., Shimizu, K., Kochhar, R., 2001, Direct and moderating effects of human capital on strategy and performance in professional service firms: A resource-based perspective, *Academy of Management Journal,* 44, 13–28.
[9] Ambrosini, V., Bowman, C., Burton-Taylor, S., 2007, Inter-team coordination activities as a source of customer satisfaction, *Human Relations,* 60, 59–98.
[10] Palacios, D., Gil, I., Garrigos, F., 2009, The impact of knowledge management on innovation and entrepreneurship in the biotechnology and telecommunications industries, *Small Business Economics,* 32, 291–301.
[11] Aaker, D.A., 1989, Managing assets and skills: The key to a sustainable competitive advantage, *California Management Review,* 31, 91–106.
[12] Roberts, P.W., Dowling, G.R., 2002, Corporate reputation and sustained superior financial performance, *Strategic Management Journal,* 23, 1077–1093.
[13] Rindova, V.P., Williamson, I.O., Petkova, A.P., 2010, Reputation as an intangible asset: Reflections on theory and methods in two empirical studies of business school reputations, *Journal of Management*, 36, 610–619.
[14] Chisholm, M.A., Nielsen, K., 2009, Social capital and the resource-based view of the firm, *International Studies of Management and Organizational Studies,* 39, 7–32.
[15] Hoskisson, R.E., Eden, L., Lau, C.M., Wright, M., 2000, Strategies in emerging economies, *Academy of Management Journal,* 43, 249–267.
[16] Ray, G., Barney, J.B., Muhanna, W.A., 2004, Capabilities, business processes, and competitive advantage: Choosing the dependent variable in empirical tests of the resource-based view, *Strategic Management Journal,* 25, 23–37.
[17] Ray, G., Xue, L., Barney, J.B., 2013, Impact of information technology capital on firm scope and performance. The role of asset characteristics, *Academy of Management Journal*, 56, 1125–1147.
[18] Powell, T.C., Dent-Micallef, A., 1997, Information technology as competitive advantage: The role of human, business and technology resources, *Strategic Management Journal,* 18, 375–405.
[19] Galbreath, J., Galvin, P., 2006, Accounting for performance variation: How important are intangible resources?, *International Journal of Organizational Analysis,* 14, 150–170.
[20] Dierickx, I., Cool, K., 1989, Asset stock accumulation and sustainability of competitive advantage, *Management Science,* 35, 1504–1511.
[21] Weigelt, C., 2013, Leveraging supplier capabilities: The role of locus of capability deployment, *Strategic Management Journal,* 34, 1–21.
[22] Fombrun, C.J., Shanley, M., 1990, What's in a name? Reputation-building and corporate strategy, *Academy of Management Journal*, 33, 233–258.
[23] Michalisin, M.D., Smith, R.D., Kline, D.M., 1997, In search of strategic assets, *The International Journal of Organizational Analysis,* 5, 360–387.
[24] Boyd, B.K., Bergh, D.D., Ketchen, D.J., 2010, Reconsidering the reputation-performance relationship: A resource-based view, *Journal of Management,* 36, 588–609.
[25] Hult, G.T.M., Ketchen, D.J., Arrfelt, M., 2007, Strategic supply chain management: Improving performance through a culture of competitiveness and knowledge development, *Strategic Management Journal,* 28, 1035–1052.
[26] Barney, J.B., 2012, Purchasing, supply chain management and sustained competitive advantage: The relevance of resource-based theory, *Journal of Supply Chain Management,* 48, 3–6.
[27] Barney, J.B., 1991, Firm resources and sustained competitive advantage, *Journal of Management,* 17, 99–120.
[28] Porter, M.E., 1980, *Competitive strategy*, New York, NY: The Free Press.

[29] Conner, K.R., 1991, A historical comparison of resource-based theory and five schools of thought with industrial organization economics: Do we have a new theory of the firm?., *Journal of Management*, 17, 121–154.
[30] Priem, R.L., Butler, J.E., 2001, Is the resource-based "view" a useful perspective for strategic management research?, *Academy of Management Review*, 26, 22–40.
[31] Galbreath, J., 2004, Determinants of firm success: A resource-based analysis, *Unpublished Doctoral Dissertation*, Curtin University of Technology.
[32] Schroeder, R.G., Bates, K.A., Junttila, M.A., 2002, A resource-based view of manufacturing strategy and the relationship to manufacturing performance, *Strategic Management Journal*, 23, 105–117.
[33] Porter, M.E., 1985, *Competitive advantage*, New York, NY: Free Press.
[34] Spanos, Y.E., Lioukas, S., 2001, An examination of the causal logic of rent generation: Contrasting Porter's competitive strategy framework and the resource-based perspective, *Strategic Management Journal*, 22, 907–934.
[35] Haden, P., 2013, Why local firms are winning in emerging markets?, *Market Leader*. Retrieved October 12, 2013 from: https://www.marketingsociety.com/the-library/why-local-firms-are-winning-emerging-markets.

MARMARA ÜNİVERSİTESİ

MARMARA ÜNİVERSİTESİ YAYINEVİ

HUMAN RESOURSE MANAGEMENT



MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Applications of Quick Exposure Check in Industrial Tasks and A Proposed Improvement

Oğuzhan Erdinç [1]

Abstract

Assessment of exposure to physical and psychosocial risk factors that contribute to musculoskeletal problems has gained importance due to severe consequences of musculoskeletal disorders and discomfort on health and productivity of the industrial workforce. Ergonomics in industrial job design also necessitates detection and mitigation of these risk factors for better worker performance. The Quick Exposure Check (QEC) is a widely used exposure assessment method which addresses work related physical and psychosocial risk factors through observational assessment and self-report. The current study reviewed several applications of the QEC in industrial tasks such as; machine sewing, rubber production, bumper tape-masking, road building, electronics manufacturing, furniture manufacturing, and assessed applicability and effectiveness of the method. Associations of the QEC with subjective musculoskeletal discomfort were also discussed. The reviewed studies mostly supported the applicability and effectiveness of the QEC in exposure assessment studies. Addition of musculoskeletal symptom data collection part was proposed as an improvement to the method. In addition, potential future applications, such as computerization of the QEC were discussed. The study would be helpful to researchers and practitioners about use of the QEC in future exposure assessment studies.

Keywords: Quick Exposure Check, Musculoskeletal Risks, Exposure Assessment

Introduction

Musculoskeletal (MS) problems substantially deteriorate health and productivity of the industrial work force [1-7]. For example, Morken et al. [5] demonstrated that MS disorders accounted for 45% of total sickness absence among aluminium industry workers in Norway. Studies have shown that MS problems among the industrial work force mostly involve the upper extremities, back and low back [2,7-11]. In the UK, for instance, Sim et al. [11] found that one-month prevalence of neck and upper limb pain was 50.5% among ceramic industry workers. In India, MS discomfort prevalence in wrist and shoulders among brass metal workers were found to be 62% and 40% respectively [9]. Such severe consequences indicated that assessment of the factors leading to MS problems is highly important from occupational health perspective.

Literature reveals that exposure to various work-related physical and psychosocial risk factors contribute to occurrence of the MS problems [2, 3, 7, 11, 12]. Common work-related physical risk factors are awkward postures, prolonged static work, repetitive movements, manual material handling, forceful exertions and vibration [3, 7, 11]. Job dissatisfaction, stress at work and time pressure comprise major psychosocial factors related to MS problems [12-14]. Assessment of exposure to these risk factors is a focal part of efforts to combat MS problems. It is further propounded in literature that the work-related physical and psychosocial risk factors interact in the work environment [12-14]. Exposure assessment results can provide a basis for planning and prioritizing workplace interventions to address prevalent MS problems, as well as changes in the level of exposure to MS risks after interventions can be monitored by repeating the assessment. Therefore, assessment methods should fit industrial work environments and industrial tasks so that levels of exposure to work-related physical and psychosocial risk factors can be effectively identified and monitored [15].

[1] Oguzhan Erdinc, Turkish Air Force Academy, Department of Industrial Engineering, Istanbul, Turkey, oerdinc@hho.edu.tr

Many exposure assessment methods are observational and include self-report [15, 16]. While observational assessment includes quantification of exposure to risk factors by experts or practitioners (e.g. assessment of awkward postures by scoring the degree of deviation from neutral posture), self-report requires use of subjective data collection tools such as surveys or questionnaires [15, 16]. It is further recommended to employ at least two methods in conjunction to perform a comprehensive and scientifically sound exposure assessment [13, 16].

The Quick Exposure Check (QEC) is an exposure assessment method which combines observational assessment and self-report. The QEC was developed at the Robens Centre for Health Ergonomics, University of Surrey [13, 17-19]. The main purpose for the development of the QEC is to equip practitioners with a scientifically valid, reliable and practical exposure assessment tool [13]. The QEC was developed and validated through extensive applications in numerous work environments and tasks such as laboratory work, computer work and warehouse jobs [18]. The first version of the QEC was published in a research report in 1999 [18]. David et al [17] further improved the usability and validity of the tool published a revised version of the QEC in 2005. The QEC addresses several physical and psychosocial risk factors. The physical risk factors include the degree of awkward postures at various body parts (i.e. neck, back, shoulder/arm and wrist/hand), repetitive movements, manual materials handling, work duration, manual force exertion, visual demand, driving and use of vibrating tools. The psychosocial risk factors include work pace and stress. While postures, repetition and deviation from neutral are assessed by the observer, other risk factors are assessed using self-report of the worker. Assessments of the observer and the worker are then quantified through a combined exposure scoring system. Exposure scores represent a hypothetical relationship between exposure levels and potential health outcomes [13]. Exposure scores for postures (i.e. of the back, shoulder/arm, wrist/hand and neck), driving, use of vibrating tools, work pace and stress are calculated separately. Predetermined ranges of exposure scores indicate Low, Medium, High, and Very High risk levels. Interactions between exposures to awkward postures, work duration, maximum manually handled weight and visual demands are also taken into consideration within scoring. Özcan et al. [20] adapted and validated the QEC in Turkish language, and the Turkish Ministry of Labour, Department of Occupational Health and Safety published a guideline for using the Turkish version of the QEC and made the tool available to industry [33].

Numerous authors applied the QEC in variety of industrial environments and compared it with other tools and methods. For example, Chiasson et al. [29] compared eight risk assessment methods including the QEC, and suggested that the QEC was effective for initial screening and prioritizing interventions, easy and rapid to use, and it provides useful information about the root causes of risk factors. They also pointed to certain weaknesses of the tool such that the risk assessment could be biased based on workers' subjective inputs, and little guidance is provided about the target risk scores [29]. The developers of the tool have stressed that the feedback from field applications would be useful particularly to improve the applicability and effectiveness of the method especially for its scoring system [13].

In this respect, the current study reviewed the applications of the QEC in various industrial tasks and assessed the applicability and effectiveness of the method. Recommendations as to addition of MS symptom data collection part to the QEC were proposed. This review would be helpful to researchers and practitioners in using the QEC for exposure assessment studies.

Applications of the QEC in various industrial tasks

Machine sewing task

Erdinç and Vayvay [21] applied the revised version of the QEC [13,17] to machine sewing task. The study was performed in a Turkish mid-sized apparel manufacturing company as part of a project to improve manufacturing quality through ergonomic interventions. They applied the QEC before ergonomic interventions to identify prevalent risk factors. Thirty one machine sewing operators who perform sit-sewing task participated in the study. Work postures of the operators were video recorded while they perform the task. Responses of the operators for the worker's assessment part were taken in the workplace, and the observer's assessment was completed by analysing videos afterwards. Along with the QEC, a questionnaire which addressed the ergonomic problems in the work environment was applied

[21]. The QEC scores and questionnaire responses indicated that the main risk factor was exposure to awkward postures. A set of ergonomic interventions including ergonomics training, workstation adjustments and machine tilting were implemented in two machine sewing lines. After the interventions, the QEC and the questionnaire were replicated to assess changes in exposure to previously identified risk factors. The QEC risk scores for all body parts were significantly reduced and the risk levels at shoulder/arm, wrist/hand and neck were reduced to a lower level. Overall, the QEC was found to be highly applicable and effective in the assessment of exposure to physical risk factors in the sedentary machine sewing task.

Rubber production

Choobineh et al. [22] applied the QEC in an Iranian rubber factory where tasks involved substantial physical risk factors (e.g. manual material handling) and awkward postures. The objective of their study was to determine the prevalence of MS symptoms and to assess exposure to physical risk factors. In total, 454 workers participated in the study. The Nordic Musculoskeletal Questionnaire [23] (NMQ) was used to collect MS symptom data. They video recorded the workers during their routine job activities and performed observer's assessment by analysing the videos. The results revealed that the percentages of workers with low, moderate, high and very high exposure to physical risk factors were 4.4%, 10.1%, 37.5% and 48% respectively. Comparative analysis of the QEC scores and the NMQ responses indicated an association between reported MS symptoms and exposure to physical risk factors. The authors highlighted that the QEC provided reliable findings and was effective in assessing the exposure to physical risk factors in the work environment under study.

Bumper tape-masking task

Forsman et al. [24] combined the revised version of the QEC [17] with the VIDAR, a video - based ergonomic assessment software designed for ergonomists working in the occupational health services. The VIDAR application is based on video recording workers while they perform the task, and assessment of the risk factors by analysing the recordings. The authors implemented the revised version of the QEC [17] to VIDAR by adding interfaces that included both observer's and worker's assessment questions. Using VIDAR, enabled workers to participate in the assessment of their own videos. A preliminary application was conducted in a factory where workers tape-masked bumpers. Eight workers were video-recorded during the work-cycle and the workers and the ergonomist identifed eight physically demanding tasks. Subsequently, the ergonomist used the QEC-module to assess risk factors in these tasks. They concluded that the QEC-module was easy to learn and it reqiured reasonable effort to complete the assessments. Though the application was preliminary, the study indicated that computerizing the QEC would allow for more efficient and participatory exposure assessments.

Road building industry

Roja et al. [25] applied the QEC in road building industry to assess exposure to physical risk factors. In total 450 road construction workers participated in the study. The QEC was applied to road repairing, road levelling and paving tasks. It was found that exposure to physical risks prevailed in the back, shoulder/arm and neck in road repairing tasks, and in the back and wrist/hand in paving tasks. However associations between the QEC results and other methods were not explored. They concluded that the QEC could be suitably used for exposure assessment in the road building industry.

Electronics manufacturing

Timlin and O'Sullivan [12] investigated the relationship between psychosocial risk factors, physical risk factors and occurrence of MS problems in an electronics manufacturing plant where light industrial tasks were performed in three shift cycles. They applied the QEC to assess exposure to physical and psychosocial risk factors, used the NMQ [23] to survey prevalence of MS discomfort, and used the Job Content Questionnaire [12] (JCQ) to survey job strain. In total 54 workers participated in their study. The QEC was applied in 32 tasks performed in the day shift, and 18 tasks that represented highest, medium and lowest risk tasks were selected. Subsequently, NMQ and JCQ were applied to the same group of 54 participants. The QEC stress scores and physical risk scores in the shoulder and wrist/hand were found to be significantly related. They comparatively analysed the QEC and NMQ results and found no relationship between the QEC risk levels and prevalence of MS discomfort for the neck,

shoulder, back or wrist. The QEC and JCQ results were comparatively analysed and QEC risk categories and stress scores were not found to correlate with job strain. They concluded that the QEC was quick and easy to use, and relatively low-cost for exposure assessment. The tool was found to enable practitioners to identify salient physical risk factors quickly and without much interruption to the work. The authors stated that if the QEC addressed lower limb biomechanics, factors that cause poor back and neck postures, particularly for sedentary workers, could be identified more effectively.

Furniture manufacturing

Mirhahomadi et al. [26] applied the first version of the QEC [18] to assess risk factors related to MS symptoms in the furniture industry. The manual tasks carried out in the factory involved substantial physical risk factors. Along with the QEC, the NMQ was applied to collect MS discomfort data. The QEC was applied in 100 workplaces where physical operations were performed. The number of participants was not reported. They classified the tasks based on action levels; the percentages of tasks at first, second, third and fourth action levels were found to be 1%, 9%, 55% and 35% respectively. They reported a significant relationship between the QEC scores and prevalence of MS discomfort at the back and neck.

Oil palm harvesting

Sukadarin et al. [28] applied the QEC to assess ergonomic risk factors in oil palm harvesting task which included repetitive manual subtasks such as cutting fresh fruit brunches (FFB) using chisel or sickle. Collecting FFB is a demanding manual handling activity. They applied the QEC to assess risk factors in harvesting FFB from tall trees with seven workers across four subtasks; harvesting, loading FFB to the truck, loading FFB from the truck to the lorry, and driving the truck. They video recorded the task and found that loading FFB to the truck involved the highest risk levels for multiple body parts. They noted that the QEC lack lower limb assessment and therefore falls short in addressing certain postural problems particular to the harvesting task. They further pointed out that when asked to estimate the force they exert manually and weight of the loads they lift, low educated harvesting workers might not be able to provide reliable responses, which could adversely affect reliability of the assessment. The authors suggested that the expert involvement or objective measurements (e.g. for load weight) in responding questions for force exertion and manual lifting.

The reviewed stuides above are summarized in Table 1.

Discussion

The current study reviewed the applications of the QEC in various industrial tasks. The feedback from field applications was considered useful to examine applicability and effectiveness of the method.

The reviewed applications were carried out in machine sewing, rubber production, bumper tape-masking, road building, electronics manufacturing, furniture manufacturing and oil palm harvesting. All studied tasks and industrial environments involved physical risks, the foremost risk factor being the awkward postures. In all studies except Mirhahomadi et al. [26], and Sukadarin et al. [28], authors positively commented fort he applicability and effectiveness of the QEC. Sukadarin et al. [28] supported the finding of Chiasson et al. [29] as to the potential bias on the assessment due to unreliable worker inputs, especially with low-educated workforce. Furthermore, Timlin and O'Sullivan [12] argued that the QEC should address sedentary and standing work postures separately, as lower body biomechanics can influence exposure to physical risks. This point was not mentioned in other applications and the QEC was found effective in assessing physical risk factors in both sedentary (e.g. machine sewing) and standing(e.g. rubber production) tasks. Timlin and O'Sullivan [12] also proposed that 20° – 40° of flexion of the low back should be categorized as high risk level for sedentary workers.

Table 1. The reviewed applications of the QEC in industrial tasks

Application	Industry / Task	n	Associations between the QEC and other factors	Comments on the QEC
Erdinc and Vayvay [21]	Machine sewing	31	-	Highly applicable and effective
Choobineh et al. [22]	Rubber production	454	MS discomfort (+)	Reliable results, an appropriate tool
Forsman et al. [24]	Bumper tape-masking	8	-	Suitable for computer application
Roja et al. [25]	Road building industry	450	-	Suitable
Timlin and O'Sullivan [12]	Electronics manufacturing	54	MS discomfort (-) Job strain (-)	Quick and easy, cheap, provides ability to identify salient risk factors
Mirhahomadi et al [26]	Furniture manufacturing	-	MS discomfort (+)	-
Sukadarin et al [28]	Oil palm harvesting	7	-	Inadequate for assessing oil palm harvesting task, needs expert involvement when education level of the workers is too low

Addition of MS symptom data collection part to the QEC

The main motivation to investigate exposure to workplace risk factors is that these factors could lead to MS problems, which is an important concern in occupational health. Three of the abovementioned studies explored the associations between the QEC results and the occurrence of MS discomfort among workers. While Choobineh et al. [22] and Mirhahomadi et al. [26] reported significant associations between the QEC scores and the prevalence of MS discomfort, Timlin and O'Sullivan [12] found no relationship between the QEC scores and the occurrence of MS discomfort. These three studies pointed to the fact that researchers could need to assess MS symptoms in conjunction with exposure to MS risks. Subjective data is a major information source for MS discomfort stuides, and researchers widely use tools such as survey and questionnaires for collecting symptom data [12, 21, 22, 26, 30, 31, 32]. All three studies mentioned above used the NMQ [23] to collect MS discomfort data. Subjective data is further used to compare discomfort level after ergonomic interventions [21, 32]. While some authors use published and validated tools such as the NMQ [12, 22, 23, 26], others develop or custom-tailor the tools for their particular study [21]. In both ways, subjective tools are effectively used for collecting symptom data.

The attempts to collect symptom data along with the QEC indicated that adding a symptom data collection part to the method could contribute to its effectiveness. To that end, MS symptom data collection items for body parts addressed in the observer's assessment could be added to the method as a separate, optional section. The question could be worded as; "Do you experience ache, pain, tingling in your…" for each body part requiring responses on symptom frequency or severity scales. Addition of this section could meet the need to use another tool for combined assessment of risk factors and MS symptoms. Moreover, body part identifications could differ in other tools [12, 22, 23] and an important benefit of adding the symptom data part to the QEC is that the data can be collected for the exact body parts assessed in the method. Also, addition of the symptom data can enable researchers to assess intervention outcomes in terms of changes in prevalence of MS symptoms as well as the changes in risk levels.

Future applications of the QEC

Literature review indicates that the QEC is weightily applied for the assessment of physical risk factors. The literature emphasizes that psychosocial risk factors can contribute to the occurence of the MS problems [12-14] and thus, the QEC can serve to explore the interaction between physical risk factors, psychosocial risk factors, thereby providing valauble insight into to the mechanism of MS problems. Addition of MS symptom data collection part can significantly enhance analytic capabilities of the QEC and enable researchers to correlate MS symptoms not only with physical risk factors, but also with psychosocial risk factors.

Computerization of the assessment methods like the QEC introduces multiple improvements to the assessment process [24]. The QEC can be applied in pen-paper form [17 – 19] and when computerized, video analysis feature can help involve workers assess their own postures and observe the risks themselves. In addition, computation of the risk scores and reporting can be significantly more efficient using computer interfaces. Therefore, computerization of the QEC including the symptom data part has important merit for future studies. The digital capabilities that can expand the use of the QEC include developing mobile applications for the QEC so practitioners can use it more easily and efficiently in natural work environment.

Conclusions

The studies reviewed in this study provided evidence to the applicability and effectiveness of the QEC in most of the industrial tasks. Association between the QEC assessment results and the occurrence of MS symptoms was also explored in some of the reviewed studies and contradictory findings implied that further research is necessary to draw more concrete conclusions. Addition of self-report questions to collect MS symptom data to the QEC could enhance the effectiveness of the assessment. Furthermore, developing and using computerized versions of the QEC, including mobile applications, could enhance efficiency in the assessment process. Future applications of the QEC in different industrial tasks and work environments would provide more feedback regarding the applicability and effectiveness of the tool and would point to further improvements.

Acknowledgement

The author would like to express his gratitude to Professor David Stubbs for his valuable support to the study.

References

[1] Bureau of Labor Statistics (BLS), 2006, Nonfatal occupational injuries and illnesses requiring days away from work, http://www.bls.gov/news.release/pdf/osh2.pdf
[2] Buckle P.W., Devereux J.J., 2002, The nature of work-related neck and upper limb musculoskeletal disorders, *Applied Ergonomics* 33, 207-217.
[3] Choobineh A., Hosseini M., Lahmi M., Jazani R.K., Shahnavaz H., 2007, Musculoskeletal problems in Iranian hand-woven carpet industry: Guidelines for workstation design, *Applied Ergonomics* 38, 617-624.
[4] Marras W.S., Cutlip R.G., Burt S.E., Waters T.R., 2009, National occupational research agenda (NORA) future directions in occupational musculoskeletal disorder health research, *Applied Ergonomics* 40, 15-22.
[5] Morken T., Riise T., Moen B., Hauge S.H.V., Holien S., Lnagedrag A., Pedersen S., Saue I.L.L., Seljebo G.M., Thoppil V., 2003, Low back pain and widespread pain predict sickness absence among industrial workers, *BMC Musculoskeletal Disorders* 4, No: 21.
[6] Nelson N.A., Hughes R.H., 2009, Quantifying relationships between selected work-related risk factors and back pain: A systematic review of objective biomechanical measures and cost-related health outcomes, *International Journal of Industrial Ergonomics* 39, 202-210.
[7] Punnet L., Wegman D.H., 2004, Work-related musculoskeletal disorders: the epidemiologic evidence and the debate, *Journal of Electromyography and Kinesiology* 14, 13-23.
[8] Chee H.L., Rampal K.G., Chandrasakaran A., 2004, Ergonomic risk factors of work processes in the semiconductor industry in peninsular Malaysia, *Industrial Health* 42, 373-381.
[9] Gangopadhyay S., Ghosh T., Das T., Ghoshal G., Das B.B., 2007, Prevalence of upper limb musculoskeletal disorders among brass metal workers in West Bengal, India, *Industrial Health* 45, 365-370.

[10] Mazloum A., Nozad H., Kumashiro M., 2006, Occupational low back pain among workers in some small-sized factories in Ardabil, Iran. *Industrial Health* 44, 135-139.
[11] Sim J., Lacey R., Lewis M., 2006, The impact of workplace risk factors on the occurrence of neck and upper limb pain: a general population study, *BMC Public Health* 6, No: 234.
[12] Timlin T.M., O'Sullivan L.W., 2005, Are psychosocial risk factors higher in day or night workers? *in: Proceedings of the Irish Ergonomics Society Annual Conference*, 32-43.
[13] David G., Woods V., Li G., Buckle P., 2008, The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors fro work-related musculoskeletal disorders, *Applied Ergonomics* 39, 57-69.
[14] Macdonald L.A., Karasek R.A., Punnet L., Scharf T., 2001, Covariation between workplace physical and psychosocial stressors: evidence and implications for occupational health research and prevention, *Ergonomics* 44, 696-718.
[15] Spielholz P., Silverstein B., Morgan M., Checkoway H., Kaufman J., 2001, Comparison of self-report, video observation and direct measurement methods for upper extremity musculoskeletal disorder physical risk factors, *Ergonomics* 44, 588-613.
[16] Li G., Buckle P., 1999, Current techniques for assessing physical exposure to work-related musculoskeletal risks with emphasis on posture based methods, *Ergonomics* 42, 674-695.
[17] David G., Woods V., Buckle P., 2005, Further development of the usability and validity of the Quick Exposure Check (QEC), *HSE Books, Research Report 211*, ISBN: 0717628256.
[18] Li G., Buckle P., 1999, Evaluating change in exposure to risk for musculoskeletal disorders-a practical tool, *HSE Books, Contract Research Report 251,* ISBN: 071761722X.
[19] Li G., Buckle P., 1998, A practical method for the assessment of work-related musculoskeletal risks – Quick Exposure Check (QEC), *in: Proceedings of the Human Factors and Ergonomics Society 42nd Annual Meeting, Chicago ILL,* 1351-1355.
[20] Özcan E., Kesiktaş N., Alptekin K., Özcan E., 2008, The reliability of Turkish translation of quick exposure check (QEC) for risk assessment of work related musculoskeletal disorders, *Journal of Back and Musculoskeletal Rehabilitation* 21, 51-56.
[21] Erdinç O., Vayvay Ö., 2008, Ergonomics interventions improve quality in manufacturing: a case study, *International Journal of Industrial and Systems Engineering*, 3, 727-745.
[22] Choobineh A., Tabatabaei S.H., Mokhtarzadeh A., Saleh M., 2007, Musculoskeletal problems among workers of an Indian Rubber Factory, *Journal of Occupational Health* 49, 418-423.
[23] Kuorinka I., Jonsson B., Kilbom A., Vinterberg H., Biering-Sorensen F., Andersson G., Jorgensen K., 1987, Standardized Nordic Questionnaires for the analysis of musculoskeletal symptoms, *Applied Ergonomics* 18, 233-237.
[24] Forsman M., Stridqvis J., Persson O., 2006, A checklist extension of VIDAR – a participative video-based method for ergonomic evaluation, *in: Proceedings of the International Ergonomics Association-IEA2006 Congress*.
[25] Roja Z., Eglite M., Kalkis V., Kalkis H., 2006, Assessment of road building worker physical workload using qualitative and quantitative ergonomical risk analysis methods, *in: Proceedings of the Latvian Academy of Sciences Section B*, 60, 20-30.
[26] Mirmohamadi M., Seraji J.N., Shahtaheri J., Lahmi M., Ghasemkhani M., 2004, Evaluation of risk factors causing musculoskeletal disorders using QEC method in a furniture producing unite, *Iranian Journal of Public Health* 33, 24-27.
[27] Dempsey P.G., Mcgorry R.W., Maynard W.S., 2005, A survey of tools and methods used by certified professional ergonomists, *Applied Ergonomics* 36, 489–503.
[28] Sukadarin E.H., Deros B.M., Ghani A.J., Ismail A.R., Mokhtar M.M., Mohamna D., 2013, Investigation of ergonomics risk factors for musculoskeletal disorders among oil palm workers using Quick Exposure Check, *Advanced Engineering Forum,* 10, 103-109.
[29] Chiasson M., Imbeau D., Aubry K., Delisle A., 2012, Comparing the results of eight methods used to evaluate risk factors associated with musculoskeletal disorders, *International Journal of Industrial Ergonomics,* 42, 478-488.
[30] Dianat I., Salimi A., 2014, Working conditions of Iranian hand-sewn shoe workers and associations with musculoskeletal symptoms, *Ergonomics*, 57,4, 602-611.
[31] Lee S.J., Tak S., Alterman T., Calvert G.M., 2014, Prevalence of musculoskeletal symptoms among agricultural workers in the United States: An analysis of the National Health Interview Survey, 2004-2008, *Journal of Agromedicine*, 19, 268-280.
[32] Bao S., Silverstein B., Stewart K., 2014, Evaluation of an ergonomics intervention among Nicaraguan coffee harvesting workers, *Ergonomics*, 56, 2, 166-181.
[33] The guidelines fort he Turkish version of the QEC, the Turkish Ministry of Labour, Department of Occupational Health and Safety [http://www.csgb.gov.tr/csgbPortal/ShowProperty/WLP%20Repository/isggm/dosyalar/yayinlar/kitapcik/kitapcik1]

MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Relationship between Empathy Skill Levels and Job Selection: A Study on Business Administration Students

A. Güldem Cerit[1], Ceren Deniz Tatarlar[2]

Abstract

Empathy is a commonly used concept these days. Even in casual life, people are always talking about being empathetic and their empathy skills. In professional life, some jobs require more social and people skills than others. These people skills also include empathy. Since collage life, people try to create a career path for themselves and in this paper, it is questioned whether they choose their careers suitable for their people skills.

Keywords: Empathy, Human Resources, Job, Job Characteristics

Introduction

Every person has an obligation to continue their lives somehow. To obtain and maintain their standards of living, people need to earn money and take care of themselves. The main way to earn life and maintain a standard of living is to have a qualified job and continue working. This brings people to a point which they need to study, work hard and make the right choices. Since their childhood period, every individual plans his or her career or future. This planning procedure is highly important in an individual's life in terms of being able to know what one can do or achieve. Choosing a right career path or profession is a huge step for individuals in order to provide life satisfaction. This procedure might show differences through people and jobs. As known, different job characteristics require different skills, competencies, individual characteristics and etc (Hackman and Oldman, 2005). As Alssid et al. (2002) stated individuals need some form of higher education and training in order to be financially self-efficient and to be able to have enough skills. Today, in many countries including Turkey, universities and higher education institutions are helping individuals/students to find their interests, develop their skills, gain new information and know which career path they might choose. On the other hand, when individual characteristics are considered, one can mention intellectual level, emotional intelligence, empathy, psychological conditions, and personality and so on. Different jobs might require different individual characteristics in different levels. While some jobs are empathy focused, the others might be emotional intelligence focused. At this point, in order to choose the right job and the career path, one should be aware of him and try to fulfill his demands according to this point.

When it comes to college students, they might be too demanding about the job market and their future career. The reason for this might be mentioned as their very little knowledge about the job markets and their strong expectations about post-graduation. As we mentioned before, planning a career starts from childhood and continues until one thinks he/she reached the top level, or maybe in some cases, it never ends. At this point, besides developing and providing professional skills, colleges may also help students shaping their future demands. While selecting a career, students should be aware of their abilities and personal characteristics and should choose their jobs suitable with those. For example, a person who is afraid of insects shouldn't consider being a zoologist or a person who is effective in communication and has verbal skills should think about sales career. A person's characteristics and abilities should match the job's requirements and characteristics. Thinking of these skills, abilities and characteristics; empathy is another dimension for successful job/career selection. Here in this paper, we aim to research empathy skills among students.

In this study, we aim to understand whether the tendency of students' career selections is related to their empathy skill levels. As known, some careers need more empathy skills than others and empathy can be vital to survive in specific sectors and positions. With this relation, we also aim to contribute managerial

[1] A. Güldem CERİT, Dokuz Eylul University, Maritime Faculty, Department of Maritime Business Administration, Izmir, Turkey, gcerit@deu.edu.tr
[2] Ceren Deniz TATARLAR, Ege University, Faculty of Administrative Sciences, Department of Business Administration, Izmir, Turkey, ceren.tatarlar@ege.edu.tr

implications for school managements (might guide their students according to their assessments on individual and psychological characteristics) and human resource management (HRM) departments for future practices towards college students.

Literature Review

Choice of profession and career selection

As mentioned before, during the process of choice of profession many dimensions are effective. For example, Carpenter and Foster (1977) proposed a three-dimensional model for choice of career. Accordingly, choice of career is based on 'intrinsic' (e.g., personal characteristics, work that is personally satisfying, etc.), 'extrinsic' (e.g., availability of jobs, amount of salary), or 'interpersonal' (i.e., influence of parents and significant others). Empathy seems to belong in intrinsic model and it influences personal issues about career selection.

Over the past years, career selection of young people was studied among cultural contexts in Turkey by Aycan and Fikret-Pasa (2003) and they stated that fulfilling one's own desires and expectations has become as important as fulfilling other's (families) wishes and expectations and personal values was an important result. On the contrary of general consideration of collectivistic culture of Turkey, young people are tend to be more individualistic when it comes to their career choices.

On the other hand, Holland (1985) argued that personal characteristics could be linked with career choice. People who know their own interests and skills would actively search an appropriate career. Personal characteristics and emotional state influence people's interests. When it comes to skills, according to Portland Business Journal, there are different types (i.e., soft skills, labor skills, people skills, hard skills etc.). The term 'people skills' is lexically defined as "the ability to communicate effectively with people in a friendly way, especially in business" (Macmillan Dictionary). Also according to Portland Business Journal, it is also defined as "understanding ourselves and moderating our responses, talking effectively and empathizing accurately, building relationships of trust, respect and productive interactions." This definition brings us to our main concern in this research; empathy.

Empathy

Empathy is called ability and it has many different meanings through decades and in different literatures. Empathy was first explored by philosopher Theodor Lipps (1909) and named as *"Einfühlungsvermögen"*. After, it has been translated as "feeling into" (Szalita, 1976) or "feeling together with" (Buchheimer, 1963). Looking at prior studies in business researches, empathy was defines as "the ability to predict representative behaviors of normative individuals" (Tobolski & Kerr, 1952), "the intellectual or imaginative apprehension of another's condition or state of mind without actually experiencing that person's feelings" (Lamont & Lundstrom, 1977), and also "ability to feel as the other fellow does" (Mayer & Greenberg, 1964).

On the other hand, Stein (1989) argues empathy as our ability to "fill in" and "project ourselves into the lives of others". In psychology literature, Mead (1934) defines empathy as a cognitive skill that develops with social experience. As Spiro (1992) stated empathy requires living and knowing. Baron-Cohen (2003) argues empathy in two components, one is cognitive the other is affective. In affective component, empathy is defined as "an observer's appropriate emotional response to another person's emotional state".

"The state of empathy, or being empathic, is to perceive the internal frame of reference of another with accuracy and with the emotional components and meanings which pertain thereto as if one were the person, but without ever losing the 'as if' condition. Thus it means to sense the hurt or the pleasure of another as he senses it and to perceive the causes thereof as he perceives them, but without ever losing the recognition that it is as if I were hurt or pleased and so forth. If this 'as if' quality is lost, then the state is one of identification." (Rogers, 1959:210-211).

Below the list of some important definitions of empathy can be found.

Table 1: Definitions of empathy through years

Author	Year	Definition
Tobolski and Kerr	1952	"the ability to predict representative behaviors of normative individuals"
Freud	1955	"mechanism by means of which we are enabled to take up any attitude at all towards another mental life"
Rogers	1959	"the state of empathy, or being empathic, is to perceive the internal frame of reference of another with accuracy and with the emotional components and meanings which pertain thereto as if one were the person, but without ever losing the 'as if' condition"
Schafer	1959	"empathy involves the inner experience of sharing in and comprehending the momentary psychological state of another person"
Mayer and Greenberg	1964	"ability to feel as the other fellow does"
Harries	1973	"a feeling of being at home with the object contemplated"
Lamond and Lundstrom	1977	"the intellectual or imaginative apprehension of another's condition or state of mind without actually experiencing that person's feelings"
Hoffman	1984	"the awareness of another person's thoughts, feelings, and intentions and the ability or tendency to be vicariously aroused by the affective state of another person"
Kohut, Goldberg and Stepanksy	1984	"empathy is the capacity to think and feel oneself into the inner life of another person"
Batson, Schultz and Schoenrade	1987	"as motivation oriented towards the other"
Berger	1987	"the capacity to know emotionally what another is experiencing from within the frame of reference of that other person, the capacity to sample the feelings of another or to put one's self in another's shoes"
Stein	1989	"empathy is the experience of foreign consciousness in general"
Eisenberg and Fabes	1990	"an effective response that stems from the apprehension or comprehension of another's emotional state or condition, and that is similar to what the other person is feeling or would be expected to feel"
Goldman	1993	"the ability to put oneself into the mental shoes of another person to understand her emotions and feelings"
McCrae & Costa	1997	"as an ability that combines thinking and feeling, empathy is distinguished from personality traits"
Baron-Cohen	2003	"empathy is about spontaneously and naturally tuning into the other person's thoughts and feelings, whatever these might be"
Lampert	2005	"empathy is what happens to us when we leave our own bodies...and find ourselves either momentarily or for a longer period of time in the mind of the other. we observe reality through her eyes, feel her emotions, share in her pain"
Rosenberg	2005	"empathic connection is an understanding of the heart in which we see the beauty in the other person, the divine energy in the other person, the life that's alive in them"
Decety and Meyer	2008	"a sense of similarity in feelings experienced by the self and the other, without confusion between the two individuals"
de Waal	2008	"the capacity to be affected by and share the emotional state of another, assess the reasons for the other's state, and identify with the other, adopting his or her perspective"

Empathy and job characteristics

Different jobs require different levels of social and interpersonal skills. Some professions require higher level of ability to communicate with others effectively, understand others' needs efficiently and empathize. George Anders from Forbes Magazine and LinkedIn once stated in one of his articles that empathy will emerge as a "must-have" job skill by 2020. For example medical and dental professions generally require caring manner. When one works with patients, one should consider their anxiety, fear and demands carefully. Physicians, dentists, dental assistants and nurses are all professionals who do better in their careers if they are empathetic.

When it comes to business area, it can be said that Customer Services and Sales & Marketing departments require people skills most. People with the ability to feel the emotions of others are very well suited to be customer service representatives. They are able to calm down customers who are angry because they feel the products or services they purchased were misrepresented. Being able to identify with their distress makes it easier for them to find a solution that will help resolve the problem. On the other hand Dawson et al. (1992) argued that empathy skills are highly effective on people who work in sales area. McBane's (1995) study has shown that all sales managers should be aware of the complex nature of empathy as they perform their recruiting, selection, and training responsibilities.

The objective of this research is, with all of these information, in our exploratory research, we aim to understand whether the students from Business Administration Faculty is aware of what their empathy skills are and if they are showing tendency to the careers which they might succeed through the empathy lens.

Methodology

In this study, since we are concerned about the relationship between empathy skills of students and their job selection decisions, quantitative research methods are used.

Sample and procedures

As seen on descriptive statistics, surveys were distributed to 110 students from Izmir University of Economics, Faculty of Business Administration. Only 103 of the surveys provided useable data. 7 of the surveys were eliminated due to missing information on empathy scale. 54,4% of the participants were female and 45,6% were male. 75,7% of the students were bachelor students, 14,6% were masters and 9,7% were PhD students.

Surveys were delivered by hand and explanations were made to clarify questions. The cover letter indicated that the study was being conducted for term project purposes with the goal of better understanding some of the issues that affect job and career selection of students and their level of empathy skills. Participants were assured of the confidentiality of their responses. The survey instrument was divided into two parts. First part was to collect demographical data and students' career choices. In this part, demographical questions (gender, age, college, faculty, department) and job/career choice ("Which job would you like to have", "If you are currently working, which job do you have/which sector are you in") were asked in order to understand the general conditions of these students. Second part was to measure students' empathy skills. In this part, "Empathy Skills Scale – B Form" which was developed by Dokmen was used. This part aimed to understand the level of students' empathy skill levels in order to interpret their job choices. All the analyses were made by using SPSS 18.0.0.

Measures

Demographics

Demographic questions were developed by author and was asked in both open-ended (age, education) and close-ended (gender) styles.

Work experience

Students were asked whether they had a work experience before or not. This was measured with one item. ("Do you have an internship experience?")

Job/Career choices

Two different questions were asked to measure this dimension. One question was for students who are unemployed, and the other one was for students who are already employed. Questions had several answer choices (different sectors) and the last one was open-ended ("Other" choice).
With that open-ended answer, students were asked to indicate their selection. When analyzing, these choices were grouped into two; managerial and mathematical. Managerial jobs are defined as social and people jobs and contained departments such as human resources, sales and marketing. Mathematical jobs are defined as more quantitative ones which will not need higher levels of empathy skills. This group contained departments such as operations management and finance.

Empathy skills

Empathy Skill Scale (EBO-B) which was developed by Dokmen was used. This scale's validity and reliability were tested for Turkey. In this scale there are 6 different cases (problems) with 12 different answers and participants are asked to choose 4 answers for each case. The highest score that a participant can get is 219 and the lowest score is 62. All the answers have its own points and this scale has a different evaluation style. Higher point a participant gets higher empathy skills he/she has.

Results

First of all, the results of Empathy Skill Scale (EBO-B) were evaluated using its own scoring system. After evaluations, statistical histogram was applied in order to gather values in the range of 0 and 100. All the values are converted. Second, descriptive statistics and frequencies analysis were made in order to summarize the sample.

Table 2: Descriptive Statistics

	Mean	Std. Deviation	N
sex	,54	,501	103
score	43,491312	12,6896088	103
gpa	2,8777	,63794	99
job	1,77	,425	103
class	2,96	,848	69

Table 3: Educational Level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BA	78	33,1	75,7	75,7
	MA	15	6,4	14,6	90,3
	PhD	10	4,2	9,7	100,0
	Total	103	43,6	100,0	
Missing	System	133	56,4		
Total		236	100,0		

Table 4: Job Selection

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Mathematical	24	10,2	23,3	23,3
	Managerial	79	33,5	76,7	100,0
	Total	103	43,6	100,0	
Missing	System	133	56,4		
Total		236	100,0		

Table 5: Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	47	19,9	45,6	45,6
	Female	56	23,7	54,4	100,0
	Total	103	43,6	100,0	
Missing	System	133	56,4		
Total		236	100,0		

After frequencies and descriptive statistics, the relationship between variables was tested. Correlation statistics were used in order to evaluate the relationships. First of all, we examined the relationship between sex and empathy skill levels.

		sex	score
sex	Pearson Correlation	1	,228*
	Sig. (2-tailed)		,020
	N	103	103
score	Pearson Correlation	,228*	1
	Sig. (2-tailed)	,020	
	N	103	103

*. Correlation is significant at the 0.05 level (2-tailed).

As seen above, there is a positive correlation ($r=.23$, $p<0.05$) between sex and empathy skill scores. As expected, female students got higher scores of empathy comparing to male students.
Another test was made for understanding the relationship between empathy scores and job selection.

		score	job
score	Pearson Correlation	1	,427**
	Sig. (2-tailed)		,000
	N	103	103
job	Pearson Correlation	,427**	1
	Sig. (2-tailed)	,000	
	N	103	103

**. Correlation is significant at the 0.01 level (2-tailed).

As also seen above, a positive correlation (r=.43, p<0.01) between job selection and empathy skill scores has been found as expected. Students who tend to choose managerial jobs got higher scores on EBO-B test. Other variables (age, class, GPA, educational level) were also tested for correlation but no significant correlation has been found.

Discussion

As seen on the results, there is a relationship between existing empathy skill level and job selection. Students who scored higher (both male and female) on EBO-B test made their choices on managerial jobs, and generally in sales and marketing field. Managerial jobs are defined as the ones which require high people skills including empathy. In these fields, people need to communicate more and understand each other more. Students with lower empathy skills made their choices on mathematical jobs which require minimum level of people skills. These students chose to work in operations, finance and accounting fields. As known, these fields do not require high levels of communication; people do not have to work with other people all the time.

Thinking of sales and marketing, customer relations or human resources departments, it can be said that people who will choose to work in these departments have to acquire high levels of empathy skills. Thinking on the organizational side, human resources departments of companies may think of assessing their candidates or potential employees about their empathy skill levels in addition to their usual recruiting routines.

Limitations and Further Research

This research is made in a foundation university and the sample size is not that large due to scheduling conflicts. For further research, a broader study may be held and sample can be widened to more universities and more different departments of universities.

References

[1] Alssid, J. L., Gruber, D., Jenkins, D., Mazzeo, C., Roberts, B., & Stanback-Stroud, R. (2002). Building a Career Pathways System: Promising Practices in Community College-Centered Workforce Development.

[2] Arifoğlu B, Razı G. S. (2011). Birinci Sınıf Hemşirelik Öğrencilerinin Empati ve İletişim Becerileriyle İletişim Yönetimi Dersi Akademik Başarı Puanı Arasındaki İlişki. Dokuz Eylül Üniversitesi Hemşirelik Yüksekokulu Elektronik Dergisi. 4, 7-11.

[3] Baron-Cohen, S. (2004). The essential difference: Men, women and the extreme male brain. Penguin UK. Barrett-Lennard GT. The Phases and Focus of Empathy. Br J Med Psychol 1993; 66:3-14.

[4] Carpenter, P. & Foster, B. (1977). The career decisions of student teachers. Educational Research and Perspectives University of Western Autralia, 4(1), 23–33.

[5] Dawson, L. E., Soper, B., & Pettijohn, C. E. (1992). The effects of empathy on salesperson effectiveness. Psychology & Marketing, 9(4), 297-310.

[6] Dökmen, Ü. İletişim Çatışmaları ve Empati. İstanbul: Sistem Yayıncılık, 1994:119-150.

[7] Hackman, J. R. & Oldham, G. R. (2005). How job characteristics theory happened. The Oxford handbook of management theory: The process of theory development, 151-170.

[8] Holland, J.L. (1985) Making vocational choices. 2nd edit. Englewood Cliffs. NJ: Prentice Hall.
[9] Hulin, C. L. (1971). Individual differences and job enrichment: The case against general treatments. New perspectives in job enrichment, 159-191.
[10] Kniveton, B. H. (2004). The influences and motivations on which students base their choice of career. Research in Education, 72(1), 47-59.
[11] McBane, D. A. (1995). Empathy and the salesperson: A multidimensional perspective. Psychology & Marketing, 12(4), 349-370.
[12] POST-KAMMER, P. H. Y. L. L. I. S. (1987). Intrinsic and Extrinsic Work Values and Career Maturity of 9th-and 11th-Grade Boys and Girls. Journal of Counseling & Development, 65(8), 420-423.
[13] Renn, R. W., & Vandenberg, R. J. (1995). The critical psychological states: An underrepresented component in job characteristics model research. Journal of Management, 21(2), 279-303.
[14] Reynolds, W. J., & Scott, B. (1999). Empathy: a crucial component of the helping relationship. Journal of Psychiatric and Mental Health Nursing, 6(5), 363-370.
[15] Rogers C. Empathic: An Unappreciated Way of Being. Conv: F.Akkoyun, Journal of Education Faculty in Ankara University 1983; 16:103-124.
[16] Spiro, H. (1992). What is empathy and can it be taught?. Annals of Internal Medicine, 116(10), 843-846.
[17] Watt, H. M., & Richardson, P. W. (2007). Motivational factors influencing teaching as a career choice: Development and validation of the FIT-Choice Scale. The Journal of Experimental Education, 75(3), 167-202.
[18] http://www.linkedin.com/today/post/article/20130611180041-59549-the-no-1-job-skill-in-2020
[19]http://www.forbes.com/sites/jennagoudreau/2012/02/28/the-20-best-paying-jobs-for-people-persons/2/

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Understanding the Attitudes of the Employees towards Women Managers: A Research in Small Sized Enterprises

Duygugül Can[1], *A. Güldem Cerit*[2]

Abstract

The women in managerial positions have received much concern especially in the developing countries for a long time. The preset social roles of women such as being a mother and wife, the presence of the glass ceiling and the so-called unvoiced prejudices towards women echo in business. Taking this into consideration, this paper aims to explore the employee attitudes towards women managers in a developing country, Turkey. The employees are selected from small sized business companies in Manisa Organized Industrial Zone (MOIZ). In this regard, this paper aims to analyze factors that affect the attitudes towards women managers.

***Keywords*:** Women Managers, Attitudes, Small Sized Business

Introduction

The issue of women in the workplace has become an important topic widely studied in the context of discrimination, gender-biases and glass ceiling especially after the industrial development. One of the main reasons why these studies gained momentum over a half century is the increasing women employment particularly in the managerial positions. Not only in the fewer developing countries but also in the developed ones there are strong stereotypical role expectations of women (Guney, Gohar, Akıncı and Akıncı, 2006). In the view of societal gender point of view, there are roles that are divided between men and women and in this regard, women are raised so as to fulfill these certain role behaviors (Acker, 1988). Trying to be a successful working women as well as fulfilling the societies' female expectations is not easy for women.

This role conflict is not only valid for women managers, but also for the employees. Employees who are working as subordinates of women managers find it hard to accept this role which is beyond what is expected (Cole, 1997). Women are seen appropriate for certain work activities such as caring and helping others as well as maintaining the relationships; however, men are more associated with achievement, success, competition and hierarchy (Rudman and Phelan, 2008). Having said this, it is not surprising to expect the employees who are working in small sized business in a developing country to develop prejudiced attitudes concerning these stereotypical role behaviors. And as a result of these attitudes and behaviors, women encounter several obstacles preventing them to get promotion, salary increase, employment and access to decision making process.

In this sense, this study aims to show the attitudes of employees who are working in small sized business in a developing country towards women managers. With this research, the women managers will understand their subordinates' attitudes and behaviors more clearly.

Literature Review

Small Sized Enterprises

Small sized enterprises are defined as organizations where fifty people or less are employed and the yearly sales revenue or financial statement is below eight million Turkish Lira (KOSGEB). As few

[1] Duygugül Can, Izmir University of Economics. Department of Business Administration. duygugulcan@gmail.com

[2] *A. Güldem Cerit*, Dokuz Eylül University. Maritime Faculty, gcerit@deu.edu.tr

people are engaged, small businesses are much more relationship oriented because people are frequently in touch with one another. In these kinds of organizations, human and relationship oriented approach from managers gains importance in the sense that those companies are human centered. According to KOSGEB, 98% of the companies in Turkey are small and medium sized companies. And the contribution to the GDP is between 70% and 90% (FFI, Inc.). In European Union, small sized business account for 66 % of total employment, therefore, they enacted Small Business Act legally (TOBB).

One of the disadvantages of the small sized business is that they are generally managed by the rules, standards and limited knowledge of the founder-manager (Sevim, Gümüştekin, Sarıkaya and Sayılır, 2013). Therefore, apart from the founder manager, majority of the small sized businesses have also middle managers. In this regard, the knowledge, attitude, effect and the behavior of this second-manager becomes really important and effective in shaping the culture of the organization as well as its effectiveness. This paper concentrates on the women in middle or top management positions and the attitudes towards women managers.

Attitudes Towards Women Managers

Attitude is defined as the positive or the negative cognitive evaluation of an object such as person, thing, event etc. (Guney, Gohar, Akıncı and Akıncı, 2006). The developed attitudes will turn into behaviors (Kağıtçıbaşı, 2012). Therefore attitudes are important for understanding the certain behaviors. Nevertheless, as Kağıtçıbaşı (2012) argues, it is not easy to measure the attitudes, therefore it is important for the sake of this research to use a reliable and valid measurement which is appropriate for Turkish culture in order to collect a clear data. And for the sake of this research Aycan, Bayazit, Berkman and Boratav's (2011) Attitudes towards Women Manager scale which has been developed in Turkey will be utilized and more information will be provided in the following methodology section.

Several researches conducted on women in business for several decades have increased our knowledge of women's positions, problems and conflicts. Table 1 summarizes the selected research on the attitudes towards women managers. Nevertheless, there is not enough study on the developing countries such as Turkey. This study enables the reader to get an insight of the attitudes taken towards the women managers in a male-dominated industry in a developing country. The study is also valuable as it constitutes data collected from small sized organizations which together with middle sized organizations have 98% of share in Turkish industry.

"At almost every level, female managers – regardless of location – complained of having to deal with blocked mobility, discrimination, and stereotypes" (Omair, 2011). Wang (2010) suggests, for the female managers it is a strong obstacle to prioritize either the children or the work (Cole, 1997). This dualism of female instinct to nurture and care both the family and the business creates advantageous and disadvantageous situations. It is disadvantageous because it creates a stress and a feeling of inner conflict between being domestic or career oriented for the female manager (Gardiner and Tiggemann, 1999; Folker, 2008). As an advantage, these characteristics of women enable them to support and keep the business together, solve problems and by nature they are more likely to prioritize the togetherness and peace (Folker, 2008). In most of the literature women are viewed as transformational leaders caring more about the employees and empowering of them, emphasizing peacekeeping and being more balanced, collaborative, loyal, flexible and committed than their male counterparts. (Dumas, 1998; Vera and Dean, 2005; Wang, 2010; Folker, 2008). This may be one of the reasons why the daughters are generally placed to stereotypically constructed roles in the family business such as secretarial jobs or they are given lower, less crucial tasks in the firm (Dumas, 1992).

The female leaders are considered as more relationship oriented while the men are considered as more task oriented. Previous literature has confirmed female managers face with greater difficulties in their careers than their male counterparts (Wajcman, 1996). Gardiner and Tiggeman (1999) contributes to

this literature by claiming that women who take the leadership positions in the male dominated industries are showing more task oriented leadership behaviors and displaying masculine traits in order to be credible and accepted. (Curimbaba, 2002).

Although women success in leadership positions, neither under representation of women, nor "negative attitudes" towards them changes (Aycan, Bayazit, Berkman and Boratav, 2011). Nevertheless, in order to appreciate the women's contribution to the work force and have the best performance from the women, we need to understand the roots of these attitudes (Eagly, 2007; Lyness & Terrazas, 2006). Aycan (2004) emphasized the importance of the attitudes of the workers towards women managers on the internalization of her career by female manager.

Objectives

This research will shed a light on the attitudes towards women managers in small sized business. The goal of this study is to explore how the attitudes towards women managers change according to gender, age, tenure and experience. The research bares an exploratory nature. Stebbins (2001) argues that exploratory research is not definitive, it is a long, cumulative, interest-governed process"; it can bear quantitative or qualitative nature and test hypothesis. Clarification and understanding are two key elements of exploratory research. In this respect, survey method is chosen in order to collect the data among a representative industrial sample.

Hypothesis

There are five hypothesis in this research testing the profile data obtained from respondends and their attitudes towards women managers.
H1: The women participants have more positive attitude towards women managers than men.
H2: The younger employees will have more positive attitudes towards women managers.
H3: The more experienced workers will have more positive attitudes towards women managers.
H4: The employee with higher education will have more positive attitudes towards women managers.

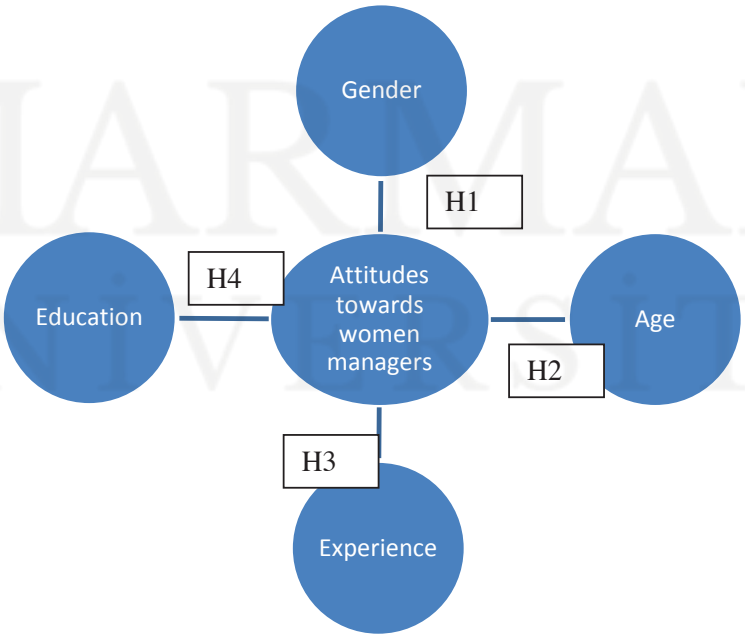


Figure 1: The Model of the Research

Table 1. Selected Research on Attitudes towards Women Managers

Author(s)	Year	Article Title	Methodology	Contribution
Dumas	1992	Integrating the Daughter into Family Business Management	Descriptive	An important guideline for female successors to the family firms has been given.
Abdalla	1996	Attitudes towards women in the Arabian Gulf region	Quantitative-Scale development	Very traditional approaches towards' women's streotypical roles are found in Kuwait and Qatar.
Dumas	1998	Women's Pathways to Participation and Leadership in the Family-Owned Firm	Quantitative – Survey (Questionnaire)	The effect of women in business and their paths to management are described by an understanding of their participation and leadership.
Gardiner and Tiggeman	1999	Gender Differences in Leadership Style, Job Stress and Mental Health in Male- and Female-Dominated Industries	Quantitative - Survey (Questionnaire)	Women in male-dominated industries reported worse mental health when they utilized an interpersonally oriented leadership style.
Aycan	2004	Key Success Factors for Women in Management in Turkey	Qualitative-In depth & Quantitative – Survey (Questionnaire)	Despite high support of women's career advancement gender-role stereotypes cannot be erased. Women help more positive attitudes towards men but overall the attitudes towards women managers are slightly positive.
Vera and Dean	2005	An Examination of the Challenges Daughters Face in Family Business Succession	Qualitative- In depth	Daughters face employee rivalry, experienced work-life balance problems and they could not see themselves as the possible successor one time.
Guney, Gohar, Akıncı and Akıncı	2006	Attitudes towards Women Managers in Turkey and Pakistan	Quantitative – Survey (Questionnaire)	In accordance with Aycan (2004) findings both women and men in Turkey have a negative attitude towards women managers especially when compared to Pakistani respondents.
Abdallah and Omair	2010	Males' Attitudes Towards Working Females in Saudi Arabia	Quantitative - Survey	Age was found to the most important predictor of the males' attitudes towards working females
Omair	2011	Women Managerial Careers in the Context of United Arab Emirates	Qualitative – In depth	Career experiences anf difficulties that are faced by Arab women managers are examined and guideline is indicated.
Aycan, Bayazit, Berkman and Boratav	2011	Attitudes towards Women Managers: Development and Validation of a New Measure With Turkish Samples	Qualitative & Quantitative – Scale development	Aycan et. al. developed a strong scale whose validity and reliablity found sufficient and they developed this scale in Turkey which is a valuable contribution in the sense that the items measuring the attitude will yield highly reliable answers.

(Source: Compiled by the authors)

Methodology

Data Collection instrument

The questionnaire is composed of two parts. In the first part, profile questions are asked. The profile questions are important for this research as it aims also to compare the results on the basis of gender, age, occupation. Some of these questions are based on nominal scale while some are open ended. In the second part; Aycan, Bayazit, Berkman and Boratav's (2011) Attitudes towards Women Managers scale (ATWoM) will be used to measure the employee attitudes towards women managers. As the scale has been developed in Turkey in 2011, the reliability and the validity of the scale are expected to be high and it is as indicated in the article. The items are not misleading and appropriate for Turkish culture. Other scales measuring the same construct, attitudes towards women managers, are not showing high results in Turkish setting because of the effect of the collectivist culture as well as religion (Aycan, Bayazit, Berkman and Boratav, 2011). The scale is based on Likert type 7 measurements and it issued in its original form in this research without any additions and adaptations.

Sample

This research has taken place in small businesses operating in Manisa Organized Industrial Zone (MOIZ). MOIZ is one of the biggest and most precious OIZ of Turkey. According to Chinese investors, MOIZ is the best OIZ for investment in the world. MOIZ is located on 9.591.600 square meters. There are nineteen one-hundred percent foreign capital investment including Ferrero, Bosch, Schneider, Imperial Tobacco and others. There are twelve companies with foreign stakeholders such as Vestel, Hayes-Lemmerz Inci etc. (MOIZ). The foreign trade volume of MOIZ is 7.400.000.000 USD which is nearly 1/5 of Turkish foreign trade volume (TUİK). There are 26.500 employees working currently in MOIZ which is a high amount. According to a survey by Istanbul Chamber of Commerce, among top 500 companies of Turkey, 16 companies are from MOIZ. In total, there are 215 companies in MOIZ and among them 55 are small sized business companies.

Table 2 : The Overview of Employees of Selected Industrial Companies

Company Code	Sector of the Company	Total Employee Working in the Company	Employees Attending the Survey
1	Plastic	48	8
2	Plastic	50	16
3	Machine Manufacturing	31	22
4	Construction	11	5
5	Plastic	24	8
6	Metal Industry	22	15
7	Food	15	6
8	Industrial Kitchen	25	3
9	Food	49	3
10	Insurance company	14	8
11	Otomation	45	8
TOTAL:		**334**	**102**

In this research, 11 of these small sized businesses are involved. These businesses are all in manufacturing and 4 of them are in plastic injection sector, 2 are involved in food production, 2 are in service business and the rest is from construction and machine production sectors. The average employee number of the companies is 30 and the average number of employees attending the survey is 10. From those companies 125 participants received the questionnaire and 102 of them replied back

(Table2). For those respondents surveys, 3 of them are unusable; therefore, the number of the clean data is 99, the response rate is %79.2.

The difference between the number of female and males are narrow. There are 44.4 % female and 53.5 % male participants. Two of the participants did not give a reply to gender question. The age of the participants ranges between 18 and 64. Most of the participants, 33 % belong to the 26-30 age group. After that comes the employees whose age range between 31 and 40 with 27% share. 41.4 % of participants are high school graduates. Employees who received undergraduate education are 12.5 %. Majority of the employees, 25.3%, have experience between 7 and 10 years. And the tenure of the employees is concentrated on 2 years, 18.2% and 3 years, 10.1%. Table 3 summarizes the distribution of employees according to profile question variables.

Table 3: Profile of the Respondents

Variables	Numbers
Gender	
Male	44
Female	53
Missing *	2
Education	
Primary School	10
Secondary School	7
High School	41
Undergraduate (BA, B., Sc.)	26
Graduate (MA, M., Sc)	12
Missing*	3
Experience	
0-5 years	26
6-10 years	27
11-15 years	21
16-45 years	25
Missing*	0
Age	
18-25	18
26-30	33
31-40	27
41-50	18
50 and above	3
Missing *	0

*Missing cases are not included in the relative frequencies

Data Collection

The data has been collected during May-June 2014 in Manisa OIZ. The surveys were given from the researcher directly. Among 11 companies, only 1 of them filled out the survey while the researcher was waiting the other companies handed the surveys in a week. All surveys were handed out in closed envelopes and collected with enveloped accordingly. The participants were ensured that their identities would not be revealed and no identity information was asked in the surveys in order to keep confidentiality.

Data Analysis

The data has been analyzed using SPSS (Statistical Package Size for Social Sciences) version 18. For testing the hypotheses, descriptive statistics such as relative frequency is used. For figuring the relationship between variables, correlation analysis, and regression methods are used. Hypotheses are based on Likert-type scales, for the comparisons t-test method is used. Means and Standard deviations are also calculated in order to support the t-test results. In the research, factor analysis has also been made and the reliability test has been applied to different factors. The relialbity analysis has also been applied for the whole of the scale in order to measure its reliability.

Factor analysis

In Aycan, Bayazit, Berkman and Boratay's (2011) original article, there are three factors of the scale. These factors have been named as "communication focus", "work ethics" and "work focus". In this sample, the factor analysis shows four factors as shown in Figure 2. The factors were named after "communication focus and "work ethics". The "work focus" factor has been divided between "objectiveness in decision making" and "problem solving" (Appendix 1).

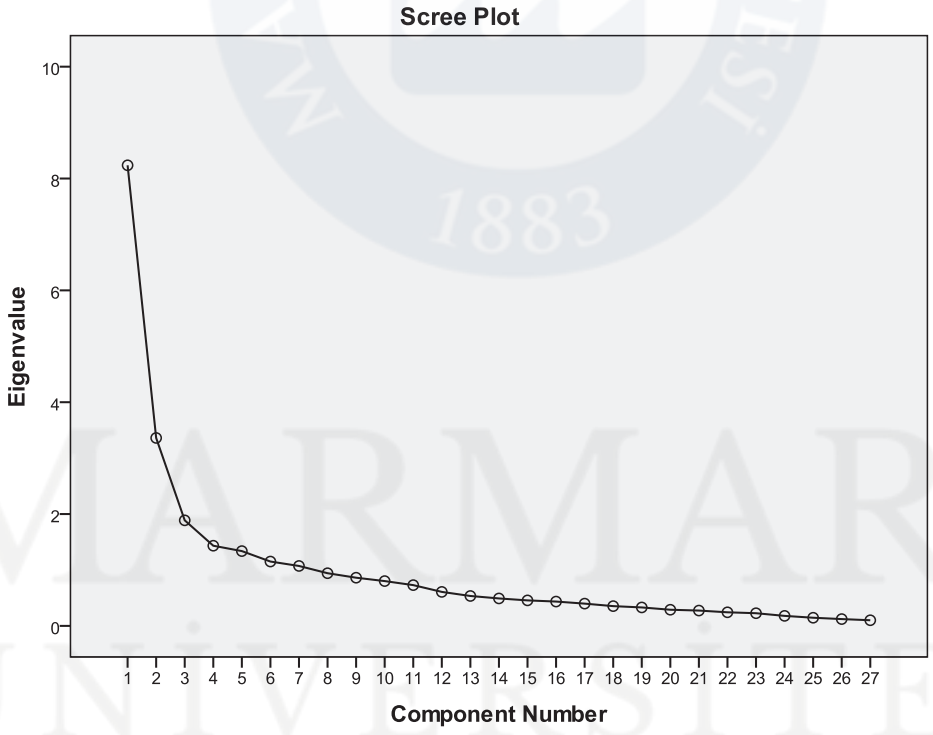


Figure 2: Scree Plot for Factor Analysis

Reliability Analysis

In order to check the internal consistency of the scale and the sample data, reliability analysis was conveyed for both factor groupings and for the scale as a whole. The Cronbach's alpha for the first factor "communication focus" is 0.88 and the mean is 4.86. The second factor "objective decision making" Cronbach's alpha is 0.81 and the mean is 4.64. The third factor "problem solving" has 0.72 Cronbach's alpha with 4.84 mean and the fourth factor has 0.63 Cronbach's alpha with 5.51 mean. The overall Crobach's alpha for the scale is 0.905. Table 4 summarizes the reliability analysis.

Table 4: Reliability Analysis of the Scale

	Cronbach's alpha (α)	Mean (M)
ATWoM	.905	
Factor 1 – Communication Focus	.88	4.86
Factor 2- Objectivity in Decision Making	.81	4.64
Factor 3- Problem Solving	.72	4.84
Factor 4- Work Ethics	.63	5.51

Findings

The results of the correlation analysis show that there is only significant negative relationship found between gender and attitudes towards women managers and education and attitudes towards women managers. The other variables have no significant effect to attitudes towards women managers.

The results of independent sample T-test and correlation analysis, the negative relationship between gender and attitudes towards women managers show that males tend to score worse on the scale ($r = -.254$, $p = .01$). That is while women have more positive attitudes towards women managers men are more negative. This result is supported by the literature; Table 5 summarizes the items and testing of the Hypothesis 1.

Table 5: Testing Hypotheses 1

Hypotheses 1: The women participants have more positive attitude towards women managers than men.	**Method of Analysis**	**Support**
Items		
Olaylara objektif yaklaşamazlar.	t-test	Not Supported
Olaylara genel bakmaz detaylarda kaybolurlar.	t-test	Not Supported
Düzenlidirler.	t-test	Supported t=2.351 p<0.05
İnsan ilişkilerinde profesyonel davranamazlar.	t-test	Not Supported
Çalışanlarının yaşadıkları sıkıntıları anlayışla karşılarlar.	t-test	Supported t=1.307 p<0.05
İşleri başkalarına delege etmekte zorlanırlar.	t-test	Not Supported
Karar alırken aceleci davranırlar.	t-test	Not Supported
Özel hayatlarındaki sorumluluklar nedeniyle kendi işlerine odaklanamazlar.	t-test	Not Supported
Gerektiğinde sert olmakta zorlanırlar.	t-test	Not Supported
Ödün vermeleri gereken noktalarda ödün verirler.	t-test	Not Supported
Çalışanlarıyla nasıl konuşmaları gerektiğini iyi bilirler.	t-test	Supported t=1.799 p<0.05
Üzerlerinde aile sorumlulukları olduğu için iş hayatlarını ön planda tutmazlar.	t-test	Not Supported
Çalışanlarının hangi sıkıtnıları yaşabileceklerini anlarlar ve onlara destek olurlar.	t-test	Not Supported
İşlerin yürüdüğünden emin olmak için çalışanları takip eder ve sorgularlar.	t-test	Not Supported
Detaylara odaklandıkları için sonuca ulaşmaları zaman alır.	t-test	Not Supported

Çok çalışırlar.	t-test	Not Supported
Çalışanların istek ve sorunlarını zamanında hissederler.	t-test	Not Supported
Çalışanların hissettiklerini anlayabilirler ve ona göre davranırlar.	t-test	Not Supported
Duygusallığı, onların profesyonelliğini arttırır.	t-test	Not Supported
Sorunlar karşısında dinamik değildirler, pasif kalırlar.	t-test	Not Supported
Zorluklarla başetmekte sıkıntı çekerler.	t-test	Not Supported
Problemler karşısında çalışanlarına güler yüzle yardımcı olurlar.	t-test	Not Supported
Özel hayatlarından fedakarlık ederek işlerine asılırlar.	t-test	Supported $t=1.055$ $p<0.05$
Rahat iletişim kurulur.	t-test	Supported $t=1.387$ $p<0.05$
Kendi çıkarları doğrultusunda politik davranırlar.	t-test	Not Supported
Sosyal yönleri kuvvetlidir.	t-test	Supported $t=2.090$ $p<0.05$
Karar alırken duygusal davranırlar.	t-test	Not Supported

The other negative relationship belongs to the education. Surprisingly, a negative relationship between the education and attitudes towards women managers has been observed. The higher the education level of the employee, the higher is the negative attitude towards women managers. Although there is not big difference when the means of the groups have been analyzed, there is a significant relationship ($r= -.252$, $p=.01$).

Conclusion

This research bares an exploratory nature and the aim of the research is to analyze different attitudes towards women managers and according to what these attitudes are changing. Although expected, there are no significant relationship found between the tenure, the experience and the age of the employee and their attitudes towards women managers. Nevertheless, in compliance with the existing literature, there is a negative relationship found between gender and attitudes towards women managers. Males tend to have more negative thought towards women managers. Surprisingly, there is a negative relationship found between education and attitudes towards women managers. The higher education levels leads to more negative attitudes. The reasons causing this should be further investigated in another research.

In continuance with this research the authors aim to increase the sample size and analyze the differences in the relationship between employees who work with women managers and male managers. For further research other variables such as marital status, position in the company can be added to the model.

Discussion And Limitations

This research shows that the relationship between education and attitudes towards women managers is negative which was not mentioned in the literature. The reason for this might be the inability to know the necessities of the work when the employee is uneducated or less educated. The more educated he/she is the more unsatisfied he/she can be from his/her manager. One thing worth mentioning here is whether this negative relationship changes according to women – male managers or not. This negative relation between education and attitudes towards women managers might not be special to women managers. For further research one may also consider this factor.

This research has taken place in small business companies in MOIZ. The convenient sampling method has been utilized. The sample size is not big enough to yield productive results. Therefore in another setting, this research could be repeated. Also there will be a difference between small and medium sized businesses. As mentioned in the literature review part, small businesses are companies where people work more in touch and more relationship oriented while in medium/big sized companies the work environment is much more hierarchical and corporate. So the results might change by company size.

Appendix 1

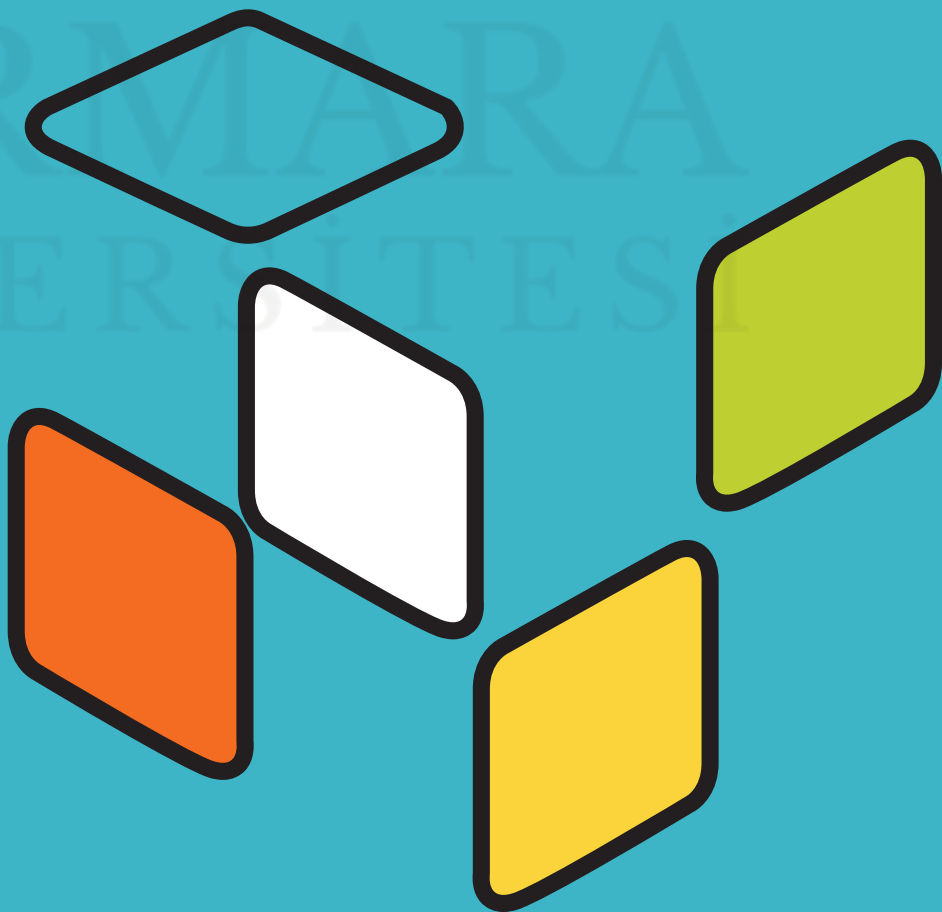
GENEL OLARAK KADIN YÖNETİCİLER;	COMMUNICATION FOCUS (α=.88) (M=4.86)	OBJECTIVITY IN DECISION MAKING (α=.81) (M=4.64)	PROBLEM SOLVING (α=.72) (M=4.84)	WORK ETHICS (α=.63) (M=5.51)
İnsan ilişkilerinde profesyonel davranamazlar. (T)	,411			
Çalışanlarının yaşadıkları sıkıntıları anlayışla karşılarlar.	,758			
Çalışanlarıyla nasıl konuşmaları gerektiğini iyi bilirler.	,593			
Çalışanlarının hangi sıkıtnıları yaşabileceklerini anlarlar ve onlara destek olurlar.	,757			
Çalışanların istek ve sorunlarını zamanında hissederler.	,798			
Çalışanların hissettiklerini anlayabilirler ve ona göre davranırlar.	,817			
Duygusallığı, onların profesyonelliğini arttırır.	,604			
Problemler karşısında çalışanlarına güler yüzle yardımcı olurlar.	,682			
Olaylara objektif yaklaşamazlar. (T)		,714		
Olaylara genel bakmaz detaylarda kaybolurlar. (T)		,799		
Özel hayatlarındaki sorumluluklar nedeniyle kendi işlerine odaklanamazlar. (T)		,482		
Üzerlerinde aile sorumlulukları olduğu için iş hayatlarını ön planda tutmazlar. (T)		,648		
Kendi çıkarları doğrultusunda politik davranırlar. (T)		,557		
Karar alırken duygusal davranırlar. (T)		,558		
Karar alırken aceleci davranırlar. (T)			,458	
Detaylara odaklandıkları için sonuca ulaşmaları zaman alır. (T)			,476	
Sorunlar karşısında dinamik değildirler, pasif kalırlar. (T)			,842	
Zorluklarla başetmekte sıkıntı çekerler. (T)			,686	
İşlerin yürüdüğünden emin olmak için çalışanları takip eder ve sorgularlar.				,566
Çok çalışırlar.				,781

References

[1] Aycan, Z. (2004). Key Success Factors for Women in Management in Turkey. *Applied Psychology: An International Review*, 53 (3), p. 453-477.
[2] Aycan, Z., Bayazit, M., Berkman, Y. and Boratav H. (2011). Attitudes towards Women Managers: Development and validation of a new measure with Turkish samples. *European Journal of Work and Organizational Psychology,* 21 (3), p. 42-455.
[3] Cole, P. M. (1997). Women in Family Business. *Family Business Review*, 10(4). 353-372.
[4] Curimbaba, F. (2002). The Dynamics of Women's Roles as Family Business Managers. *Family Business Review,* 15(3). 239-252.
[5] Dumas, C. (1989). Understanding of father-daughter and father-son dyads in family owned businesses. *Family Business Review, 2*(1), 31–46.
[6] Dumas, C. (1990). Preparing the new CEO: Managing the father-daughter succession process in family business. *Family Business Review, 3*(2), 169–181.
[7] Dumas, C. A. (1992). Integrating the daughter into family business management. *Entrepreneurship Theory & Practice, 16*(4), 41-56.
[8] Eagly, A. H., (2007). Female Leadership Advantage and Disadvantage: Resolving the Contradictions. Psychology of Women Quarterly, 31 (1),p.1-12.
[9] Family Firm Institute, Inc. (FFI), Global Data Points, http://www.ffi.org/, Retrieved on: 13.12.2013.
[10] Folker, C. (2008). Women in Family Firms: Characteristics, Roles and Contributions. *Small Business Institute Research Review*, 35. 157-168.
[11] Gardiner, M. &Tiggemann M. (1999). Gender Differences in Leadership Style, Job Stress And Mental Health in Male-and Female-Dominated Industries. *Journal of Occupational and Organizational Psychology*, 72. 301-305.
[12] Guney, S., Gohar, R., Akıncı, S. & Akıncı, M. M., (2006). Attitudes towards Women Managers in Turkey and Pakistan. *Journal of International Women's Studies*, 8 (1), p. 193-211).
[13] Kağıtçıbaşı, Ç. (2012). *Günümüzde insan ve insanlar*. Evrim yayınevi, İstanbul.
[14] Kızıldağ, D. (2013). Silence of Female Members in Family Firms. International Journal of Business and Social Science, 55(10). 108-117.
[15] MOIZ website. www.mosb.org.tr. Retrieved on: 10.06.2014.
[16] 1Sevim, N., Gümüştekin, G., Sarıkaya M. and Sayılır, Ö. (2013). Küçük İşletme Yönetimi. Anadolu Üniversitesi, Eskişehir.
[17] Sharma, P. (2004). An overview of the field of family business studies: Current status and directions for the future. *Family Business Review*, 17, 1-36.
[18] Small and Medium Enterprises Development Organization (KOSGEB). http://www.kosgeb.gov.tr/Pages/UI/Default.aspx. Retrieved on: 20.05.2014.
[19] Stebbins, R. A. (Ed.). (2001). *Exploratory research in the social sciences* (Vol. 48). Sage.
[20] TOBB, Küçük İşletmeler Yasası, KOBİ Bilgi Sitesi. http://www.kobi.org.tr/. Retrieved on: 13.06.2014.
[21] TUIK website. www.tuiik.gov.tr. Retrieved on: 10.06.2014.
[22] Vera, C. F. & Dean M. A. (2005). An Examination of the Challenges Daughters Face in Family Business Succession. *Family Business Review*, 18(4). 321-345.
[23] Wajcman,J.(1996), "Desperately seeking differences: Is management style gendered?", *British Journal of Industrial Relations,* Vol 34 No3, pp.333-349.
[24] Wang, C. (2010). Daughter Exclusion in Family Business Succession: A Review of the Literature. *Journal of Family Economics Issue,* 31. 475-484.

MARMARA ÜNİVERSİTESİ YAYINEVİ

SUPPLY CHAIN MANAGEMENT II



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

An Investigation for Performance Measurement in Humanitarian Relief Logistics Management

Erkan Celik[1], Alev Taskin Gumus[2]

Abstract

Humanitarian relief logistics management activities aim to help sufferers and injured people on disaster areas. All humanitarian relief actors must improve their performances to achieve these aims in a more effective and efficient way. In this paper, performance measurement in humanitarian relief logistics management is investigated to enable the usage of it by all humanitarian relief actors. Hence, a detailed literature review is presented, for performance measurement in humanitarian relief logistics management.

Keywords: Humanitarian Relief, Performance Measurement

Introduction

Relief-oriented nongovernmental organizations are nonprofit organizations and differ from for-profit organizations in the commercial sector. The general aspects of nonprofit and for-profit organizations are important in characterizing their supply chains [1]. Beamon and Balcik [1] apply three different performance measurement metrics consisting of resource metrics, output metrics, and flexibility metrics for developing humanitarian relief chains metrics which is developed by Beamon [2] for commercial supply chains. Davidson [3] proposes four performance indicator frameworks as for appeal coverage, donation-to delivery time, financial efficiency, and assessment accuracy for humanitarian logistics using interview results with professionals at the International Federation of Red Cross and Red Crescent Societies (IFRC). Petit and Beresford [4] proposed critical success factors for humanitarian aid supply chain by taking into consideration commercial supply chains' critical success factors. They investigate five different critical as strategic planning, inventory management, transportation planning, capacity planning, and information management that are identified by Gunasekaran and Ngai [5] for a small logistics company. Zhou et al [6] proposed a fuzzy decision-making trial and evaluation laboratory approach for identifying critical success factors for emergency management. They proposed twenty different criteria for evaluating based on expert decision. According to the fuzzy approach results, continuous improvement of the operational system of emergency management is determined as the most important critical success factor for the operation of emergency management system. Schulz and Heigh [7] design a development indicator tool for performance measurement for humanitarian logistics. Their indicators are designed according to the four perspectives as customer service, financial control, process adherence, and innovation and learning. This indicators are using as an instrument to measure the current performance of identify development need and measure the impact of the action taken upon it by IFRC. Piecyk [8] proposed a performance measurement framework that takes into consideration the key stakeholders of the logistics departments or personnel in humanitarian organizations. Celik et al. [9] proposed analytical hierarchy process approach based on interval type-2 fuzzy sets for determining the critical success factors for humanitarian relief logistics management. Oloruntoba [10] described two key success factors in the operational effectiveness of the Cyclone Larry ERC and the overall management of Cyclone Larry. Table 1 presents five papers which proposed performance measurement or critical success factor for humanitarian relief logistics. They all developed different aspects and highlights the importance of performance measurement for humanitarian relief management. It is important to develop a framework of performance measurement for humanitarian relief logistics management to evaluate changes and to assess the performance of the humanitarian relief logistics. Hence, in this paper, we investigate five main performance measurement based on literature review for humanitarian relief logistics management as management and planning, human resources and volunteer management, transportation and distribution, warehouse management and information systems.

[1] Erkan Celik, Yıldız Technical University, Mechanical Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, erkcelik@yildiz.edu.tr
[2] Alev Taskin Gumus, Yıldız Technical University, Mechanical Engineering Faculty, Department of Industrial Engineering, Istanbul, Turkey, ataskin@yildiz.edu.tr

Table 1. Performance measurement based on literature review

Reference	Performance measurement
Davidson [3]	Appeal coverage Donation-to delivery time Financial efficiency Assessment accuracy
Beamon and Balcik [1]	Resource performance metrics Output performance metrics Flexibility metrics
Petit and Beresford [4]	Strategic Planning Inventory management Transport and capacity planning Information management and technology utilization Human resource management Continuous improvement and collaboration Supply chain strategy
Oloruntoba [10]	Routine cyclone awareness and education campaigns Specific early warning about Cyclone Larry Prior standing pre-cyclone plans and strategic planning Government unity of direction and whole of government response The Australian Defense Force and tactical ERC planning and execution
Zhou et al. [6]	Reasonable organizational structure and clear awareness of responsibilities Information system to ensure information transferring Government unity of leadership to plan and coordinate as a whole Application of modern logistics technology Continuous improvement of the operational system of emergency management

The rest of this paper is organized as follows. Section 2 presents the explanation and literature for each performance measurement. Conclusions are given in last section.

The Performance Measurement for Humanitarian Relief Logistics Management

Effective performance measurement for humanitarian relief logistics management would support practitioners and managers in their decision making process, help improve the effectiveness and efficiency of relief operations, and demonstrate the performance of the relief chain, thereby increasing the transparency and accountability of disaster response [1]. In this paper, five different main performance measurement and twenty three sub performance measurement are obtained based on literature review. Management and planning directly affects the relief activities. Five sub-criteria are determined under this criterion as: Effective inventory management, effective supplier relationships, well-planned supply system, strategic and operational planning, and effective human resource management system (Table 2).

Table 2. Performance measurement for management and planning

	Performance measurement	References
Management and Planning	Strategic and operational planning	Fritz Institute [11], Lu et al. [12], Pettit and Beresford [4], Moe and Pathranarakul [13]
	Effective human resource management system	Pettit and Beresford [4], Apte [14], Tomasini and Wassenhove [15], Moe and Pathranarakul [13]
	Effective inventory management	Beamon and Kotleba [16], Whybark [17], Petit and Bresford [4], Balcik et al. [18]
	Well-planned supply system	Davidson [3], Pettit and Beresford [4], Zhou et al. [6], Oloruntoba [10], Seneviratne et al. [19], Moe and Pathranarakul [19]
	Effective suppliers relationships	Beamon and Balcik [1]

Humanitarian relief efforts generally operate on limited funds or budgets which increase the importance

of effective inventory management (Beamon and Balcik). Effective supplier relationship is crucial for governmental and non-governmental relief organizations for satisfying demand once a disaster occurs. They can also make framework agreement for minimizing the raise of prices on disaster time. Organization is composed of five sub-criteria: Organizational structure, certain job descriptions, employee training, continuous improvement and corporation, and performance evaluation system (Table 3).

Table 3. Performance measurement for organization

	Performance measurement	References
Organization	Organizational structure	Oloruntoba [20], Davidson [3], Zhou et al. [6]
	Employee training	Oloruntoba [10], Zhou et al. [6], Apte [14], Kovács et al. [21], Kovács ans Spens [22]
	Continuous improvement And corporation	Kovács and Spens [23], Pettit and Beresford [4], Zhou et al. [6]
	Performance evaluation system	Pettit and Beresford [4], Beamon and Balcik [1], Sandwell [24]
	Certain job descriptions	Oloruntoba [20], Davidson [3], Zhou et al. [6], Sandwell [24], Moe and Pathranarakul [13]

Transportation and distribution is also crucial and an important aspect in humanitarian relief logistics management which is a requirement to address suitability of distribution vehicles, distribution speed, suitability of distribution personnel, suitability of distribution network, and safety of personnel and inventory in such circumstances (Table 4).

Table 4. Performance measurement for transportation and distribution

	Performance measurement	References
Transportation and Distribution	Safety of personnel and inventory	Beamon and Balcik [1], Zhou et al. [6]
	Distribution speed	Beamon and Balcik [1], Petit and Bresford [4], Zhou et al. [6], Apte [14], Moe et al. [13]
	Suitability and availability of distribution personnel	Pettit and Beresford [4]
	Suitability of availability distribution vehicles	Petit and Bresford [4], Wassenhove and Martinez [25], Kovács and Spens [22]
	Suitability of distribution network	Pettit and Beresford [4,26]), Sandwell [24], Seneviratne et al. [19]

Warehouse management is a long term and generally one of the most important strategic decisions in humanitarian relief logistics management. Suitability warehouse location, warehouse personnel, warehouse tools are determined as performance measurement of warehouse management (Table 5).

Table 5. Performance measurement for warehouse management

	Performance measurement	References
Warehouse management	Suitability of location	Lu et al. [12], Balcik and Beamon [27], Apte [14], Kovács and Spens [22], Döyen et al. [28], Duran et al. [29], GUnnec and Salama [30]
	Suitability of personnel	Zhou et al. [6], Kovács et al. [21]
	Suitability of tools and vehicles	Lu et al.[12], Pettit and Beresford [4], Kovács and Spens [22]

Effective information systems can minimize the major reasons behind the unsatisfactory performance levels of humanitarian relief logistics management practices. Hence, information systems are one of the CSFs that highly affect humanitarian relief logistics management. This main criterion contains early warning systems, short answer and feedback time, effective information analysis, quick and effective

reporting, and effective communication and emergency information systems.

Table 6. Performance measurement for information systems

	Performance measurement	References
Information Systems	Early Warning Systems	Ju et al. [31], Oloruntoba [10], Seneviratne et al. [19]
	Short Answer and Feedback Time	Zhou et al. [6], Oloruntoba [10]
	Effective Communication and Emergency Information Systems	Zhou et al. [6], Ju et al. [31], Apte [14], Moe and Pathranarakul [13], Moe et al. [32], Kovács and Spens [22]
	Quick and Effective Reporting	Pettit and Beresford [26], Zhou et al. [6], Moe and Pathranarakul [13]
	Effective Information Analysis	Zhou et al. [6], Apte [14], Moe and Pathranarakul [13]

Conclusion

Humanitarian relief logistics management activities directly focus on helping the sufferers and injured people on disaster areas. In other words, its first aim is saving the life of people and decreasing the death rate during a disaster. Performance measurement for humanitarian relief logistics management is critical for improving the relief activities. In this paper, twenty three different performance measurements are presented based on literature review. For future studies, the performance measurement for humanitarian relief logistics management can be also investigated in detail based on literature review and the experts' decision from nongovernmental and governmental humanitarian relief logistic organization. The proposed performance measurement can be also analyzed using decision-making trial and evaluation laboratory approach or its extension based on interval type-2 fuzzy sets for obtaining which is critical for humanitarian relief logistics management.

References

[1] Beamon, B.M., Balcik, B., 2008, Performance measurement in humanitarian relief chains, *International Journal of Public Sector Management,* 21(1), 4-25.
[2] Beamon, B.M., 1999, Measuring supply chain performance, *International Journal of Operations & Production Management*, 19 (3/4), 275-92.
[3] Davidson, A.L., 2006, Key performance indicators in humanitarian logistics, *Master of Engineering in Logistics Thesis*, Massachusetts Institute of Technology, Cambridge, MA.
[4] Pettit, S., Beresford, A., 2009. Critical success factors in the context of humanitarian aid supply chains. *International Journal of Physical Distribution & Logistics Management,* 39(6), 450-468.
[5] Gunasekaran, A., Ngai, E.W.T., 2003, The successful management of a small logistics company, *International Journal of Physical Distribution and Logistics Management,* 33(9), 825–842.
[6] Zhou, Q., Weilai, H., Ying, Z., 2011, Identifying critical success factors in emergency management using a fuzzy DEMATEL method, *Safety Science*, 49(2), 243-252.
[7] Schulz, S.F., Heigh, I., 2009, Logistics performance management in action within a humanitarian organization, *Management Research News*, 32(11), 1038-1049.
[8] Schiffling, S. A., Piecyk, M., 2014, Performance measurement in humanitarian logistics: a customer-oriented approach. *Journal of Humanitarian Logistics and Supply Chain Management*, 4(2), 4-25.
[9] Celik, E., Gumus, A. T., Alegoz, M., 2014, A trapezoidal type-2 fuzzy MCDM method to identify and evaluate critical success factors for humanitarian relief logistics management, *Journal of Intelligent and Fuzzy Systems*, 27(6), 2857-2855.
[10] Oloruntoba, R., 2010, An analysis of the Cyclone Larry emergency relief chain: some key success factors. *International Journal of Production Economics,* 126, 85–101
[11] Fritz Institute, 2005, Logistics and the effective delivery of humanitarian relief, *Fritz Institute*, San Francisco, CA: 12.
[12] Lu, D.K., Pettit, S., Beresford, A., 2006, Critical success factors for emergency relief logistics. *Whampoa: An Interdisciplinary Journal,* 51(1), 177-84.

[13] Moe, T.L., Pathranarakul, P., 2006, An integrated approach to natural disaster management: public project management and its critical success factors, *Disaster Prevention and Management*, 15(3), 396-413.
[14] Apte, A., 2009, Humanitarian Logistics: A new field of research and action, foundations and trends in technology, *Information and Operations Management*, 3(1), 1-100.
[15] Tomasini, R.M., Van Wassenhove, L.N., 2009, Humanitarian logistics, New York: INSEAD Business Press.
[16] Beamon, B.M., Kotleba, S.A., 2006, Inventory management support systems for emergency humanitarian relief operations in South Sudan, *The International Journal of Logistics Management*, 17(2), 187-212.
[17] Whybark, D.C., 2007, Issues in managing disaster relief inventories, *International Journal of Production Economics*, 108(1), 228-235.
[18] Balcik, B., Beamon, B. M., Krejci, C.C., Muramatsu, K.M., Ramirez, M., 2010, Coordination in humanitarian relief chains: practices, challenges and opportunities, *International Journal of Production Economics*, 126(1), 22-34.
[19] Seneviratne, S.I., Corti, T., Davin, E.L., Hirschi, M., Jaeger, E.B., Lehner, I., Teuling, A.J., 2010, Investigating soil moisture–climate interactions in a changing climate: A review, *Earth-Science Reviews*, 99(3), 125-161.
[20] Oloruntoba, R., 2005, A wave of destruction and the waves of relief: issues, challenges and strategies, *Disaster Prevention and Management: An International Journal*, 4, 506-521.
[21] Kovács, G., Tatham, P., Larson, P.D., 2012, What skills are needed to be a humanitarian logistician?, *Journal of Business Logistics*, 33(3), 245-258.
[22] Kovács, G., Spens, K., 2009, Identifying challenges in humanitarian logistics, *International Journal of Physical Distribution & Logistics Management*, 39(6), 506-528.
[23] Kovács, G., Spens, K.M., 2007, Humanitarian logistics in disaster relief operations, *International Journal of Physical Distribution & Logistics Management*, 37(2), 99-114.
[24] Sandwell, C., 2011, A qualitative study exploring the challenges of humanitarian organizations, *Journal of Humanitarian Logistics and Supply Chain Management*, 1(2), 132-150.
[25] Van Wassenhove, L.N., Pedraza Martinez, A.J., 2012, Using OR to adapt supply chain management best practices to humanitarian logistics, *International Transactions in Operational Research* 19(1-2), 307-322.
[26] Pettit, S.J., Beresford, A.K.C., 2005, Emergency relief logistics: an evaluation of military, non-military and composite response models, *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management*, 8(4), 313-331.
[27] Balcik, B., Beamon, B.M., 2008, Facility location in humanitarian relief, *International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management*, 11(2), 101-121.
[28] Döyen, A., Aras, N., Barbarosoğlu, G., 2012, A two-echelon stochastic facility location model for humanitarian relief logistics, *Optimization Letters*, 6(6), 1123-1145.
[29] Duran, S., Gutierrez, M.A., Keskinocak, P., 2011, Pre-positioning of emergency items for care international, *Interfaces*, 41(3), 223-237.
[30] Gunnec, D., Salman, F.S., 2007, A two-stage multi-criteria stochastic programming model for location of emergency response and distribution centers, *Proceedings of the International Network Optimization Conference (INOC)*, April 22-25, 2007, Spa, Belgium.
[31] Ju, Y., Wang, A., Liu, X. 2012, Evaluating emergency response capacity by fuzzy AHP and 2-tuple fuzzy linguistic approach, *Expert Systems with Applications*, 39(8), 6972-6981.
[32] Moe, T.L., Gehbauer, F., Senitz, S., Mueller, M., 2007, Balanced scorecard for natural disaster management projects, *Disaster Prevention and Management*, 16(5), 785-806.

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

The Effects of Postponement Strategy on Company KPI's And An Industry Application

Lütfi Apilioğulları [1]

Abstract

Customer expectations in today's world are changing at an incredible speed. These expectations lead to the creation of new products and naturally an increase in product variety. As a result, the high volume / low mix concept of the past replaces with the high mix / low volume concept.
On the other hand, by each passing day in today's globalized world, more companies continue their search for new customers in foreign markets. However, management processes are required in order to be able to enter into those markets and to be permanent, while particularly being competitive in terms of cost and, at the same time, without compromising the customer service level. Problems, such as inventory turnover, lead-time, the cost of logistics, are always waiting for them to be solved in this situation.
Postponement strategy is an approach in case of supply chain management that allows you to manage operational processes, despite the variety of products, without compromising the service level. Today there are many successful examples of it.
In this study, the effect of the operational processes in which postponement strategies being adapted to a company in the paint industry has been studied.

Keywords: Postponement Strategy, Lean Supply Chain, SCM

Introduction

We live in incredibly changed world. The main factors that stimulate this change are customer's requests and expectations. The change in customer's requests and expectations cause rising new products and old low volume/high mix concept gives place to new high mix/ low volume concept [1]. Now, customers substantially decide the products' properties, colors, and functions, in short, what products produce. In other words, customers want very different, specific, customized special products [2].

Other result of this change is that lifetime of product becomes shorter day by day; increasing product variety can cause uncertainties and changes in customers' decision process till the last moment. Increasing conditions of competition and ability of doing similar products by almost everybody show the competition is the highest priority in speed.

So, new current state is as follows.

- Customers are requested more variety and customized products,
- Speed is emerging as the ultimate competitive weapon (Business Week, 2006)[2].

With this factors, continuously increased cost pressure is became compulsory the change of production / logistics methods. Make to stock method is closed in order to both produce many different types of product competitively, and transfer without sacrificing customers' service level. Motionless products are found in the stocks of companies that prefer this method, stock turnover rates decrease, cash flows are become lower and as a result of these, company considerably lose their competition advantages.

[1] Lutfi Apiliogullari, Maltepe University, Department of International Trade and Logistics Management, Ph.D. Program in Logistics and Supply Chain Management, Istanbul, Turkey, lutfi.apiliogullari@leanofis.com

Companies, which realized negative effects of this situation are now adopted a new demand-driven manufacturing philosophy as new concept and they are, waited a clear signal from the customer to move to the next stage in each stage. Postponement strategy is emerged as a process that is applied successfully in many sectors and carried decision-making process to the final stage required for receiving final version of the product [2].

In this study, how vary with company operational KPI's as a result of implementation the postponement principles of lean supply chain to a business in manufacturing sector and the effect of this variability on expenses is indicated with case study method. The success of application is evaluated in comparison of KPI indicators of current state and new KPI indicators occur as a result of new state of process.

Background

The term postponement refers to delayed decision-making about a product. It is beneficial to delay commitment to product-specific characteristics as late as possible in order to avoid a mismatch between orders and inventory on hand[2]. The concept of postponing product differentiation beyond manufacturing has been discussed for over 50 years. Alderson (1950) appears to be the first who coined the term postponement in marketing literature[5].

Postponement strategy could be applied starting from design stage to shipment stage. Basically there are two type of postponement strategy. 1) Production postponement, 2) Logistics postponement. In production stage the semi-finished products or standard products are kept in stock area that called vanilla box and differentiated (manufactured or assembled) as soon as order received. Logistics postponement strategy is also postponing some activities in logistics processes such as packaging, labeling and shipment activities of the products until order received from the customer.

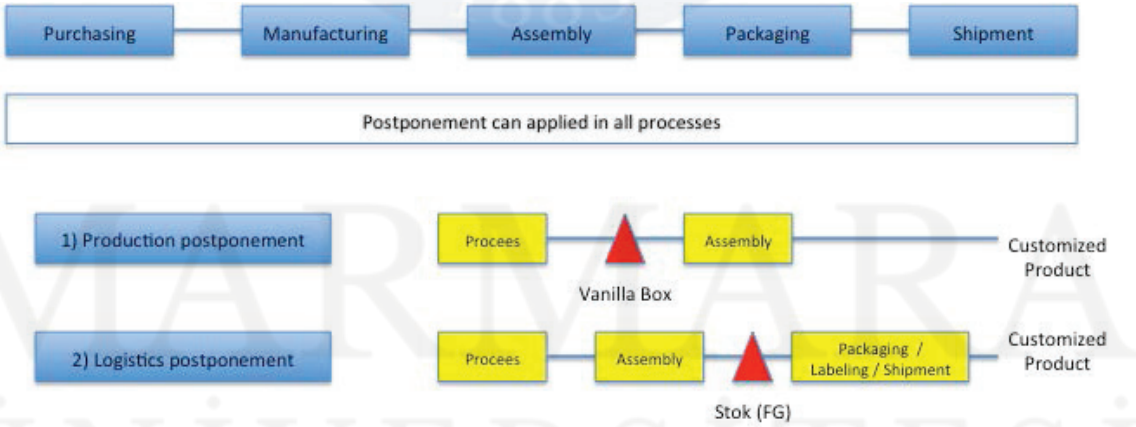


Figure 1: Postponement types

Until now, much application/ study was carried out about postponement in industry and proven the impact of this process on operational performance.

- Dell computer Manufacturer Company has applied product diversification process according to customer requirements successfully and has achieved a significant competitive advantage. With this method, products are waiting semi-finished stocks called vanilla box until a certain stage (standard). According to the properties of order came from customer, products are received the final form and shipped. In addition to this, Dell Company holds less price of the most preferred products than the price of special products by holding a finished product stocks for the most preferred products. In this way, company both make deliveries from stocks by directing customers to the most preferred products and answer the customers who requests specific products with postponement strategy.

- Gillette Company has made another application of postponement strategy by sending standard products as bulk, performing at distribution center outside the factory in line with customer demands.
- Whirlpool Company has provided savings in total cost of inventory both the logistics and supply chain by making postponement application by sending products, which was sold by dealers from directly its own distribution center.

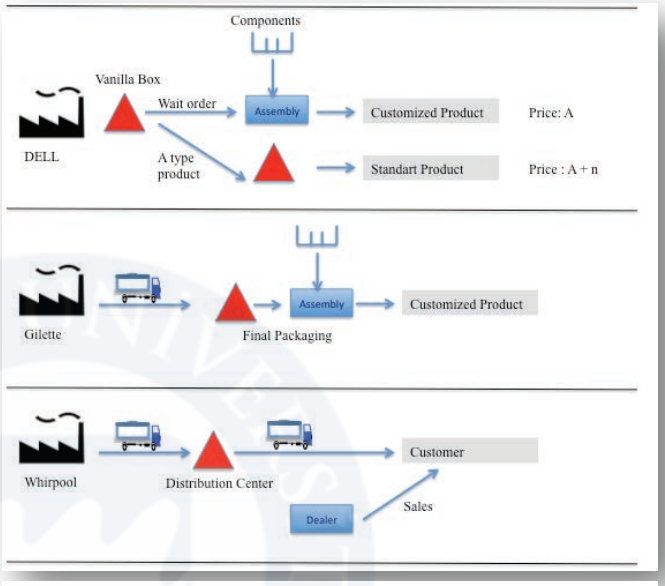


Figure 2: Some exampled from industry

Theoretical supports have come to similar studies in the academic sense. Riets (2006) did researches on the postponement strategies can be applied in both manufacturing and logistics sector and mentioned that this process improves lead time, stock turnover rate performance in company performance. Ngniated (2010) mentioned in doctorate study that postponement process is an important tool during pulling down process of companies [7] and again similarly Bulgak (2006) emphasized in studies that postponement process is an effective competition tool [4].

Method and Framework

LSA Company that the study was carried has been operating in paint manufacturing sector. The company has customers both domestically and foreign.

It is utilized from continuous improvement cycle methodology consists of totally five steps for observation, evaluation and analysis process.

1) **Current state mapping**: Value stream mapping (VSM) method is used for current state analysis of entire process of selected product family from suppliers to product shipment. VSM is a process that everybody understands by depicting with using standard symbols of all stream (process- materials and knowledge) beginning from suppliers to product shipment for selected product family[10]
2) **Future state mapping**: Value stream mapping (VSM) method is used for current state analysis of entire process of selected product family from suppliers to product shipment. VSM is a process that everybody understands by depicting with using standard symbols of all stream (process- materials and information) beginning from suppliers to product shipment for selected product family.

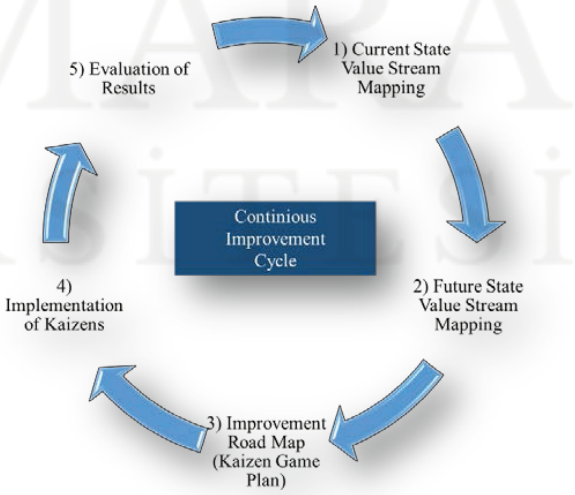


Figure 2: Continuous Improvement Cycle

3) **Improvement road map**: It is a preparation process of necessary improvement action plans that should be needed to come from current situation to future situation.

4) **Implementation**: It is a process that carrying out kaizen's which specified in improvement road map one-to-one in the field.
5) **Check result**: It is a checking whether desired target is achieved or not as a result of kaizen application, planning a new kaizen application if results are far from the target and applying process.

General process:

1. LKS firstly obtain semi-finished products by mixing chemicals that are procured from suppliers at specific ratios (prescriptions) in paint production (phase_1: this part is company's know-how and it's confidential.).
2. Base products are obtained by mixing the obtained semi-finished products with cement which called as filling materials that constitute 60% of product weight in mixers (phase_2).
3. These base products can be used directly by customers as well as different colors of products can be obtained in colorization process by mixing appropriate amount of color pigments (phase_3).
4. Products that colored in colorization process are firstly placed in finished product stocks and then shipped to customers after order receives (phase_4).
5. Orders that are shipped to customers (dealers) are shipped again from there to final customers (phase-5).

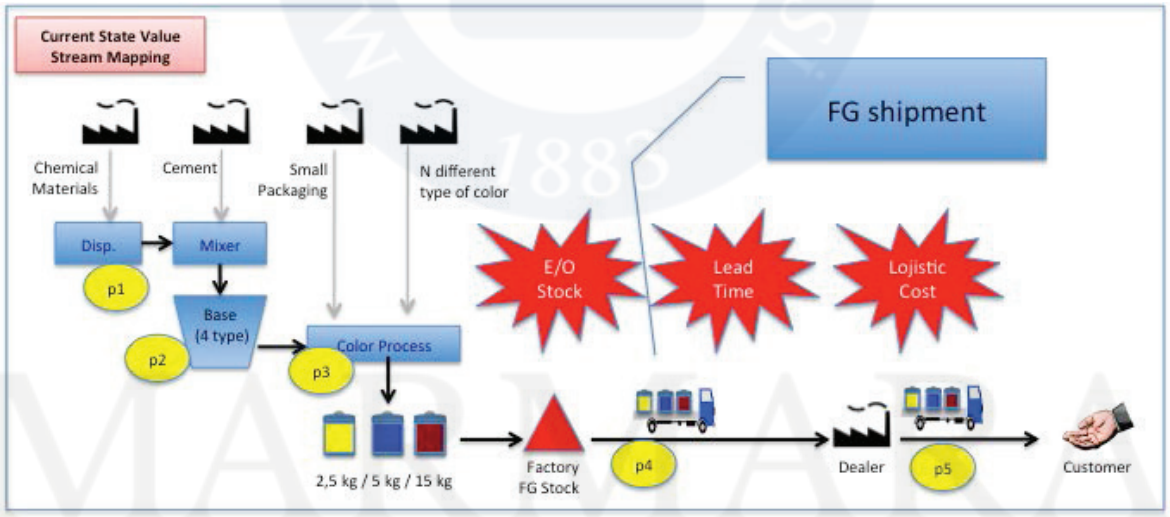


Figure 3: Current state value stream mapping

Company that study was carried has 3 semi-finished products, 4 base products and more than 500 colored SKU. The most general operational difficulties that this sector faced with are the factors like the greater number of colored SKU, inability to control the amount and color variability in customer demand, necessity of preparing and sending products as soon as possible even if the products are very small amount.

In order to overcome these problems, LKS stocks the best selling colors based on the information received from forecasts in finished product stocks and try to meet demands by shipping from stocks when ordering these colors (Option_1: Stock to Shipment). When it come non-stock color order, company tries to respond with shipping from process to needs method by manufacturing from the beginning of the process (Option_2: Manufacturing to Order).

- Being excess/obsolete risks are high at option_1 as a result of inventory costs and very little movement in some products.

- Lead time is longer at option_2. In addition, economic quantities that can be have been identified in semi-finished product / product / colorization processes. Even if demand is less than this level, LKS manufactures the economic production amount that has been identified itself, ships demand amount and remaining amounts are waited in stocks. In such cases, if demand product is a specific color items, remaining amount are waited quite long time and it can be removed to wastage after a time.

In this study, it is investigated that how LKS company ships colorized products both domestic and foreign customers (dealers) with postponement method and how improve the operational efficiency by this means.

Domestic customers: LKS Company has dozens of domestic dealers. Final customer demands come to the dealers and if demand can meet from stocks, products are shipped to customers. However, in absence of the desired product, dealer indents for product by ordering. If colorful product, which is dealer demand, is in stocks, there is direct shipping, otherwise final customer expectations are tried to meet with shipping from process. Some disadvantages ensue like late deliveries, loss of customer and increase of inventory costs.

Product in a different colors that customer wants is obtained in colorization process. So, up to this process, other processes are same, after this step product differentiates by undergoing color change. Colorization process is carried out in bigger equipment's and higher lot amounts in industrial sense. However, final customer's expectations are much smaller quantities of colorful products (2.5 kg / 5 kg / 15 kg).
In this context, a mechanism / system were installed to dealers which called as color bank (phase_3 process were transferred to the dealers side.). The most fundamental feature of this system is making industrial high amount colorization operation doing in LKS factory for much less quantity products in dealer's environment.



Figure 3: Coloring process in dealer

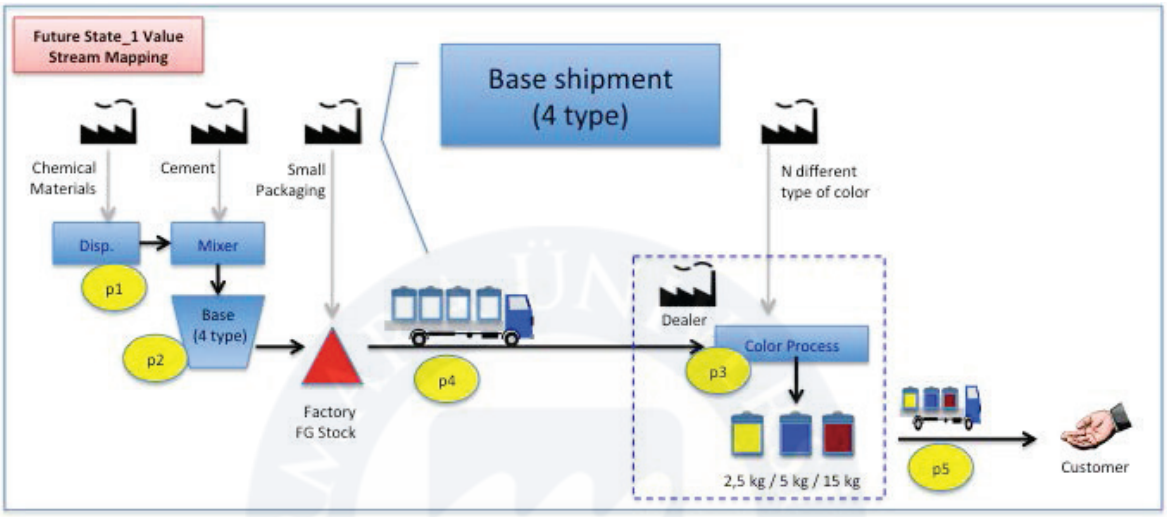


Figure 4: Future state_1 (postponement of coloring process)

So, dealers take four different products in small baskets (2,5 kg → 15 kg) instead of colorful products from LKS and stocks these four fundamental products in varying amounts. If the customers ask how much quantity of the product from which color, it is taken from inventory, colorized with color bank and given to the customer. Compared with old system, dealers will be started to pick up only the coloring pigments from suppliers.

Foreign customers: LKS Company has a main dealers abroad. In addition to domestic dealers, this dealer distributes products that came to it into the sub-dealers in the country and products are reached the final user from there. Similar problems with domestic are experienced here. Hence, establishment of same color bank application was considered as an ideal solution. But, logistics costs have to reduced significantly in order to being competitive.

There is no significant weight of color pigment in product. However, filling material, cement, represents 60% of average product weight. Even if there is color bank application, both products have to be sent small buckets and filling materials were transported in product abroad during transportation. The most critical process of paint production is preparing semi-finished products, mixing step of chemical extent of specific prescriptions. These should be kept confidential and not shared with any terms. However, after this process, adding filling material, cement, to semi-finished product with obtained previous process is not very difficult step. Also, filling material (cement) is a material that can be found throughout of the world.

In this context, LKS decided to make the process of adding filling material that provides differentiation during production process in abroad customer. In this way it was decided to send semi-finished product (four type product) in larger buckets (IBS barrel) rather than small buckets. The required mixer mechanism was made and sent to the dealer (phase_2 process was transferred to the dealer's side). Manufacturing finished product from semi-finished product and producing colorful product from finished product was transferred to the dealer's side by establishing color bank continued in this arrangement (phase_3 process was transferred to the dealer's side). Thus, filling material (cement) that constitutes 60 units in 100 units finished product was not transferred in vain. Process was managed by sending only 40 unit semi-finished product (chemical specific mix). Likewise, bucket supply process, cement supply process and procurement process of pigment needed for color bank was transferred to dealer's side and LKS started to manage this process with pull system by adding to semi-finished product supermarket

(Finished Goods SM) for this dealer's process.

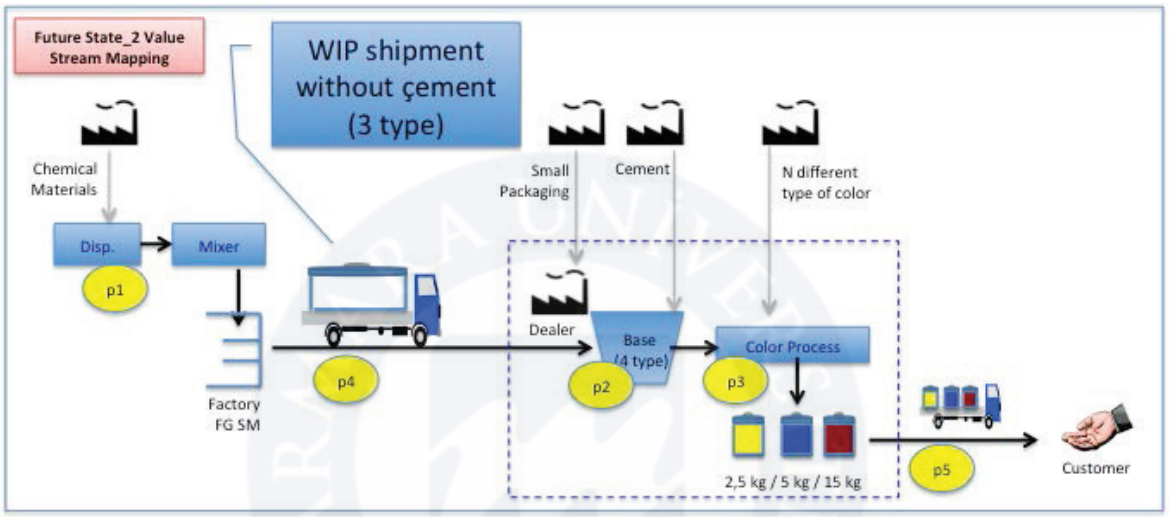


Figure 5: Future state_2 (postponement of making base & coloring process)

Results

On time delivery	: from 75% to 95% (Improved)
Stock turnover	: from 7 to 11 (Improved)
Excess / Obsolete	: 2% to 0.5% (Reduced)
Logistics cost	: 20% (Improved)
Operational efficiency	: OEE, from 75% to 80% (Improved)

Conclusion

In this study, it is examined how postponement strategy effects to the companies operational performance. Production and logistics postponement methods are applied systematically and positive effects on system performance are observed.

It is confirmed that managing processes according to postponement principles effects positively to all supply chain performance in order to produce solutions under the market condition which specially have uncertainty in important issues as stock turnover rate, on time delivery, efficiency.

References

[1] Apiliogullari, L., 2013, "Operational Excellence / Change Management", System publishing, 1st edition.
[2] Rietse, S., 2006, Case Studies of Postponement in the Supply Chain, Master of Science in Transportation at the Massachusetts Institute of Technology
[3] Apiliogullari, L., 2014, "Lean Supply Chain and it's effect on Company Key Performance Indicators and an Industry Applications", XII. Logistic and Supply Chain Congress,
[4] Apiliogullari, L., 2014, "Tedarik Zinciri Süreçlerinde Toplam Maliyet ve Nakit Akış Hızı Kavramlarının Finansal Sonuçlar Üzerine etkisi", LODER dergisi, s: 20-26
[5] Bulgak, A., Pawar, A., 2006, Analysis of postponement strategies in supply chains, Istanbul Ticaret Üniversitesi Fen Bilimleri Dergisi Yıl: 5 Sayı: 9 Bahar 2006/1 s. 1-21
[6] Yao, N., Evers, P., 2005, Supply chain integration in vendor-managed inventory, 2012, Decisions Support Systems 43 (2007) 663-674
[7] Wang, H., Chen, R., 2006, Case Study on the Application of Postponement Strategy and Managerial Insights, Asia Pacific Management Review (2006) 11(3), 141-153

[8] Ngniatedema, T.Chen, R., 2010, Cost reduction through assembly postponement in mass customization, Kent State University Graduate School of Management.
[9] Hoek, R. 2001, the rediscovery of postponement a literature review and directions for research, Journal of Operations Management 19 (2001) 161–184
[10] Apiliogullari, L., 2010, "Lean Transformation / The Code of Productivity", System publishing, 1st edition.

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Creating Solutions: Perspectives from Turkey

Cansu Yıldırım[1], Öznur Yurt[2]

Abstract

Traditionally it was possible to gain wealth or create competitive advantage by producing tangible goods. However, due to several factors such as developments in technology and economic crises, goods have become commodities and thus, the landscape of business has been changed. With this acknowledgement, companies began to use services in order to differentiate themselves from their competitors and to solve customer problems. These bundles of products and services (and also software and, knowledge) are called as solutions or integrated solutions that help companies to customize their offerings as they firstly try to understand the requirements of customers. The current study is an ongoing research in which we aim to understand the perfectives of both suppliers and buyers of solutions in white-appliances industry, in Turkey.

Keywords: Buyer-Supplier Relationship, Integrated Solutions, Supply Chain Management

Introduction

Approximately five decades ago, it was possible to create wealth either through producing tangible products [1]. However, several changes occurred throughout these years such as the economic downtowns and the developments in science and technology. These forces along with the increased product commoditization that wears away competitiveness [2] have changed the marketplace and the landscape of the businesses. These changes brought slow growth rates and; reduced margins [3] shorter life cycles for products and thus; declining profitability [4] and these changes made organisations realize that "products are merely means to an end" [5]. Therefore, organisations are forced to find new ways rather than modifications in tangible goods in order to increase their competitiveness and profitability. As a result, the importance of services has been increased both in the eyes of practitioners and the scholars since they are sources for higher margins [6], continuous revenue streams [4], customer loyalty [7], and competitive advantage [5].

Since the conventional ways of developing competitive advantage are not enough to warrant the competitive success in several industries [8], organisations began to help consumers to solve their problems and achieve their ultimate goals [5] (p.366) through a shift towards services. This shift necessitates the integration of products and services in order to (re)acquire the competitive position in the marketplace and it requires several changes: (a) from products to solutions, (b) outputs to outcomes, (c) transactions to relationships, (d) suppliers to network partners, and (e) elements to eco-systems [26]. However, as value proposition is still a fundamental premise [2], in order to create competitive advantage in severe market conditions and deal with precise customer needs, companies start bundling products and services [3], which means they start to provide solutions for consumers.

Integrated Solutions

Integrated solutions are described as a combination of products, services and software which provides more value than stand-alone products [9]. A more detailed explanation has been given by Sawhney [5] : "*an integrated combination of products and services customized for a set of customers that allows customers to achieve better outcomes than the sum of the individual components of the solution*.". Moreover, providing solutions is both an ongoing and a relational process in which the provider of the integrated solutions constantly tries to meet the demand of the consumer [7]. As known, the traditional view states manufacturers end the relationship with their product offering after the delivery. In contrast to this view, providing solutions starts before the manufacturing process as the provider tries to develop a definition for the requirement of a

[1] Cansu Yıldırım,Izmir University of Economic, Business Faculty, Department of Logistics Management,İzmir, Turkey, cansu.yildirim@ieu.edu.tr
[2] Öznur Yurt, Izmir University of Economic, Business Faculty, Department of Logistics Management,İzmir, Turkey,oznur.yurt@ieu.edu.tr

customer and, the process does not end with the delivery of the offering since consumers require post-deployment support from the provider [10]. Thus, customers are not willing to pay just for a bundle of products and services; they are buying solutions in order to make their operations trouble-free [4].

From practitioners' point of view, companies prefer to provide integrated solutions for their customers due to several reasons. All products and services become a commodity after a while [2]. However, providing integrated solutions overcome this barrier since it fosters differentiation through customized services and confidential knowledge regarding customers and industries [5] (p. 368). Through this extended knowledge regarding customer needs, providers of solutions would better understand the requirements of customer problems and provide them with unique solutions.

Moreover, organisations are doing more business with the existing customer through providing them with an extended product offering and, throughout this process; they take on some of the work that is traditionally done by customers [5] (p. 367). The author suggests that this create bigger market opportunity and thus, increase the market size. Similarly, the providers of solutions take the customers' risks and responsibilities on and as a result, they are able to develop more creative ways for components to be integrated as a whole which would increase the overall customer value [8]. This may, in turn, increase the competitive advantage of a company, since providing solutions requires integrations with the customer's operations [5]. This integration helps customer loyalty to increase and thus, the possibility of becoming replaced by competing company decreases [5](p. 368).

Solutions create steady revenues through fostering growth and profitability of organisations [11] and, thus providing organisations with lucrative [12] . For instance, IBM started its solutions-related businesses in the early 1990s and now these businesses make up 53% of its total revenue [13]. Moreover, the company has been able to maintain shareholder value stable and develop both capabilities that are difficult to copy and, customization which prevents commoditization [12].

Furthermore, there are also some improvements in managerial issues. For instance, providers of integrated solutions may gain new capabilities through the process such as system integration, operational service, business consulting and financing capabilities [4] . According to Neely et al. [27] these capabilities can be divided as market-based, social capital-based and, technological capabilities. As those capabilities provide solved problems for customers, providers become a strategic business partner [14] which in turn present added value for providers of integrated solutions. This also directly affects the perceived purchase risk of customers. In order to be strategic business partners, providers should act as competent and experienced, give detailed information about the way they generate the solution and, most importantly they should be committed, in this way they may decrease the perceived purchase risk of customers [15]. However, in order to have these qualifications, first organisations need to understand what their customers require. This forces them to build a relationship with them. Although, the relationship terminates with the deployment of the product in a traditional product-dominant logic; for customers, providing solutions means understanding the requirements of them, customization and integration of products, deployment of the solution and then being supported on an ongoing basis [10]. As Foote et al. [12] suggest in order to solve a problem of a customer, providers of solutions may even need to integrate operations of both suppliers and customers. Actually as Sawhney [5] states a solution without an operational integration generates a bundle of products and services, thus operational integration makes the difference (See Table 1 for an overview of integrated solutions advantages).

Table 1. The advantages of integrated solutions

Market Benefits	Solved problem(s)	Through differentiation created by customized services and confidential knowledge regarding both customers and industries
	Increased market size	Through extending product offerings for existing customers and arousing interest for potential customers.
	"*a peace of mind*" for customers	Through taking over the risks and responsibilities of customers and so, increase the overall customer value.

	Competitive advantage	Through creating loyalty as solutions require a deeper integration with the operations of the customer and developing a stronger relationship.
Economic benefits	Higher and steady revenues	
Managerial benefits	New capabilities	i.e.: Systems Integration Capabilities, Operational Service Capabilities, Business Consulting Capabilities, Financing Capabilities

Although the outcomes of the process are beneficial, it also presents challenges. Due to these challenges, organisations ought not to underestimate the movement towards providing integrated solutions [8]. Especially, the requirements that are associated with managerial improvement threaten the success of providing integrated solutions. For instance, internal inefficiencies of operations, that propose a challenge in itself, should be managed carefully [11]. Similarly, Windahl and her associates [3] claim solutions require a fit between technical/ product competences and the capabilities in terms of integration and relationships with partners without overlooking the importance of understanding customer requirements.

Another challenge presents itself within the process of providing integrated solutions and the characteristics of solutions. First of all, the process of providing solutions requires a change in the mind-set of the organisations thus; it is a management issue [16]. For example, top management needs to regard services as provider of high value [17]. Similarly, Solonen [11] demonstrates the need for cultural shift by stating a transformation towards an improved consciousness of consumer needs rather than the focus on tangible products. Thus, this culture shift necessitates time and resources [18].

One of the biggest challenges is probably the development of the capabilities mentioned above in order to integrate diverse parts of a system (as known as the integrated solutions) that are accommodated by an external network composed of suppliers, subcontractors and service providers [8]. Thus, interactions are needed for evolving from transaction-based ones to relationship-based ones [6] which can be accounted as a competence in which organisations form alliances and partnerships with their suppliers and consultants (upstream) for providing more efficient solutions [3]. Furthermore, organisations also need to form relationships with customers (downstream). For a provider of integrated solutions, this might mean becoming a "*part of customers' ongoing operations (p.220)*" [3]. In this way, it is more likely to define requirements of consumers which are the first step of providing integrated solutions [10]. Thus, despite the need to control just the channel to the customer in order to have a profitable business as Davies [8] suggests, the channel/ network should include both the upstream and downstream sides of the value chain. As Foote et al. [12] recommend organisations should not go through this process alone since other partners (i.e.: suppliers, or distributors or customers) may have a positive impact on solution development through their skills or market knowledge. However, developing such a relationship is not easy because of two reasons: the need to build the synergy between the business units and departments and, the relationships of partners in the business network/value chain [19]. Moreover, these kind of long-term bonds needs an important degree of trust [14] which has a positive impact on the quality of the relationship and which triggers partners to accept risks. Therefore, as the authors state, the lack of trust in a relationship also brings out challenges and, due to these challenges, integrated solutions are considered to be too costly and risky to produce or buy [20]. (See Table 2 for an overview of integrated solutions challenges).

Table 2. The challenges of integrated solutions

Operational difficulties	Developing operational integration	As the alteration of the components of the product offering is not easy and it is difficult to change internal inefficiencies of operations.
Managerial difficulties	The mind-set of the managers and the workforce	Due to difficulty of changing the belief that services are add-ons and of the required culture shift.
	Developing capabilities and relationships	Due to the difficulty to build trust.

Although the literature is rich in terms of the definition of integrated solutions or the advantages and challenges of providing them, most of the studies are conducted within Europe. However, the situation presents some differences in Turkey. Since Turkey is a developing country and has an economy mostly dependent on manufacturing, we believe Turkey presents an interesting example. Thus, the aim of this study is to understand the perceptions of both the managers of providers of integrated solutions and the customers in terms of what they understand from the concept of integrated solutions and the process of providing it.

Research Methodology

As this study aims to gain deep insight regarding integrated solutions, qualitative research techniques are suitable for data collection. Since our aim is to gain insights regarding integrated solutions and since the concept is related with developing relationships, we need to build trust and collect this sensitive information from participants through in-depth interviews [21]. In addition, in order to be aware of naturally occurring behaviours and conversations, observation is useful to record [22].

In total, seven in-depth interviews have conducted which were with both the customers and producers of integrated solutions in business to business markets. In order to acknowledge the dynamics of the relationship between the partners in the supply chain, we first carry out this study with the managers of procurement departments of two famous white-appliances and electronics Company in Turkey. One of these companies is a Turkish company and it is one of the few Turkish companies which has a brand awareness around the world. The other one is a global white-appliances brand which set up a factory in Turkey. Both of the companies are known brand both in Turkey and around the world. These companies are considered to be appropriate for this research setting since, several previous studies have focused on this industry (e.g.: [28]) and, both of the companies claim they are providing solutions in their web-sites. Then, during the interviews, we also use snow-ball technique in order to select the suppliers from whom they are buying an integrated solution. With this attempt, the first and second company provide us with three and two names, respectively. From the first group, sales managers of two companies have agreed to conduct interviews, however; from the second group, we were able to conduct an interview with just one company.

Interviews are semi-structured, including a protocol specifying main topics with open-ended questions. In order to increase the credibility, iterative questioning techniques and probing have been used [21].

Interviews were conducted, each lasting between forty-five to sixty minutes, and recorded with the permissions of the participants. Interviews, then, transcribed and coded by following the suggestions of Strauss and Corbin [23]. First an axial coding has been performed by writing a code for each paragraph and/or sentence. After, through a selective coding phase, we grouped and compared data in order to reveal similarities and differences.

In order not to manipulate any data, triangulation between researchers and methods has been utilized. Triangulation between researchers provides us with diverse perspectives and explanations of the findings which enhances the validity of the results [24]. Furthermore, triangulation across methods (e.g.: in-depth interviews and observations) reveals the pieces of data, that may be overlooked by using just one method [22].

Findings and Discussion

In this section, we firstly present the perceptions of the buyers of integrated solutions and in order to ensure the anonymity of the procurement managers of two companies operating in white appliances and electronic industry, pseudo names are going to be used.

In both of the companies the procurement is divided into two departments as direct procurement and indirect procurement. Direct procurement is the activities related with the purchasing of all the ingredients and materials related with the actual products such as refrigerators and washing machines. Indirect procurement is described as the materials that are not directly used during the production of, for instance, a refrigerator, but used inside the factory such as catering or security services. Since our aim is to understand the perceptions of both the provider and buyer of integrated solutions, we focused on the direct procurement departments.

In terms of the definition of solutions, the procurement managers of companies were aware of such a concept although they name it as *"çözüm"* which is *"solution"* in Turkish. Although the literature is rich regarding providing definitions for solutions, for instance, Davies et al. [4] explain the term as "*...to identify and solve each customer's business problem by providing services to design, integrate, operate and finance a product or system during its life cycle*. (p.40)". This requirement of providing services to customers throughout the products life cycle forces companies to become strategic business partners [14]. Similarly, when asked about what they understand from the term integrated solutions, they use the words 'solution partner':

> Buket (female, Company X): "*When we say integrated solutions in a supply chain, we mean solution partners...being a solution partner is not necessary for all the materials that we procure. For instance, if the material is easy to find, we don't need a solution for that, we simply bid the suppliers and select the one with minimum cost. However, if the material is critical we need to form a strategic relationship with the supplier in order to share the risks.*"
>
> Gökmen (male, Company X): "*Integrated solutions in a supply chain...It is not just related with the cost of the material. Apart from that, supplier needs to help us with logistics activities such as packaging*."

As the above statements show, there needs to be a shift from transactions to relationships and, from suppliers to network partners when providing solutions [26]. Moreover, our respondents clarify what they expect from such a relationship with suppliers. The one thing which is indispensible is the quality of the product. The suppliers need to deliver high-quality products, and the aspect that they compete is the cost. Since both of the companies are cost-oriented, they expect suppliers to deliver the products with high-quality, but low-cost. Apart from that, one of the respondents explains the expectations from such a relationship:

> Gonca (female, Company X): "*Quality, supplier needs to be sure about the product. Besides, inventory management is really important for us. Since it takes four months to procure a material from, for instance, far East, and, deliver the final product to the end consumer, we need to optimize this process. Moreover, the prices change constantly in our industry so; management of the inventory is significant.*"

Although the quality and cost is the most mentioned qualifications for a supplier to become a solution partner, the respondents point out the necessity to be flexible and rapid decision making. Moreover, although the literature does not mention innovation while defining integrated solutions, some of our respondents mentioned the need for creativity:

> Gökmen (male, Company X): "*Nowadays, quality is not mentioned much because it is a must. Moreover there is a pressure about the cost of the products; therefore, in order to differentiate themselves, suppliers' ability to design is important. How can they change the design, what they can offer becomes significant for us, because some products are produced by every company and thus, they need to make some innovations in order to be different from others*."

Although innovation is defined as the introduction of a new product, idea or service into the market place by American Marketing Association, innovation may have some levels. According to [25], innovation can be divided into six levels, one of which is called as *new to the company*, meaning the product is not new to the market, but new to the company. In white-appliances industry, this form of innovation is more associated with integrated solutions. During our interviews, our respondents gave some examples of such integrated solutions. For instance, one of the suppliers of Company A came up with a creative idea. They found a material in China which increases the durability of a refrigerators' deep freezer. The supplier showed the proto-types of the material to the Company X and, they found it very convenient. However, the supplier was unable to obtain the material from China due to financial reasons. In order to solve the problem, Company X supported the supplier financially and as a result, they now produce more robust refrigerators. In this way, the supplier actually took over some of the work that needs to be done by the company. This means the supplier understood what the customer needs and provide the customer with what is required. This finding shows the necessity of the first step of providing integrated solutions which is requirements definition [10].

In conclusion, our preliminary findings demonstrate similarities with the study of Tuli et al. [10]. In general our respondents describe a solution as the integration of products and services but, most importantly in order

to create solutions, the parties should see each other as partners meaning, for example, they need to be taking risks for each other. In that sense, as a buyer of solutions, companies expect suppliers to come up with good quality, low cost, innovative solutions with extra services, depending on the nature of the business, such as packaging or inventory management. In the following phase of the study, we are planning to increase the number of interviews, especially, with the suppliers of these companies as they are the providers of solutions in order to understand the other party's perception.

References

[1] S. Vandermerve, "The Market Power is in the Services: Because the value is in the results," *European Management Journal,* vol. 8, no. 4, pp. 464-473, 1990.

[2] P. Matthyssens and K. Vandenbempt, "Creating Competitive Advantage in Industrial Services," *Journal of Business & Industrial Marketing,* vol. 13, no. 4/5, pp. 339-355, 1998.

[3] C. Windahl, P. Andersson, C. Berggren and C. Nehler, "Manufacturing firms and integrated solutions: characteristics and implications," *European Journal of Innovation Management,* vol. 7, no. 3, pp. 218-228, 2004.

[4] A. Davies, T. Brady and M. Hobday, "Charting the Path Towards Integrated Solutions," *MIT Sloan Management Review,* vol. 47, no. 3, pp. 39-48, 2006.

[5] M. Sawhney, "Going Beyond the product,defining,designing and delivering customer solutions," in *The service-dominant logic of marketing:Dialog,debate and directions*, New York, M.E.Sharpe, 2006, pp. 365-380.

[6] R. Oliva and R. Kallenberg, "Managing the Transition from Products to Services," *International Journal of Service Industry Management,* vol. 14, no. 2, pp. 160-172, 2003.

[7] H. Evanschitzky, F. Wangenheim and D. Woisetschläger, "Service & solution innovation: Overview and research agenda," *Industrial Marketing Management,* vol. 40, no. 5, pp. 657-660, 2011.

[8] A. Davies, "moving base into high-value integrated solutions:a value stream approach," *Industrial and Corporate Change,* vol. 13, no. 5, pp. 727-756, 2004.

[9] J. Galbraith, "Organizing to deliver solutions," *Organizational Dynamics,* vol. 31, no. 2, pp. 194-207, 2002.

[10] K. R. Tuli, A. K. Kohli and S. G. Bharadwaj, "Rethinking customer solutions:From product bundles to relational processes," *Journal of Marketing,* vol. 71, pp. 1-17, 2007.

[11] A. Salonen, "Service transition strategies of industrial manufacturers," *Industrial Marketing Management,* vol. 40, no. 5, pp. 683-690, 2011.

[12] N. Foote, J. Galbraith, Q. Hope and D. Miller, "Making Solutions the Answer," *McKinsey Quarterly,* vol. 3, pp. 84-93, 2001.

[13] G. Ren and M. Gregory, "Servitization in Manufacturing Companies: Literature Review,Research Progress and Cambridge Service Research," in *Cranfield Product Service Systems Seminar*, Cranfield, 2007.

[14] F. Nordin and C. Kowalkowski, "Solutions offerings: a critical review review and reconceptualisation," *Journal of Service Management,* vol. 21, no. 4, pp. 441-459, 2010.

[15] A. Töllner, M. Blut and H. Holzmüller, "Customer solutions in the capital goods industry: Examining the impact of the buying center," *Industrial Marketing Management,* vol. 40, no. 5, pp. 712-722, 2011.

[16] S. Vandermerwe and J. Rada, "Servitization of business," *European Management Journal,* vol. 6, no. 4, pp. 314-324, 1988.

[17] H. Gebauer, B. Edvardsson and M. Bjurko, "The Impact of Service Orientation in Corporate Culture on Business Performance in Manufacturing Companies," *Journal of Service Management,* vol. 21, no. 2, pp. 237-259, 2010.

[18] O. Mont, "Clarifying the Concept of Product-Service System," *Journal of Cleaner Production,* vol. 10, no. 3, pp. 237-245, 2002.

[19] C. Windahl and N. Lakemond, "Developing Integrated Solutions: The Importance of Relationships within the Network," *Industrial Marketing Management,* vol. 35, no. 7, pp. 806-818, 2006.

[20] H. Agndal, B. Axelsson, N. Lindberg and F. Nordin, "Trends in service sourcing practices," *Journal of Business Market Management,* vol. 1, no. 3, pp. 187-207, 2007.

[21] S. Kvale, Interviews: An Introductionto Qualitative Research Interviewing, Thousand Oaks: Sage, 1996.

[22] D. Silverman, Doing Qualitative Research, 2nd ed., London: Sage, 2005.

[23] A. Strauss and J. Corbin, Basics of Qualitative Research Techniques and Procedures for Developing Grounded Theory, London: Sage, 1990.

[24] H. Maylor and K. Blackmon, Researching Business and Management, Hampshire: Palgrave Macmillan, 2005.

[25] G. Avlonitis, P. Papastathopoulou and S. Gounaris, " An empirically-based typology of product innovativeness for new financial services: Success and failure scenarios," *The Journal of Product Innovation Management*, vol. 18, no. 5, pp. 324-342, 2001.

[26] A. Neely, O. Benedittini and I. Visnjic, "The servitization of manufacturing: Further Evidence," in *18th European Operations Management Association Conference*, Cambridge, 2011.

[27] A. Neely, D. McFarlane and I. Visnjic, "Complex Service Systems – Identifying Drivers, Characteristics and Success Factors," in *18th European Operations Management Association Conference*, Cambridge, 2011.

[28] S. Wiesner, P. Padrock and K. Thoben, "Extended Product Business Model Development in Four MAnufacturing Case Studies," *Procedia CIRP*, vol. 16, pp. 110-115, 2014.

MARMARA ÜNİVERSİTESİ 1883
MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

A Fuzzy Approach for Supplier Selection in a Supply Chain Management

Pınar MİÇ[1]

Abstract

In a broad sense, supply chain management is the concern in optimizing customer service level requirements along with optimizing the cost of steps involved in it. Since various sources of uncertainty and complex relationships between various entities exist in Supply Chain, managing a supply chain is a very difficult process. Consequently, determining suitable suppliers in the supply chain has become a key strategic subject during past years. In general, many quantitative and qualitative factors such as price, quality, flexibility and delivery performance should be considered for determining suitable suppliers. In this paper, linguistic values are used to assess the ratings and weights for these factors. A hierarchical multiple criteria decision-making model based on fuzzy sets theory with TOPSIS concept is used to deal with the supplier selection problems in the supply chain. In the end, a hypothetical example is shown to highlight the process of the mentioned method above.

Keywords: Fuzzy set theory, Linguistic variables, MCDM , Supplier selection, Supply chain

Introduction

A supply chain (SC) is an integrated process where a number of business entities (including suppliers, manufacturers, distributors, and retailers) work together to convert raw materials into the specified finished products and deliver these finished products to retailers or customers [1]. Figure 1 shows this material flow in a supply chain.

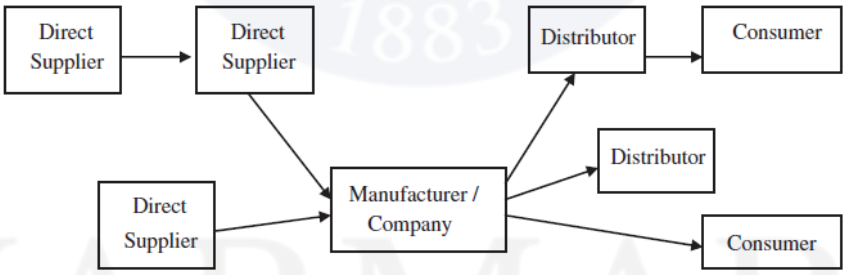


Figure 1. Material Flow in a Supply Chain [2]

Supply chain management and the supplier selection process have taken considerable attention in the business-management literature recently. Many manufacturers looked for to cooperate with their suppliers to be able to upgrade their management performance and competitiveness during the 1990s [3]. Business enterprises are forced to improve their supply chains to reduce inventory cost and develop customer service levels by reason of the increasing competition in today's global market. If ever a supplier becomes part of a well-managed and established supply chain, this relationship will have a lasting effect on the competitiveness of the entire supply chain. Therefore, the supplier selection problem has become one of the most important issues for establishing an effective supply chain system. The overall objective of supplier selection process is to reduce purchase risk, maximize overall value to the purchaser, and build the closeness and long term relationships between buyers and suppliers [4].

[1] Pınar Miç, Cukurova University, Engineering and Architecture Faculty, Department of Industrial Engineering, Adana, Turkey, xxxx@cu.edu.tr

In supply chains, coordination between a manufacturer and suppliers is naturally a difficult and important link in the channel of distribution. Many models developed for supplier selection decisions are based on rather simplistic perceptions of decision-making process [5] [6]. Most of these methods do not look like to address the complex and unstructured nature and context of many present day purchasing decisions [5]. According to the broad literature on supplier selection [5], [7], [8] we can come to a decision that decision-making is often influenced by uncertainty in practice. An increasing number of supplier decisions can be characterized as dynamic and unstructured [9]. Situations are changing rapidly or are uncertain and decision variables are difficult or impossible to quantify [10]. From the literature it can be concluded that in supplier selection the classic concept of ''optimality'' may not always be the most appropriate model [5]. We can conclude that supplier selection may involve several and different types of criteria, combination of different decision models, group decision-making and various forms of uncertainty. It is difficult to find the best way to evaluate and select supplier, and companies use a variety of different methods to deal with it. Therefore, the most important issue in the process of supplier selection is to develop a suitable method to select the right supplier.

In essential, the supplier selection problem in supply chain system is a group decision-making under multiple criteria. The degree of uncertainty, the number of decision makers and the nature of the criteria have to be taken into account in solving this problem. In classical MCDM methods, the ratings and the weights of the criteria are known precisely [11]. Technique for Order Performance by Similarity to Ideal Solution (TOPSIS), one of the known classical MCDM methods, may provide the basis for developing supplier selection models that can effectively deal with these properties. It bases upon the concept that the chosen alternative should have the shortest distance from the Positive Ideal Solution (PIS) and the farthest from the Negative Ideal Solution (NIS). In addition to this, under many conditions, data is inadequate to model real-life situations. Since human judgements including preferences are often uncertain and cannot estimate its preference with an exact numerical value, a more realistic approach can use linguistic assessments instead of numerical values. In other words, the ratings and weights of the criteria in the problem are assessed by means of linguistic variables [11], [12], [13], [14], [15]. In this paper, considering the fuzziness in the decision data and group decision-making process, linguistic variables are used to assess the weights of the each criteria and the ratings of each alternative with respect to each criterion. According to the concept of TOPSIS, the fuzzy positive ideal solution (FPIS) and the fuzzy negative ideal solution (FNIS) are calculated. And then, a vertex method is applied to find out the distance between two fuzzy ratings. Using the vertex method, the distance of each alternative from FPIS and FNIS can be calculated, respectively. Finally, a closeness coefficient of each alternative is defined to determine the ranking order of all alternatives. The higher value of closeness coefficient indicates that an alternative is closer to FPIS and farther from FNIS simultaneously. This paper is arranged as follows: Next section introduces the basic definitions and notations of the fuzzy set theory. In Section 3, the algorithm of a fuzzy decision-making method with TOPSIS concept is given, and its adapted to cope with the supplier selection problem. And then, the proposed method is illustrated with a hypothetic example by Section 4. Finally, conclusions are pointed out at the end of this paper, by Section 5.

Fuzzy Set Theory

Zadeh, whom presented fuzzy set theory, stated that using linguistic expressions are necessary to solve the problems noninclusive of certainty and to express human thought [16] [17]. Many uncertainty came upon in daily life can not be modelled by certainty approach, but fuzzy sets can do this by modelling. Fuzzy set theory enhances to express this uncertainty with mathematically by fuzzy numbers while modelling the linguistic uncertainty about human sense and special judgements. Due to the providing operation easiness, the commonly used fuzzy number type is triangular fuzzy numbers. A triangular fuzzy number is shown in the form of "n" (n_1, n_2, n_3). Let m and n be positive fuzzy numbers, r a positive real number, $m_1^{\propto}$ and $n_1^{\propto}$ be the upper limit of closed interval; and $m^{\propto} = [m_1^{\propto}, m_u^{\propto}]$, $n^{\propto} = [n_1^{\propto}, n_u^{\propto}]$ the $\propto$ cut of two fuzzy number. The elementary operations worked with triangular fuzzy numbers can be summarized as follows [17]:

$$(m(+)n)^{\propto} = [m_1^{\propto} + n_1^{\propto}, m_u^{\propto} + n_u^{\propto}] \quad (1)$$

$$(m(-)n)^{\propto} = [m_1^{\propto} - n_u^{\propto}, m_u^{\propto} - n_1^{\propto}] \quad (2)$$

$$(m(.)n)^{\propto} = [m_1^{\propto}.r, m_u^{\propto}.r] \quad (3)$$

Vertex method, is a method used to find the distance between fuzzy numbers. The distance between two fuzzy numbers such as $m = (m_1, m_2, m_3)$ and $n = (n_1, n_2, n_3)$ calculated with vertex method is as follows [17]:

$$d(m,n) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]} \quad (4)$$

Fuzzy TOPSIS Method

One of the most common methods used in MCDM problems is TOPSIS method, first suggested in 1981 [18]. The most important feature of this method as a linear weighting technique is identifiying the solution which has the shortest geometric distance from the positive ideal solution and the farthest geometric distance from the negative ideal solution. By calculating these two-way distances, the situations needed to minimize are taken into consideration in addition to the situations to be maximized [19]. At the same time, in real life and in many circumstances numerical values can remain incapable by the reason of human thoughts and judgements, particularly choices contains uncertainty. TOPSIS method is developed in such a way that will be able to use fuzzy datas [20]. Fuzzy TOPSIS method enables decision-makers to assess and range the alternatives under uncertainty in respect to certain criteria, and to make the truest choice between them.

Based on this, a supplier selection in supply chain system is a group of multiple-criteria decision-making (GMCDM) problem and may be described by means of the following sets:

(1) a set of K decision-makers called $E = \{D_1, D_2, \ldots, D_K\}$;
(2) a set of m possible suppliers (alternatives) called $A = \{A_1, A_2, \ldots, A_m\}$;
(3) a set of n criteria, $C = \{C_1, C_2, \ldots, C_N\}$ with which supplier (alternative) performances are measured;
(4) a set of performance ratings of A_i (i = 1,2,…,m) with respect to criteria C_j (j = 1,2,…,n), called $X = \{x_{ij}, i = 1,2,\ldots,m,\ j = 1,2,\ldots,n\}$.

Following this, linguistic values to be used in determining the importance weights of alternatives and in assesment of alternatives are chosen, and decision-makers evaluate the criteria and alternatives by the help of these linguistic values. The expression of these evaluations in the form of fuzzy numbers are given by Table 1 and Table 2 [2].

Table 1. Linguistic Values Used to Determine the Importance Weights of Criteria [2]

Very High (VH)	(0.8,1,1)
High (H)	(0.7,0.8,0.9)
Medium High (MH)	(0.5,0.65,0.8)
Medium (M)	(0.4,0.5,0.6)
Medium Low (ML)	(0.2,0.35,0.5)
Low (L)	(0.1,0.2,0.3)
Very Low (VL)	(0,0,0.2

Table 2. Linguistic Values Used to Assess the Alternatives [2]

Very Good (VG)	(8,10,10)
Good (G)	(7,8,9)
Medium Good (MG)	(5,6.5,8)
Medium (M)	(4,5,6)
Medium Poor (MP)	(2,3.5,5)
Poor (P)	(1,2,3)
Very Poor (VP)	(0,0,2)

Assume that a decision group has K decision makers, and the fuzzy rating of each decision-maker $D_K(k = 1,2,\dots,K)$ can be represented as a positive trapezoidal fuzzy number $\tilde{R}_k(k = 1,2,\dots,K)$ with membership function $\mu_{\tilde{R}_k}(x)$. A good aggregation method should be considered the range of fuzzy rating of each decision-maker. It means that the range of aggregated fuzzy rating must include the ranges of all decision-makers' fuzzy ratings. Let the fuzzy ratings of all decisionmakers be trapezoidal fuzzy numbers $\tilde{R}_k = (a_k,\ b_k, c_k)$, k = 1,2,…,K. Then the aggregated fuzzy rating can be defined as:

$$\tilde{R} = (a, b, c),\ k = 1,2,\dots,\ ;\ \text{where } a = \min_k\{a_k\},\ b = \frac{1}{K}\sum_{k=1}^{K} b_k,\ c = \max_k\{c_k\} \quad (5)$$

Let the fuzzy rating and importance weight of the kth decision maker be $\tilde{x}_{ij}k = (a_{ijk}, b_{ijk}, c_{ijk})$, and $\tilde{w}_{jk} = w_{jk1}, w_{jk2}, w_{jk3}$, i = 1,2,…,m, j = 1,2,…,n, respectively. Hence, the aggregated fuzzy ratings $(\tilde{x}_{ij})$ of alternatives with respect to each criterion can be calculated as;

$$\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}),\ \text{where } a_{ij} = \min_k\{a_{ijk}\},\ b_{ij} = \frac{1}{K}\sum_{k=1}^{K} b_{ijk},\ c_{ij} = \max_k\{c_{ijk}\} \quad (6)$$

The aggregated fuzzy weights $(\tilde{w}_j)$ of each criterion can be calculated as:

$$\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3}),\ \text{where } w_{j1} = \min_k\{w_{jk1}\},\ w_{j2} = \frac{1}{K}\sum_{k=1}^{K} w_{jk2},\ w_{j3} = \max_k\{w_{jk3}\} \quad (7)$$

As stated above, a supplier-selection problem can be concisely expressed in matrix format as follows:

$$\tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \dots & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \dots & \tilde{x}_{2n} \\ \vdots & \vdots & \dots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \dots & \tilde{x}_{mn} \end{bmatrix}$$

$$\tilde{W} = [\tilde{w}_1, \tilde{w}_2, \dots, \tilde{w}_n], \quad (8)$$

where $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and $\tilde{w}_j = (w_{j1}, w_{j2}, w_{j3})$; , i = 1,2,…,m, j = 1,2,…,n can be approximated by positive trapezoidal fuzzy numbers.

The normalized fuzzy-decision matrix can be represented as:

$$\tilde{R} = [\tilde{r}_{ij}]_{mxn} \quad (9)$$

where B and C are the sets of benefit criteria and cost criteria, respectively, and;

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \quad c_j^* = \max_i c_{ij}\ , \quad j \in B\ ; \quad (10)$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_j}, \frac{a_j^-}{c_j}, \frac{a_j^-}{c_j}\right), \quad a_j^- = \min_i a_j, \quad j \in C; \tag{11}$$

The normalization method mentioned above is designed to preserve the property in which the elements $\tilde{r}_{ij}$, $\forall i, j$ are the standardized (normalized) trapezoidal fuzzy numbers.

Considering the different importance of each criterion, the weighted normalized fuzzy-decision matrix is constructed as:

$$\tilde{V} = [\tilde{v}_{ij}]_{mxn}, \quad i = 1,2,\ldots,m, j = 1,2,\ldots,n \quad \text{where} \quad \tilde{v}_{ij} = \tilde{r}_{ij}(.)\tilde{w}_j \tag{12}$$

According to the weighted normalized fuzzy-decision matrix, normalized positive trapezoidal fuzzy numbers can also approximate the elements $\tilde{v}_{ij}$, $\forall i, j$. Then, the fuzzy positive-ideal solution (FPIS, A^*) and fuzzy negative-ideal solution (FNIS, A^-) can be defined as:

$$A^* = (\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^*), \tag{13}$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-), \tag{14}$$

$$\text{where } \tilde{v}_j^* = \max_i \{v_{ij3}\} \text{ and } \tilde{v}_j^- = \min_i \{v_{ij1}\}; i = 1,2,\ldots,m, j = 1,2,\ldots,n \tag{15}$$

The distance of each alternative (supplier) from A^* and A^* can be currently calculated as:

$$d_i^* = \sum_{j=1}^n d_v(\tilde{v}_{ij}, \tilde{v}_j^*), \quad i = 1,2,\ldots,m, \tag{16}$$

$$d_i^- = \sum_{j=1}^n d_v(\tilde{v}_{ij}, \tilde{v}_j^-), \quad i = 1,2,\ldots,m, \tag{17}$$

where $d_v(.,.)$ is the distance measurement between two fuzzy numbers.

A closeness coefficient is defined to determine the ranking order of all possible suppliers once d_i^* and d_i^- of each supplier A_i ($i = 1,2,\ldots,m$) has been calculated. The closeness coefficient represents the distances to the fuzzy positive-ideal solution (A^*) and the fuzzy negative-ideal solution (A^-) simultaneously by taking the relative closeness to the fuzzy positive-ideal solution. The closeness coefficient (CC_i) of each alternative (supplier) is calculated as:

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-}, \quad i = 1,2,\ldots,m, \tag{18}$$

To sum up, an algorithm of the fuzzy decision-making method to deal with the supplier selection problem is given as follows:

Step 1: Identify the supplier selection criteria.
Step 2: Choose the appropriate linguistic variables for the importance weight of the criteria and the linguistic ratings for suppliers.
Step 3: Aggregate the weight of each criteria to get the aggregated fuzzy weight $\tilde{w}_j$ of criterion C_j, and combine the decision-makers' ratings to get the aggregated fuzzy rating $\tilde{x}_{ij}$ of supplier A_i under criterion C_j.
Step 4: Construct the fuzzy-decision matrix and the normalized fuzzy-decision matrix.
Step 5: Construct weighted normalized fuzzydecision matrix.
Step 6: Determine FPIS and FNIS.
Step 7: Calculate the distance of each supplier from FPIS and FNIS, respectively and then calculate the closeness coefficient of each supplier.

Step 8: According to the closeness coefficient, determine to select which supplier.

A Hypothetical Numerical Example

A manufacturing company wants to select a suitable material supplier to purchase the key components of new products. After preliminary screening, four candidates (A_1, A_2, A_3, A_4) remain for further evaluation. A committee of four decision makers, D_1, D_2 , D_3 and D_4 has been formed to select the most suitable supplier. Four selection criteria are as follows:

- Price (C_1),
- Delivery Date (C_2),
- Quantity (C_3),
- Quality (C_4).

Step 1: Four decision-makers use the linguistic weighting values shown in Table 1 to assess the importance of the criteria. The importance weights of the criteria determined by these four decision makers are shown in Table 3.

Table 3. Importance Weights of Criteria from Four Decision Makers

Criteria	Decision Makers			
	D_1	D_2	D_3	D_4
C_1	VH	H	VH	H
C_2	H	H	H	H
C_3	H	VH	VH	H
C_4	VH	VH	H	VH

Step 2: Four decision-makers use the linguistic rating variables shown in Table 2 to evaluate the ratings of candidates with respect to each criterion. The ratings of the four candidates by the decision makers under various criteria are shown in Table 4.

Table 4. Ratings of the Four Candidates by Decision Makers Under Various Criteria

Criteria	Suppliers	Decision Makers			
		D_1	D_2	D_3	D_4
C_1	A_1	VG	VG	VG	MP
	A_2	VG	VG	MG	VG
	A_3	M	G	MP	G
	A_4	G	VG	VG	VG
C_2	A_1	MP	MG	G	VG
	A_2	VG	MG	VG	G
	A_3	MG	MP	MG	G
	A_4	G	VG	G	MP
C_3	A_1	VG	G	MG	M
	A_2	G	M	MG	VG
	A_3	VG	MG	MP	M
	A_4	VG	MP	G	M
C_4	A_1	MG	G	MG	MG
	A_2	G	VG	VG	VG
	A_3	P	G	M	MG
	A_4	VG	M	MP	G

Step 3: Then the linguistic evaluations shown in Tables 3 and 4 are converted into trapezoidal fuzzy numbers to construct the fuzzy-decision matrix and determine the fuzzy weight of each criterion, as in

Table 5 and Table 6.

Table 5. The Weights of Each Criteria

Criteria	Weights
C_1	(0.75,0.9,0.95)
C_2	(0.7,0.8,0.9)
C_3	(0.75,0.9,0.95)
C_4	(0.78,0.95,0.98)

Table 6. Fuzzy Decision Matrix

	C_1	C_2	C_3	C_4
A_1	(6.5,8.38,8.75)	(5.5,7,8)	(6,7.38,8.25)	(5.5,6.88,8.25)
A_2	(7.25,9.13,9.5)	(7,8.63,9.25)	(6,7.38,8.25)	(7.75,9.5,9.75)
A_3	(5,6.13,7.5)	(4.75,6.13,7.5)	(4.75,6.3,7.25)	(4.25,5.38,6.5)
A_4	(7.75,9.5,9.75)	(6,7.38,8.25)	(5.25,6.63,7.5)	(5.25,6.63,7.5)

Step 4: The fuzzy decision matrix is normalized with Equation (5), and normalized fuzzy decision matrix is given with Table 7.

Table 7. Normalized Fuzzy Decision Matrix

	C_1	C_2	C_3	C_4
A_1	(0.67,0.86,0.9)	(0.6590.76,0.86)	(0.73,0.89,1)	(0.56,0.71,0.85)
A_2	(0.74,0.94,0.97)	(0.76,0.93,1)	(0.73,0.89,1)	(0.79,0.97,1)
A_3	(0.51,0.63,0.77)	(0.51,0.66,0.81)	(0.58,0.76,0.88)	(0.44,0.55,0.67)
A_4	(0.79,0.97,1)	(0.65,0.8,0.89	(0.64,0.80,0.91)	(0.54,0.68,0.77)

Step 5: Weighted normalized fuzzy-decision matrix is constructed as in Table 8.

Table 8. Weighted Normalized Fuzzy Decision Matrix

	C_1	C_2	C_3	C_4
A_1	(0.5,0.77,0.85)	(0.45,0.68,0.82)	(0.55,0.81,0.95)	(0.42,0.64,0.8)
A_2	(0.52,0.75,0.88)	(0.53,0.75,0.9)	(0.51,0.72,0.9)	(0.56,0.78,0.9)
A_3	(0.38,0.57,0.73)	(0.39,0.6,0.77)	(0.43,0.69,0.83)	(0.33,0.5,0.63)
A_4	(0.62,0.93,98)	(0.51,0.76,0.87)	(0.50,0.76,0.89)	(0.42,0.65,0.75)

Step 6: Determine FPIS and FNIS as;

$A^* = [(1,1,1),(1,1,1),(1,1,1),(1,1,1)]$,
$A^- = [(0,0,0),(0,0,0),(0,0,0),(0,0,0)]$,

Step 7: Calculate the distance of each supplier from FPIS and FNIS with respect to each criterion, respectively, as Table 9 and Table 10.

Table 9. Distances Between $A_i(i=1,2,3,4)$ and A^* with respect to Each Criteria

	C_1	C_2	C_3	C_4
$d(A_1,A^*)$	0.33	0.38	0.29	0.41
$d(A_2,A^*)$	0.32	0.31	0.33	0.29
$d(A_3,A^*)$	0.46	0.44	0.39	0.53
$d(A_4,A^*)$	0.22	0.33	0.33	0.42

Table 10. Distances Between $A_i(i=1,2,3,4)$ and A^- with respect to Each Criteria

	C_1	C_2	C_3	C_4
$d(A_1,A^-)$	0.72	0.67	0.78	0.64
$d(A_2,A^-)$	0.73	0.74	0.73	0.76
$d(A_3,A^-)$	0.58	0.60	0.67	0.50
$d(A_4,A^-)$	0.86	0.73	0.73	0.62

Calculation of d_i^* , d_i^- and the closeness coefficients of each supplier are calculated in Table 11.

Table 11. Computations of d_i^* , d_i^- and CC_i

Alternatives	d_i^*	d_i^-	$d_i^* + d_i^-$	CC_i
A_1	1.41	2.82	4.23	0.67
A_2	1.26	2.96	4.22	0.7
A_3	1.82	2.36	4.18	0.56
A_4	1.3	2.94	4.24	0.69

According to these closeness coefficients, the alternatives are ranges as $A_2 > A_4 > A_1 > A_3$. In other words, for this hypothetic example implemented by fuzzy TOPSIS method, A_2 (Alternative Supplier 2) is the best candidate for this supplier selection problem.

Conclusions

The advantages of suppy chain management have been presented by many researchers and firms up to now. In the light of these developments, many companies consider suppy chain management as an important tool to increase the competitory advantage. In these circumstances, building the long-term relationships between buyers and suppliers is critical success factor to establish an effective supply chain system. Therefore, supplier selection problem becomes the most important issue to implement a successful supply chain system.

In general, supplier selection problems are based onto uncertain and indecisive data and fuzzy-set theory is adequate to deal with these. Due to supplier selection problems contain human judges by definition, its important to associate it with fuzzy set theory to represent the real life. In addition to these, in a decision-making process, the use of linguistic variables in decision problems is highly beneficial when performance values cannot be expressed by means of numerical values. In other words, in assessing of possible suppliers with respect to criteria and importance weights, it is appropriate to use linguistic variables instead of numerical values frequently. The fuzzy TOPSIS method can deal with the ratings of both quantitative as well as qualitative criteria and select the suitable supplier effectively. According to the closeness coefficient, we can determine not only the ranking order but also the assessment of all possible suppliers and this makes method flexible.

In this paper, a hierarchical multiple criteria decision-making model based on fuzzy sets theory with TOPSIS concept is used to deal with the supplier selection problem in the supply chain and a hypothetical example is been applied with the mentioned method. Consequently, as a result of the assesments made by 4 decision makers according to four criteria (price, delivery date, quatity and quality), the candidate suppliers are ranged as Alternative Supplier 2, Alternative Supplier 4, Alternative Supplier 1 and Alternative Supplier 3 from the best to the worse, respectively.

The proposed method provides objective information for supplier selection and evaluation in a supply chain system significantly. A statistical study can be suggested to determine the criteria and weights more rational and also to choose the decision makers more feasible. The systematic framework for supplier selection in a fuzzy environment presented in this paper can be easily extended to the analysis of other management decision problems. Besides, as a topic or suggestion for future researchs, developing a group decision support system in a fuzzy environment can be considered.

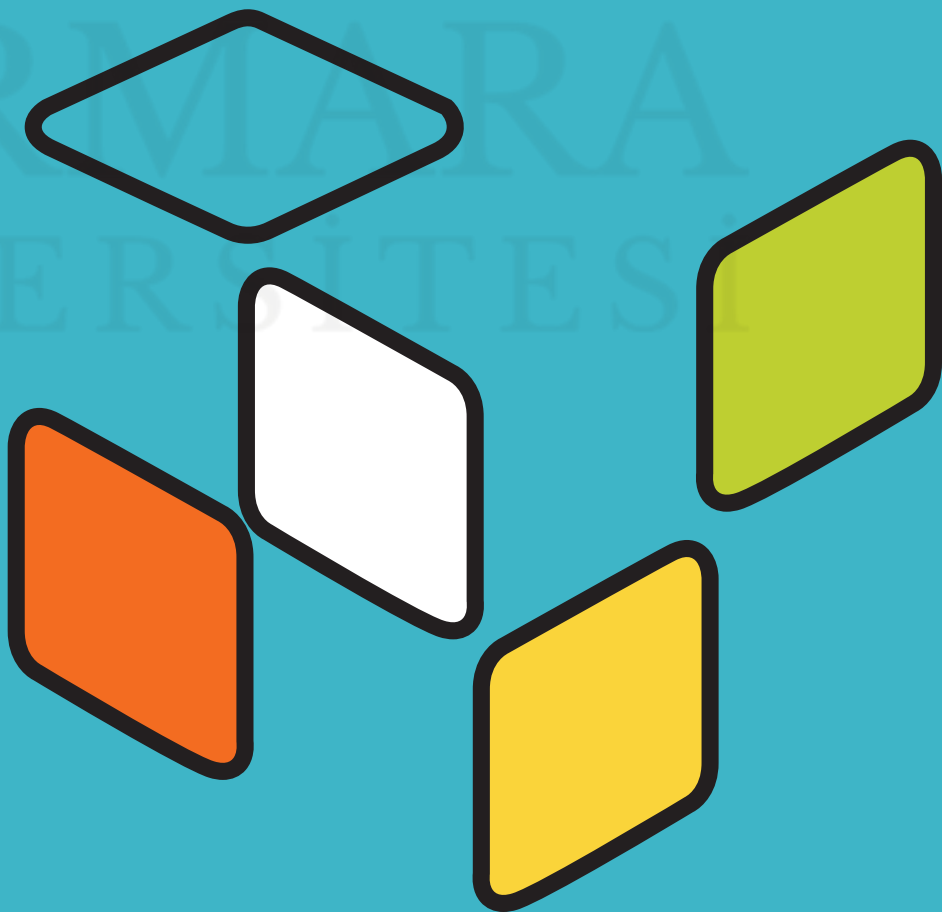
MARMARA ÜNİVERSİTESİ YAYINEVİ
MARMARA ÜNİVERSİTESİ 1883
MARMARA ÜNİVERSİTESİ

References

[1] Shin, H., Collier, D.A., Wilson, D.D., 2000, Supply management orientation and supplier/buyer performance, *Journal of Operations Management*, 18, 317-333.
[2] Chen,C.T., Lin,C.T., ,Huang, S.F. ,2006, A Fuzzy Approach for Supplier Evaluation and Selection in Supply Chain Management, *International Journal of Production Economics*, 289-301.
[3] D. Simchi-Levi, P. Kaminsky, E. Simchi-Levi, 2000, *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies,* McGraw-Hill, NewYork.
[4] Monczka, R., Trent, R., Handfield, R., 1998, *Purchasing and Supply Chain Management*, South-Western College Publishing, New York.
[5] de Boer, L., van der Wegen, L., Telgen, J., 1998, Outranking methods in support of supplier selection, *European Journal of Purchasing & Supply Management* , 4, 109–118.
[6] Lee, E.K., Ha, S., Kim, S.K., Delgado, M., 2001, Supplier selection and management system considering relationships in supply chain management, *IEEE Transactions on Engineering Management,* 48 (3), 307–318.
[7] Choi, T.Y., Hartley, J.L., 1996, An exploration of supplier selection practices across the supply chain, *Journal of Operations Management* , 14, 333–343.
[8] Weber, C.A., Current, J.R., Benton, W.C., 1991, Vendor selection criteria and methods, *European Journal of Operational Research* , 50, 2–18.
[9] Donaldson, B., 1994, Supplier selection criteria on the service dimension, *European Journal of Purchasing & Supply Management* ,1, 209–217.
[10] Cook, R.L., 1992, Expert systems in purchasing applications and development, *International Journal of Purchasing and Management*, 18, 20–27.
[11] Delgado, M., Verdegay, J.L., Vila, M.A., 1992, Linguistic decision-making models, *International Journal of Intelligent Systems* , 7, 479–492.
[12] Bellman, B.E., Zadeh, L.A., 1970, Decision-making in a fuzzy environment, *Management Science* , 17 (4), 141–164.
[13] Chen, C.T., 2000, Extensions of the TOPSIS for group decision-making under fuzzy environment, *Fuzzy Sets and Systems* , 114, 1–9.
[14] Herrera, F., Herrera-Viedma, E., Verdegay, J.L., 1996, A model of consensus in group decision making under linguistic assessments, *Fuzzy Sets and Systems* , 78, 73–87.
[15] Herrera, F., Herrera-Viedma, E., 2000, Linguistic decision analysis: Steps for solving decision problems under linguistic information, *Fuzzy Sets and Systems* , 115, 67–82.
[16] Chou,T.S, Liang G.S., 2001, Application of A Fuzzy Multi Criteria Decision Making Model for a Shipping Company Performance Evaluation , *Maritime Policy&Management*, 28(4), 375-392.
[17] Chen,C.T.,2000, A Fuzzy Approach to Select the Location of the Distribution Center, *Fuzzy Sets and Systems*, 114, 1-9.
[18] Hwang, C.L., Yoon, K.,1981, *Multiple Attributes Decision Making Methods and Applications*, Springer, Berlin Heidelberg.
[19] Ozdemir A.I., Secme N.Y., 2009, İki Aşamalı Tedarikçi Seçiminin Bulanık Topsis Yöntemi ile Analizi , *Afyon Kocatepe Üniversitesi, İ.İ.B.F Dergisi*, C. XI, S II, 79-111.
[20] Jahanshahloo, G.R., Hosseinzadeh, L.F., Izadikhah, M., 2006, Extension of the TOPSIS method for Decision Making Problems with Fuzzy Data, *Applied Mathematics and Computation*, 181(2), 1544-1551.

MARMARA ÜNİVERSİTESİ YAYINEVİ

TECHNOLOGY and RISK MANAGEMENT



ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Multi-objective Optimization of Contingency Logistics Networks with Distorted Risks

Esra Dağ [1], *Mehmet Miman*[2]

Abstract

This study develops a mathematical formulation of multi-objective optimization of contingency logistics networks (CLN) with stock allocation, cost of allocation and network reliability using weighted objective function and applying distorted risk. The model first time analyze such systems and provide illustrative case for the solution of such systems through Excel Solver with Non-linear optimization option as the model provided in this study is a non-linear, non-convex, and non-separable. The solution found for illustrative case is an Pareto optimum depending on the weights selected.

Keywords: Multi-objective, Optimization, CLN

Introduction

Thomas, [1], appears to be the first person who explicitly considers the reliability of a contingency logistic system where he defines a contingency as an "unexpected crises event that creates a major threat to the safety and security of a population". As he indicates, they range from military conflicts that require engagement with hostile forces, police actions for civil disorder, to humanitarian relief of victims from disasters such as earthquakes, hurricanes, floods, and related catastrophes. The reliability of base is defined based on interference theory between supply and demand carried to and emerged from the base. In a contingency setting demand emerged from operational base and supply that can be carried to the base are random and unknown beforehand. If the supply to the base is less than demand emerged the base is called as "failed" as the base in incapable of performing the associated contingency operation. Miman and Pohl, [2], extend Thomas's [1] work by including stock allocation in Contingency Logistics Network(CLN) in planning stage and provide the formula for the reliability of the base which are allowed to hold stocks based on inference theory.

Offut et. al, [3], provide distorted risks models namely proportional hazard (PH) and Dual Power (DP) models. Miman and Pohl, [2], provide the distorted risks analysis according to risk averseness of the decision makers for CLNs and provide multi-dimensional knapsack approach for natural vulnerability of the system defined in their study.

In the literature, Miman and Pohl, [4], provide a multi-objective optimization of CLNs through physical programming in the context of selective maintenance. For he same context, Dağ and Miman, [5], provide the multi-objective optimization modeling of CLNs through utopia-distance.

This study will provide the multi-objective formulation of the system and its solution through Excel Solver. First a Notation list is provided, then mathematical formulation is developed. Based on this, an optimization model is constructed, and its solution is illustrated using the same case as Miman and Pohl, [2], used but formulating the problem as a multi-objective optimization model.

[1] Esra Dağ, Toros University, Faculty of Engineering, Department of Industrial Engineering, Mersin, Turkey, g.esra.dag@toros.edu.tr
[2] Mehmet Miman, Toros University, Faculty of Engineering, Department of Industrial Engineering, Mersin, Turkey, mehmet.miman@toros.edu.tr

Model Development

This section provides all the notation list and mathematical formulation necessary to model the multi-objective optimization in CLN with distorted risk.

Notation List

S_i	Random variable representing the supply at site $i = 1,\ldots,n$
D_i	Random variable representing the demand at site $i = 1,\ldots,n$
X_i	Probability distribution of the supply at site $i = 1,\ldots,n$
Y_i	Probability distribution of the demand at site $i = 1,\ldots,n$
f_i	Density (or probability mass) function of the supply at site $i = 1,\ldots,n$
g_i	Density (or probability mass) function of the demand at site $i = 1,\ldots,n$
G_i	CDF for the demand at site $i = 1,\ldots,n$
μ_i	Exponential rate of the supply for Y_i
λ_i	Exponential rate of the demand for X_i
MD_i	Mean demand at site i ;$1/\lambda_i$
MS_i	Mean supply for site i; $1/\mu_i$
ψ_i	The probability distribution of excess demand for site $i = 1,\ldots,n$
s_i	Safety stock kept at the site $i = 1,\ldots,n$
s	Max total stock to be allocated through n sites
c_i^s	Cost of keeping one unit stock at supply site $i = 1,\ldots,n$
ρ_i	Failure probability of site $i = 1,\ldots,n$
υ_i	Natural vulnerability of site $i = 1,\ldots,n$
$\hat{\rho}_i^d$	Distorted risk for site $i = 1,\ldots,n$ under the distortion d
R_i	Site reliability, $i = 1,\ldots,n$
a_i	Distortion parameter for node i under PH model
b_i	Distortion parameter for node i under DP model
R	Reliability of the CLN
C	Cost of stock allocation in CLN
S	Total number of stocks o be allocated.
α	Weight for reliability
β	Weight for cost
δ	Weight for stock
$\varsigma(X)$	Aggregation Function of X

Mathematical Formulation

According to Miman and Pohl, [2], the definition of the failure probability of operational site i can be computed as:

$$\rho_i = \Pr\{D_i - S_i \geq s_i\} = \Pr\{E_i \geq s_i\} = 1 - \psi_i(s_i) \quad (1)$$

ψ_i can be derived by conditioning on S_i. (Assuming exponential supply and demand)

$$\psi_i(s_i) = \Pr\{D_i < S_i + s_i\} = \int_x Y_i(x+s_i) f_i(x) = \int_0^\infty (1 - e^{-\lambda_i(s_i+x)}) \mu_i e^{-\mu_i x} dx$$
$$= \int_0^\infty \mu_i e^{-\mu_i x} dx - \mu_i \int_0^\infty e^{-\lambda_i(s_i+x)} e^{-\mu_i x} dx = 1 - \mu_i e^{-\lambda_i s_i} \int_0^\infty e^{-x(\mu_i+\lambda_i)} dx = 1 - \frac{\mu_i}{\mu_i + \lambda_i} e^{-\lambda_i s_i} \quad (2)$$

Based on Equation (1) and Equation (2, the following risk measure for site *i* is given by Equation (3).

$$\rho_i = 1 - \psi_i(s_i) = \frac{\mu_i}{\mu_i + \lambda_i} e^{-\lambda_i s_i} \quad (3)$$

The distorted risks can be computed through Equation (4).

$$\hat{\rho}_i^{PH} = (\rho_i)^a \quad ,0 \le a \le 1$$
$$\hat{\rho}_i^{DP} = 1 - (1 - \rho_i)^b \quad ,b \ge 1 \quad (4)$$

The reliability of the CLN, R, can be derived according to structure function, the cost of stock allocation, C, would be given by Equation (5), while total stocks allocated, *S*, would be given by Equation (6).

$$C = \sum_i c_i^s s_i \quad (5)$$

$$S = \sum_i s_i \quad (6)$$

In this paradigm, while reliability of network is desired to be maximized, number of stocks allocated and cost of allocations are desired to be minimized. That is there is a trade of between *R* and *S*/*C*. To include all of the criteria in a single objective aggregation function is used for each criteria as provided by Equation (7)

$\varsigma(R) = R$, $\varsigma(S) = S^{-1}$, and $\varsigma(C) = C^{-1}$ (7)

The resulting weighted objective optimization model can be expressed by *P*.

$$Max \quad \alpha R + \frac{\beta}{C} + \frac{\delta}{S}$$
$$s.t$$
$$\alpha + \beta + \delta = 1$$
$$s_i \ge 0 \quad \text{integer} \ ,\forall i$$

Figure 1. Mathematical Model: *P*

Note that *P* defines a non-linear, non-convex, and non-separable model.

Illustration

Same example as one used by Miman and Pohl, [2], is used to illustrate the model and its solution. They modeled and solved the CLN as multi-dimensional knapsack problem. Here it is modeled as multi-objective optimization problem.

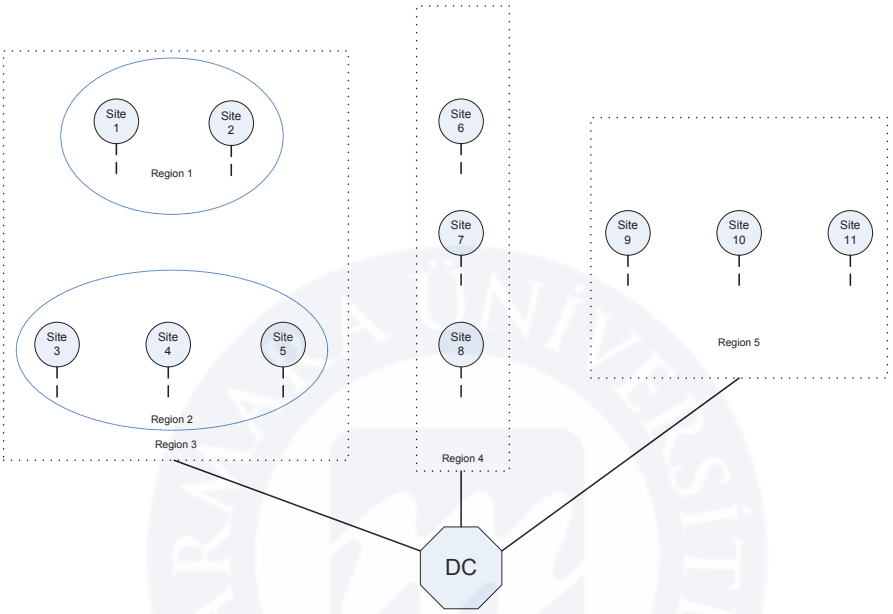


Figure 2. Illustrative Contingency Logistics Network ([2])

In this scenario, the success of the contingency operation is based upon the accomplishment of the sub missions for Regions 3, 4, and 5. These regions consist of a total of 11 operational sites. The accomplishment of each task at each site can be achieved when the site is mission capable, i.e. it has enough items to satisfy the demand for the specific contingency operation.

Region 3 is mission capable when either Region 1 or Region 2 is mission capable. Region 1 is mission capable if both sites one and two are working, similarly Region 2 is mission capable if sites 3, 4, and 5 are all mission capable. Region 4 is mission capable when at least 2 of sites 6, 7, or 8 are mission capable. Finally, Region 5 requires that sites 9, 10, and 11 be capable of performing assigned tasks that require resources supplied from the DC. Demand and supply for the items required to accomplish the assigned tasks, at each operational site i; i =1, 2…11; are assumed to be exponentially distributed with rates λ_i and μ_i, respectively. Table 1 provides the probabilities of being mission capable for each region as well as entire supply chain system where ρ_i is specified by Equation (3).

Table 1. Mission Capability Probabilities for the CLN

Region		Probability of Mission Capability
1	R_1	$(1-\rho_1)(1-\rho_2)$
2	R_2	$(1-\rho_3)(1-\rho_4)(1-\rho_5)$
3	R_3	$1-(1-R_1)(1-R_2)$
4	R_4	$1-\rho_6\rho_7-\rho_6\rho_8-\rho_7\rho_8-\rho_6\rho_7\rho_8$
5	R_5	$(1-\rho_9)(1-\rho_{10})(1-\rho_{11})$
System	R	$R_3R_4R_5$

For the distorted risk analysis, a PH distortion is used for sites 3, 4, 5, and 7 where the perceived risk is greater for site 7 than for sites 3-5. Therefore, using the PH distortion model, the parameter for site 7 is set at 0.3, which is significantly smaller than the 0.7 used for sites 3-5. The choice of distortion level should reflect the decision maker's risk tolerance for that region. (For the other sites, the decision maker is assumed to be risk neutral, i.e. a = 1). The input parameters are given in Table 2. Note that the weight for each of three criteria is set to be 1/3.

Table 2. Inputs for Illustrative Case

	Region	Site	MD	MS	λ	μ	s	c	a
Region 3	1	1	100	80	0.01	0.0125		1,00	1,00
		2	100	125	0.01	0.008		1,50	1,00
	2	3	125	125	0.008	0.008		1,20	0,70
		4	100	125	0.01	0.008		1,20	0,70
		5	150	150	0.00667	0.0067		0.8	0,70
Region 4	4	6	125	150	0.008	0.0067		1,20	1,00
		7	150	150	0.00667	0.0067		1,50	0,30
		8	100	150	0.01	0.0067		1,00	1,00
Region 5	5	9	100	100	0.01	0.01		1,00	1,00
		10	100	125	0.01	0.008		1,10	1,00
		11	125	125	0.008	0.008		1,10	1,00
						Total			

Using Excel Solver, the optimal values are obtained as shown in Figure 3.

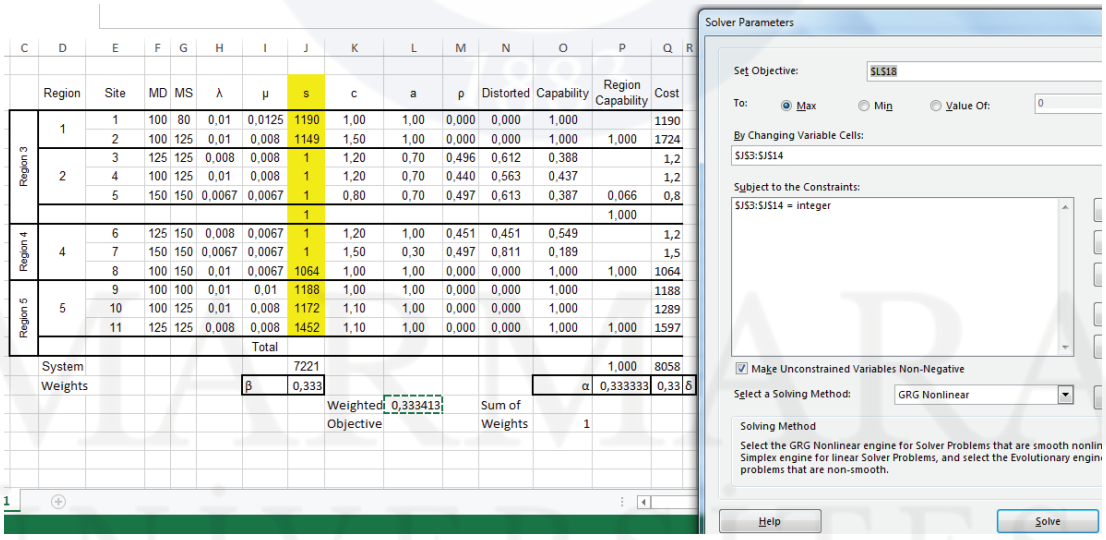


Figure 3. Solution of Illustrative Case through Excel Solver

The optimal solution in the illustrative case enforce reliability to be approximately equal to 1 with a cost of 8058 dollars and with total stocks of 7221 allocated. Note that the solution found is a Pareto optimum.

Conclusion and Discussion

In this study, a multi-objective optimization model with distorted risk in a CLN is provided and illustrated with an example. This study can be regarded as a preliminary study in the field and furthermore extended by including analysis in the selection of weights and aggregation function for each criteria and selection of the values as distortion parameters.

References

[1] Thomas, M.U., 2004, "Assessing Reliability of Contingency Logistic network", *Military Operation Research*, Vol. 9, No. 1, pp. 33-41.

[2] Miman, M. and Pohl, E. A., 2008, "Modeling and Analysis of Risk and Reliability for a Contingency Logistics Supply Chain", *Journal of Risk and Reliability*, v222, n4, 477- 494.

[3] Offut, M.E., Kharoufeh, J. P. and Deckro, R. F., 2006, "Distorted Risk Measures with Application to Military Capability Shortfalls", *Military Operation Research*, Vol. 11, No. 4, pp. 25-39.

[4] Miman, M. and Pohl, E.A., 2012, "Multi-objective optimisation of a contingency logistics network through physical programming", *International Journal of Collaborative Enterprise*, v3, n1,1-17.

[5] Dağ, E. ve Miman, M., 2014, "Beklenmedik Durumlar Lojistiğinin Optimizasyonunda Ütopya Uzaklık Metodu", *III. Ulusal Lojistik ve Tedarik Zinciri Kongresi*, pp680-688, 15-17 Mayıs 2014, Trabzon.

MARMARA ÜNİVERSİTESİ

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Risk Modelling in Health Care

Ayşenur Erdil [1], Ahmet Ekerim[2], Hikmet Erbıyık[3]

Abstract

The most vital problems of health care and health sector, which is one of the most rapidly growing sectors in the business world are the deficiencies of data and sex groups. Therefore, the present health expenditure pricing plans unfortunately are not arranged reasonably. This study aims risk for care area.

Many of the studies for health care reform include system of risk adjustment payments among health plans and health applications. These systems are like as the insurers should improve an emergency plan in which financial helps are minimized and the people who are enrolled are assigned mostly to low-risk people.

According to this topic and purpose of the study, the health care services companies can cover the needs of people enrolled with using their minimum possible financial resources. They obtain this process via two steps: Forecasting the health care cost of people enrolled(risk assessment) and transferring funds from plants that have less than their share of high-risk enrollees to plans that have more than their share of high-risk enrolles(risk adjustment).

Keywords: Health Care, Forecasting, Risk Assessment

Introduction

One of the most important problems seen in health care services, a field that progresses very rapidly in the last years, is the insufficiency and unreliability of the statistics and data related with this service sector. Therefore, the existing risk is marketed and priced wrongly and the net risk premiums are not determined accurately. In this study, with a flexible and effective model, it is aimed to calculate the net risk Premium actually by defining the variables affecting the prices of present healthcare services products and by making the necessary statistical analysis.

Grouping of Benefit Types

Although there are some distinctions among current healthcare packages in Turkish Market, the benefits and assurances offered show similarities in almost all of the policies. These benefits can be classified into two main groups. The first ones are the benefits named ‘‘Hospital Benefits’’ and the second group is ‘‘On foot Medical Treatment-Diagnosis Benefits’’. In general, Hospital Benefits including Surgical Operations, Room-Meal, Intensive Care, Accompanier and Urgent Transportation expenses are paid 100% in return. On the other hand, the latter benefits containing Doctor, Medicine, X-Ray, Analyses and Physical Treatment expenses are paid 80% in return. Furthermore, it may be secured another group of benefits called ‘‘Additional Benefits’’ including Birth, Glasses, Teeth, Air Ambulance and Check-Up. However, ‘‘On foot Medical Treatment-Diagnosis Benefits’’ and Additional Benefits cannot be given alone, whereas the insurance products of the health care services covering ‘‘Hospital Medical Treatment Benefits’’ can be allowed to given separately. The definitions and contents of the benefits are detailed below[11-12].

[1] Ayşenur Erdil, Yalova University, Engineering Faculty, Department of Industrial Engineering, Yalova , Turkey, aysenurerdil@gmail.com
[2]Ahmet Ekerim, Yildiz Technical University, Chemical and Metallurgical Engineering Faculty , Department of Metallurgical and Materials Engineering, Production Metallurgy, Istanbul, Turkey, ekerim@yildiz.edu.tr
[3]Hikmet Erbıyık , Yalova University, Engineering Faculty, Department of Industrial Engineering, Yalova , Turkey, hkerbiyik@gmail.com

a) Medical Treatment On-foot and In Hospital
All types of expenditures realized in health insurance for diagnostic and treatment purposes including Doctor, X-ray, Tomography, Advanced Operations, Analyses and Medicine are paid unlimitedly up to benefit limit with the 20% monetary participation of the claimant(i.e. patient).

b) Surgical Operations
This benefit incorporates all types of Operator, Assistant, Narcosis, Medicine-related and Angiography expenses associated with Surgical Operations

c) In-Hospital Medical Treatment
All types of Consultation, Blood and Plasma Transfusion, Medicine, Oxygen, Anesthesia, Plaster, Bandage, Wound Dressing, Cardiographs, X-ray, Diagnostic Laboratory Tests and Nursing costs concerned with In-Hospital Medical Treatment.

d)Room-Meal
All kinds of room, meal and nursing services expenses for the period that a patient stays in the hospital.

e)Intensive Care
Expenses that come out as result of intensive care services in the same unit.

f)Urgent Transportation
Expenses of ambulances that carry out the patients.

g) Medicine
Pharmaceutical expenses of the patients arising from the pharmacological needs prescribed by doctors.

h)X-Ray & Tomography
All kinds advanced examination made by X-Ray, Tomograhy, MR, Sintigraphy, Endoscopy etc. expenses determined by the doctor for the medical treatment of illnesses.

ı)Analyses
All kinds of necessary analyses and chemical substance usage for diagnostic purposes expenses related with analyses[2, 5]. The most crucial factors affecting the net risk Premium of a specific health insurance product are as follows: Age&Sex, Benefit Type, Benefit Limit, Cost of Benefit, Patient Monetary Participation Rate, Inflation

These companies market their standard product as both on an individual and a group health insurance basis. The greatest problem occuring in group marketing is the different kinds of benefits demanded by the different groups rather than the standard products offered by the insurers.

In a very competitive market, insurance companies may suffer from the strategies that do not take the group's age&sex distribution and their characteristics into consideration[8, 9].

Another problem encountered by insurance companies is the inability of accurate evaluation of data and statistics. This is because there is no adequate professional insurance analysts in the companies staff and as a result of these the data associated with health subjects are analyzed by the life actuaries who have not any statistical analysis knowledge[8].

It is desired for a health insurance product-pricing model as to be flexible and simple to be easily understood and pursued by users(i.e.marketing, accounting and reassurance units).

HEALTH CARE SERVİCES AND RISK

History of Health Care Services Based on a Risk

Health Care Services(Insurance) is a prepayment plan providing services or cash indemnities for medical care needed in times of illness or disability.It is effected by voluntary plans, either commercial or nonprofit, or by compulsory National Insurance plans, usually connected with a social security program[6, 7].

Although health care service programs vary from country to country and from nation to nation, nowadays there are usually three types of it either commercial or nonprofit, usually encouraged by the government, or mix of two[7].

Basic Health Insurance

Hospital Insurance

A hospital insurance policy indemnifies for necessary hospitalization expenses,such as room costs,laboratory fees, nursing care, use of the operating room and certain medicines and supplies[9, 10].

Surgical Insurance

Surgical insurance covers fees of physicans associated with covered surgeries. To prevent unnecessary hospitalization, both inpatient and outpatient surgical procedures are covered. Some policies may only pay only fees charged by the doctor who actually performs the surgery, whereas some may also pay charges of the assistant surgeons and anesthesiologist[9, 10].

Regular Medical Expense Insurance

Regular Medical Expense Insurance policies mostly cover services of physicans other than surgical procedures.These policies do not require the hospitalization of the insured, whereas some may require[9, 10].

BACKGROUND of HEALTH SYSTEM in TURKEY

Fundamentals of Health System

The Turkish health sector is characterized by extreme complexity.A large number of publics, semi-public and private institutions are engaged in the financing and delivery of health services.The public sector is not limited to the Ministry of Health.

The Social Insurance Organization(SSK) operates not only its own hospitals; it also purchases services for its members from public and private facilities. Medical schools, through their university hospitals, cover a substantial part of demand for health services.The Army has a large network of facilities and covers the health needs of its active members,retirees and their dependents. Other ministries(Education), public organizations (PTT, railways) and state economic enterprises still operate their hospitals. In addition to the very active private for-profit sector , there are many foundations and hospitals for religious groups and foreign communities [12, 13].

Most of health services are however supplied under three largely autonomous systems:

The Ministry of Health, The Social Insurance System(SSK) and Medical schools.

While the Ministry of Health is formally responsible for the design and implementation of the country's health policies, its authority over other health services providers remain rather limited.

Nowadays, the ministry assumes a regulatory and policy function and through a national network of hospitals, clinics, health care centers and policlinics, provides preventive services as well as impatient and outpatient treatments. The institution also operates schools for the training of nurses, technicians and midwives. However, it has a limited control over the activities of the Social Insurance Organization (SSK) which provides medical care for its members and their families in its own hospitals. Likewise ,the Ministry of Health has practically no authority over the medical schools, which, in addition to providing graduate and postgraduate training , operate large training hospitals, which over an increasing share of country's medical care[12,13].
Majority of the health care centers and health care providing services are under probation of the Ministry of Health. The State Planning Organization plans health services needs in next five years' development schedule. The budgetary issues and investment plans are designed and controlled by the Ministry of Finance, while the Ministry of Health has collaborative effect in it.

At the most general level, health sector policy is formulated within the framework of Constitution. The Constitution further states that in order to establish wide spread health services general health insurance may be introduced by law.

Essentials of Health Care System

All citizens should equally benefit from the health care services.Each health center will have a health team that consists of one physican, one nurse ,one male health officer, 2 to 4 village midwives and one medical secretary, under the directorate of a physican. Health services within a province will not be limited to the borderline of a distinct but will cover a certain size of population regardless of the border. Health center physicans will not be responsible to distinct official, but to the provincial health directorates,which areas in the past, connected to the respective governors[3,11].

Members of the health care team are allowed to work privately and must be full time employees. Treatment of outpatients or visiting patients at their homes has priority over hospital services. Doctors and the rest of the health personel are to visit villages where they are offer preventive medical services[11].

Up to date, the socialization of the health service established a total of 3267 health centers in 76 provincial and 9 educational areas.However,the number of health personnel in these centers is sufficient, 15 percent having no physicans, 25 percent without a nurse, 9 percent without a male health officer, 15 percent without a village midwife. Considerable improvements have been achieved in the sphere over the past two decades and most Turkish indicators now compare favorably with similar data for other middle income countries[9].

Substantial improvements have taken place in Turkey's health system over the last two or three decades. However, in terms of overall level of public health, fertility levels and access to health services, differences between the east and west; the rural and the urban areas of the country still exist. Large segments of the population still suffer from a surprisingly high rate of child mortality,infectious diseases, malnutrition,and sanitary environmental conditions.Developing countries, especially, are trying to find a feasible way of financing their health services to reach a satisfactory level of health. However, unfortunately, their resources remain insufficient for a goal. The resources allocated to health services are too low in Turkey[9, 10,12]. Turkish Health Sector Master Plan study, which has carried out, some major problems are as follows:

Inadequate information systems, Frequent policy changes, Deficient quality of administratorsicans, Inadequate finances, Lack of inter-sectorial coordination, Qualifications of Problems of Physicians , Shortage of qualified midwives, Shortage of sanitarium, Shortage of vehicles, Shorage of basic equipment, Physical inadequacies, Double authorizations, Duplicate services, Over-Centralization

Range of Benefits

The policies provide coverage for health expenses resulting from illnesses or form injuries due to any accident. In general, the insurer and the policyholder up to annual limits for individual policies agree the reimbursement, sometimes with the contribution of the policyholder.

Table 1. Insurance Coverage Plan Benefit Rates % Limits

IN PATIENT BENEFITS		
Hospital Services	100 or 80%	Unlimited
Maternity&Family Planning	100 or 80%	$500-$1500
OUT-PATIENT BENEFITS		
Physician Fee	100 or 80%	6 or 20 visits per policy year
Prescribed Drugs	100or 80%	Annual
Laboratory, X-ray, etc.	100 or 80%	Annual
Minor treatment	100 or 80%	Annual
Dental Treatment	80%	Annual
OUT OF TURKEY BENEFITS		
Hospital Benefits	80%	$60.000 per event
Unavailable Treatment in Turkey	80%	$300.000 per event
SUPPLEMENTARY TREATMENT BENEFIT	100%	Excess of $ 3000

But,for group policies,limits per event are commonly preferred. The individual can buy a policy which is valid abroad by paying an extra premium, but with some of the policies, even with geographical scope as Turkey,one can have a treatment abroad in emergency cases or the treatments not available in Turkey within certain limits.

A fixed daily benefit may be payable during hospitalization when given as a promotion with the life policies, credit insurance policies…etc.

Here are two examples of popular benefit plans of one individual,one-group plan from X medical institution.

Table 2. A Sample of a Group Coverage Plan

BENEFITS	**BENEFIT RATES%**	**LIMITS**
Physician Fee	100 or 80%	per visit
Prescribed Drugs	100 or 80%	per prescription
Laboratory,X-ray,etc.	100 or 80%	per ilness
Minor Treatment	100 or 80%	Annual
Hospital Room&Board	100 or 80%	per day
Surgical Expenses	100 or 80%	per operation
Maternity	100 or 80%	
OPTIONAL BENEFITS		
Dental Treatments	100 or 80%	annual
Spectacles-Contact Lenses	100 or 80%	annual
Hearing Aids	100 or 80%	annual

There is no compulsory long-term care insurance exercised in Turkey.

By law, life, health and personal accident premiums for all dependents of private plansa re tax deductible up to the same level as the Social Security contribution of an employee (approximately US$ 35-45 per month). A tax called Banking and Insurance Operations Tax,which amounts to 5% of the net Premium,is added to the collected Premium.

An extra 15% of the amount is paid within every claim cost as value added tax. If the amount is not compensated through an insurer, at the end of the year it is reimbursed from the following year's income tax.

Risk Profile

Systematically in this study,a price adjustment is made subject to a certain age and sex groups by calculating the average net risk premium of a particular person [1].

To do this, it must be initially determined a risk profile place for any person existing in a risk profile group. The determination of the risk profile of any person in the insured population is based on the factors occuring as a result of total claim costs and aggregate insurance days in a specific period. Some assumptions are made when determining the risk profile of any group. Because, the existing portfolio may differentiate slightly subject to age, sex, health insurance product and time. In this study , the year as 365 days and calculated the corresponding risk profile values for each sex and age groups based on this.

Risk profile for each sex and age groups can be found according to following formula (1).

$$\text{Risk Profile}[Age,Sex] = \frac{TotalClaimCosts[Age,Sex] / TotalInsuranceDays[Age,Sex]}{TotalClaimCosts / TotalInsuranceDays} \times 100\% \quad (1)$$

Table 3. Total Claim Costs($)

Birth	Men	Woman	Children
	-	-	74282.18
	-	215.64	27783.49
	33854.17	117475.34	3533.99
	71005.81	100857.77	221.12
	52608.43	30767.29	559.86
	21372.95	9153	-
	846.34	490.34	-

Table 4. Risk Profiles(%)

Birth	Men	Woman	Children(5)	Average
	-	-	124.0622	124.06
	-	67.4175	66.78472	67.2
	48.64865	86.92868	59.12331	65.23
	79.85303	123.8071	23.04375	70.18
	193.2155	147.7012	175.0344	175.94
	217.2587	301.2195	-	225.26
	105.8396	76.64961	-	86.54
Average	128.96	133.96	89.61	100.00

In the above formula, the expressions found on the numerator represent the amounts corresponding to the different age and sex combinations, whereas the values in the denominator represent the values for the whole insured claim costs and insurance days.

When we examine Table 3 and Table 4 above, we see that the most risky sex group is women with an average of risk profile about 133.96%.Followingly,the most risky age group is the people who were born between years

- Furthermore, the most risky age-sex group is the women who born between
- Moreover, the least risky age and sex group is the children who are born between

There are at least two reasons for these events. The first and the most important one is the less usage of benefits rather than other groups. Secondly, the population concerned with this group is small. The averages are not calculated on a linear basis since the population varies from one group to another.

On the other hand, if we look at these tables more thoroughly, we (Table 5) can see that the risk profile for children decreases from 124% to 23% up to period. We can conclude that the people about 45-50 ages have more risk than the other groups. The other age-sex groups show random risk profiles.

Annual Benefit Usage Amount

Two important variables in determining the annual net risk premium of any benefit of a person are the annual usage frequency of a benefit, X and the amount paid for each usage, Y. If the price of a benefit for each usage were the same then the benefit's annual net risk Premium could be obtained by multiplying the frequency of usage of the benefit by the corresponding price. Different statistical models and parameter estimation methods are used to determine the frequency of usage of benefits.The Poisson model may be used for this study:

$$P(X,x)=(\lambda x e^{-\lambda})/(x!) \qquad x=0,1,2,\ldots\ldots \qquad (2)$$

This model may used because there is no annual limit for the usage of benefits and the provision of the benefits for each treatment and illness.

In this study Binomial distribution could be used alternatively if there were annual limits for the usage of benefits. In this model λ is the annual average benefit usage.

Moreover, unknown λ should be determined for each benefit separately. According to maximum probability method the average satisfactory sample average of this parameter. Expected value is obtained by dividing the total claim cost by the total number of the people. In order this method to be valid and successful all of the people should be insured on the same date, allowances can be made if the dates are within a month, and should also be insured on the same date, allowances can be made if the dates are within a month, and should also be inured during the whole year.

Furthermore, to prevent the data loss and to use the ones that do not completed their use during the year the parameter estimation can be on daily basis and multiplied by 365 to convert to a yearly basis. The annual usage of a benefit can be calculated by the following formula:

$$\lambda=[(\text{Total Claims Amount})/(\text{Total Insurance Days})]*365\text{days} \qquad (3)$$

λ,the annual average benefit usage is calculated for each benefit and the results are given in Table 5. The standard deviation of each benefit can be found by propery of the Poisson distribution as (Standard Deviation=) Square Root of λ.

Table 5. Annual Average Usage Rates of the Benefits

Benefit Code	Description	#of Usage	Usage per Person(l)
1000	Doctor	5585	1.632086
1100	Medicine	5349	1.563121
1220	Modern Diagnostic Methods	1464	0.42782
1240	Analyses	1562	0.456458
1500	Minor Interference	617	0.180304
1530	Physical Treatments	24	0.007013
2048	Other Drugs	1	0.000292
2051	Domestic Hospital Services	143	0.041788
2300	Chemotheraphy&Radiotheraphy	4	0.001169
2850	Other	1	0.000292
Total		14714	4.299825

Average Benefit Costs

Second stage after determining the annual rate of usage of each benefit to calculate the net risk premium is to determine the distribution and the average value of the benefit costs.Claim costs data and data obtained from the hospital records can be used in order to determine the average benefit costs distribution and consequently its average value.

However,it should be always beard in mind that claim costs are affected and therefore altered as a result of high inflation rate in the country.In order to lessen the inflationary effect in the data,diagnosis and light treatments associated claim costs data should be used.Similary,in determining the benefit costs of benefits like hospital treatments last 6 months claim costs data should be used.Türkiye Tabipler Birliği determines the rates in order to adjust the given data by certain periods a year,which is the primary source for the health organization.

In determining the benefit costs some of the theoretical can be utilized as well.By analyzing the benefit cost distribution of the benefits supplied by the health insurance organization is it quite possible to encounter the distribution of data,which is not distributed normally.In such situation Gamma or/and Chi-Square distribution functions can be practiced.The benefit with their corresponding average costs calculated fort his study is given in Table 6.

Table 6. Benefits Usage Costs

Benefit Code	Description	Total Cost($)	Average Cost(USD) Y
1000	Doctor	152401.47	27.28764
1100	Medicine	92889.47	17.36576
1220	Modern Diagnostic Methods	81201.45	55.46547
1240	Analyses	62828.24	40.22294
1500	Minor Interference	25869.69	41.92818
1530	Physical Treatments	3100.83	129.2013
2048	Other Drugs	1.43	1.43
2051	Domestic Hospital Services	124408.08	8.699.866
2300	Chemotheraphy&Radiotheraphy	2299.40	574.85
2850	Other	37.74	37.74
Total		545037.80	37.74

Conclusion

Health care services in the world and in Turkey are involved in risk and risk analysis more compared to other sectors of the business or even similar nonprofit organizations, therefore sound analysis of risks is requirement factor in order to stay in business for such institutions. Risk is divided into two main groups as pure and speculative risk[4, 11]. Pure risk can be defined as the existence of uncertainity as to whether loss will occur. No possibilty of gain is presented by pure risk. Only the potential for loss is presented. Examples of pure risk include the uncertainty of damage by fire or flood or the prospect of that caused by accident for illness. On the other hand, speculative risk refers to the uncertainity about an event that could produce either a profit or loss. Business ventures and gambling transactions are examples of this situation. Gains as well as losses may occur, chainging the nature of the uncertainty that is present.

Static and Dymanic risks are two main types of risks into two different groups. Uncertainities due to such random events as lighting, windstorms and dead can be given as examples of pure static risks. Business undertakings in a stable economy illustrate the concept of speculative static risk. Dynamic risks are produced according to changes in society. Examples of dynamic risks involve urban unrest, increasingly complex technology and chainging attitudes of legislatures and courts about a variety of issues. Some types of static risks may be caused because of the increase in dynamic risks. Weather-related losses can be considered as an example to the dependency between dynamic and static risks.

Risk, as being a turning point in healthcare system is defined interactively with health insurance premiums and health care services. Related with aim in this study, comparing determined model for risk identification criteria with different models which is supported by statistical calculations and analysis.The people's net risk were calculated taking the benefits limits, claim costs and annual average benefit usage like doctor, surgical operations etc. into consideration.

References

[1] Casale, P. N., Thomas G.S., Gillam L.D., Kennett J.D., Lewis S., Elayda S., Flood K.B., Whitman B., Punsalan R., Cacchione J.G.(2011), Payment Reform: Current and Emerging Reimbursement Models, American College of Cardiology.
[2] Dial, T.H., Newman, M.G. and Sullivan, J.(2005), Profile of Health Plans and Utilizaiton Review Organizations, 2005-2006 Edition.
[3] Downs, M., Cohen, M., Hanna, C., Uccello, C., Jerbi, H. (2010), Risk Assessment and Risk Adjustment The American Academy of Actuaries
[4] Erdem, I., Yapar, G. (1997), Sigortacılık Sektörü Bilimsel Çalışma Yarışması 1997, Sağlık Sigortası Risk Modellemesi.
[5] Gaskins, M., Busse, R.(2009), Health Policy Developments, Morbidity-based risk adjustment in Germany Long in coming, but worth the wait?, Eurohealth Vol 15 No 3.
[6] Harcus, I.(1999), European Health Care Insurance-Growing Opportunities in the Private Sector, 1999.
[7] Punter, A., Coburn, A., Ralph, D., Tuveson, M., Ruffle, S., Bowman, G.,(2013), Modelling Resilient business systems as Interconnected Networks Evolving Risk Frameworks: Modelling resilient business systems and interconnected Networks, Proceedings of 'Think Outside the Risk', on Benfield Hazards Conference, Gold Coast, Australia, Centre for Risk Studies, University of Cambridge.
[8] Racıc, T.Lıbar(2012), The Actuarial Uses of Health Servıce Indicators and projections of health service expenditures in croatia, f&r insurance consulting
[9] Saksena, P., Antunes, A.F., Xu, K., Musango, L., Carrin, G. (2010), Impact of mutual health insurance on access to health care and financial risk protection in Rwanda, World Health Report Background Paper, 6
[10] Saltman, R.B.,Busse, R., Figueras, J.(2004), Social health insurance systems in western Europe, European Observatory on Health Systems and Policies Series, Open University Press.
[11] Trheschmann, J.S. and Gustavson, S.G.(1996), Risk Management and Insurance, 9th Edition.
[12] Turkish Ministry of Health Services Survey in Turkey(1995), 1 st Edition, Ankara.
[13] Webber, J.M. and Orros, G.C.(1987), Medical Expenses Insurance- An Acturial Review,London.

MARMARA ÜNİVERSİTESİ YAYINEVİ
ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

Effect of Organic Certifications on Buying Decision for Cosmetics Products in Turkey

Oğuzcan Ünver [1], *Emine Çobanoğlu* [2]

Abstract

Many institutions are providing non-mandatory independent organic certifications for cosmetics products. These certificates promote sustainability of products in different aspects, such as mandatory use of ecologically-farmed ingredients, controlling ecotoxicology, limiting use of petrochemicals, increasing information transparency and so on. In this study, the impact of organic certifications on buying decision was investigated. A pilot group of 55 university students and graduates (43 female, 12 male) were surveyed. The participants were asked how much organic certificates would affect their buying decision and how much more they would be willing to pay for organic certified products. The answers were taken separately for 5 product groups, hand cleaning, face cleansing, hair care, body care and baby care. The results shown that participants' buying decision would be moderately affected on average (3.8 on a 1-5 scale), with higher effect on baby care products (4.62 on a 1-5 scale) and lower effect on hand cleaning products (3.24 on a 1-5 scale). The participants were willing to pay an average of 30.1% more for organic certified products. The findings of this pilot study should be beneficial for brand managers, certification institutions and market researchers interested in organic certifications.

Keywords: Certification, Willingness to Pay, Organic Cosmetics, Corporate Social Responsibility, Eco-Label

Introduction

Sustainability is one of the main concerns of the modern era. Governments, institutions, corporations and consumers are seeking for environment friendly product alternatives. One of the means for sustainable consumption and production is organic farming [1]. Organic farming differs from other farming methods with two major principles; soluble mineral inputs are prohibited and synthetic herbicides and pesticides are rejected in favor of natural pesticides [2]. Organic Cosmetics on the other hand, relies on using ingredients obtained by Organic Farming. Organic Cosmetics Certifications are tracing the origin of the ingredients, controlling ecotoxicology, limiting use of petrochemicals, increasing information transparency and so on. Independent authorities control and certify organic products to prove their authenticity.

The major claims of Organic Cosmetics are sustainability and environmentalism. Organic Certifications are one of the many attempts to move towards more sustainable and environmentally friendly approaches [3]. This way, Organic Certifications promotes implementation of more sustainable supply-chain methodologies.

Every organic certification organization has its own standards and procedures, but there are efforts to unify certifications as well. For example COSMOS Standard has been developed at the European and international level by 5 different institutions in order to define common requirements and definitions for organic and/or natural cosmetics [4]. United States and Japan also have their government-level standards for defining Organic Farming however, they do not have any standards for Organic Cosmetics yet. There are also some proof-of-claim policies, which limits use of words such as organic and ecologic unless plausible evidence is provided. Some policies in Turkey is also limiting use of words such as "organic" and "ecologic" for past several years.

[1] Oğuzcan Ünver, Marmara University, Institute of Pure and Applied Sciences, Department of Engineering Management, Istanbul, Turkey, oguzcanunver@gmail.com
[2] Emine Cobanoglu, Marmara University, Business Administration Faculty, Department of Business Administration (English), Istanbul, Turkey, ecobanoglu@marmara.edu.tr

Like any other developments on sustainability, any organic certification would need investment in the value chain. Cheaper yet not sustainable ingredient alternatives must be discarded, processes need strict inspection measures, man-hours are needed for proper documentation and infrastructural investments may be required. Therefore, any economic entity would be expecting some return of investment before investing in Organic Certifications.

Preference for organic products and increased Willingness to Pay (WTP) for the end-products are typical reasons for the investment on Organic Certificates. Companies would be expecting to have higher number of customers willing to pay more for their products when they obtain Organic Certification. Therefore, investment decision on these certificates can be taken after forecasting WTP and changes in buying decision.

The effects on buying decision and WTP depends on a variety of factors, such as product category, country of origin, packaging, brand, label information, discounts and so on. There had been many studies on WTP for Organic Food. Gil et al. investigated WTP for organic food in two different regions in Spain, and across 7 categories [5]. They have also performed a segmentation analysis; and found increase in WTP between 8 and 14 percent. A study by Krystallis et al. in Greece in 2005 investigated 22 factors affecting WTP, across 16 categories and found an increase from 45 to 120 percent in 14 categories [6]. In 2007, Akgüngör et al. investigated WTP for Organic Food in Turkish market in cooperation with a professional research team, and found the increase in WTP as 36 percent [7].

So far we did not come across any studies on WTP for organic cosmetics products, neither global nor local. In this study our aim was to have some insights on the effects of organic cosmetics certifications on buying decision and WTP in in Turkish market.

Methodology

This pilot study aims to find if customers claim that their buying decision are affected by organic cosmetics certificates and how much more they are willing to pay. A structured questionnaire was prepared and posted in popular online forums and Facebook pages on cosmetics. Convenience sampling was used to reach volunteering participants to take part in the survey. 55 respondents (43 female, 12 male) were all university students and graduates, aged between 20 and 45.

The participants were asked how much organic certificates would affect their buying decision on a 5 five-point agreement Likert-type scale variables with end-points 1: not affected and 5: strongly affected. The 5 questions were directed to 5 different product groups, hand cleaning, face cleansing, hair care, body care and baby care.

WTP increase is estimated by contingent valuation method, where customers are expected to declare an amount for the maximum premium they would be willing to pay for organic products. Some researchers such as Gil et al. preferred to strengthen this method by asking multiple choice WTP declarations beforehand, in form of "Would you be willing to pay an amount of A_i % for this product" [5]. However, this model must be validated and calibrated in order to find the right A_i amounts, thus needs a larger sample. We therefore used contingent valuation method alone like Krystallis et al. [6]. We asked the question "How much more would you be willing to pay for this products if it has organic certificate". This answers were also taken separately for 5 product groups

The participants were also asked how they would rate their knowledge on cosmetics products. The self-declared knowledge was asked on a 5 five-point Likert-type scale variables with end-points 1: no knowledge and 5: good knowledge.

Besides asking for their self-claimed knowledge, the participants were also asked which organic certification brands they know, assisted and unassisted.

The results were gathered using Google Forms, edited in Excel and analyzed in SPSS.

Results

When participants were asked how much they know about cosmetics products, most of the participants stated that they have average or above average information (Likert-type scale answers 3 and 4, making a total of 75%). When the participants were asked which Organic Certifications they know 47% of respondents could name at least one certificate assisted and 9% of respondents could name at least one certificate unassisted.

Participants' buying decision would be moderately affected on average (3.8 on a 1-5 scale), varying between 4.62 and 3.24 for product groups. Average increase in WTP was 30.1%, varying between 19.1% and 54.1% between product groups. The complete results are shown in Table 1.

Table 1. Effect of product type on Buying Decision and Increase in WTP with respect to product type

Product Group	Effect on Buying Decision	% Increase in WTP
Baby Care	4.62	53.1
Face Cleansing	4.04	31.9
Hair Care	3.69	27.3
Body Care	3.44	23.1
Hand Cleaning	3.24	19.5
Average	**3.80**	**30.1**

When analyzed with respect to gender, and education level, effect on buying decision and change in WTP was not statistically significant.

Analysis with respect to knowledge on organic certifications shown that as knowledge on certifications increases effect on buying decision is increasing. The increase in buying decision is statistically significant on 95% confidence interval (p=0.013). Effects of knowledge on organic certificates are shown in Table 2.

Table 2. Effects of knowledge on organic certificates on Buying Decision and WTP

Gender	N	Average Effect on Buying Decision	Average % Increase in WTP
No organic certificates can be identified	24	3.38	26.3
Some organic certificates can be recalled assisted	26	4.05	36.8
Some organic certificates can be recalled unassisted	5	4.60	23.2

Discussion

The results of pilot study demonstrated that there are customers in Turkey willing to pay more, up to 53% more for products with Organic Certificates. These customers state that organic certificates would affect their buying decision. Participants stated that their decision would be affected by Organic Cosmetics certificates and for most of the cases they would be willing to pay an average of 30.9% more, varying between 19.1% and 54.1% for product groups.

In literature, we have not came across any studies on effects of Organic Certificates on WTP and buying decision for cosmetics products, but there are many studies on Organic Food products. The increase in WTP was between 8% and 140% depending on product category and market location. Our result is very close to the only study that was performed in Turkey by Akgüngör et al. on organic food, which found the increase in WTP as 36% [7].

The effect of Organic Certificates are strongest on baby products, and weakest on hand cleaning products. One might say that as the use of the product gets more intimate, customers state that they would be more willing to prefer products with Organic Certificates.

However, these very potential customers, who claim that they would prefer organic products and they are willing to pay up to 50% more, have limited information on organic certificates. Only 9% of participants can name any organic certificate. 53% of respondents cannot even recall any organic certificates from a list. This raises the question, what are these customers are paying this money for. The term "organic" is well known and has its own brand value, but how to connect this marketing asset into the value chain and benefit should be a serious concern.

As the knowledge of customers on Organic Cosmetics increases, the effect on buying decision increases. This means that as the customers get better informed, they tend to give more attention to organic certificates. On the other hand, we could not find statistically significant difference in WTP changes between knowledge levels.

Conclusion and Future Work

This pilot study clearly indicates that there is a strong demand in Turkey for Organic Cosmetics products. When investing in sustainable supply-chain systems, corporations should take into account that Organic Certifications can be a proper way to get the return over the investment. Many customers are willing to prefer Organic Cosmetics, and they are willing to pay more.

The findings have shown that potential customers in Turkey have limited knowledge on cosmetics certificates. The regulatory authorities should therefore keep restricting use of marketing terms such as "organic" and "ecologic" like they have been doing for the past several years. The certification agencies on the other hand should see this space for development and focus more on informing the customers.

This exploratory study is limited in many ways. The participants were all volunteering university students, mostly females. A randomized and calibrated field study might provide a better insight on the market and demand.

The WTP declarations can be validated by asking similar questions in different ways. Further studies might be address changes in buying decision and WTP with respect to country of origin, brand, packaging, products size and other factors.

The term organic is a claim, whereas organic certificates are obtained through a processes. Customers in Turkey might have limited knowledge on this difference, since they have limited knowledge on the certificates. Some further studies can try to find the answer to the question: Are the customers willing to pay for the term organic or organic certification?

A final point of interest for further studies would be to find difference of WTP between product groups. While the customers were willing to pay much more for baby products and face cleaning products, they were more price sensitive on body care and hand cleaning products.

References

[1] Rigby D., Cáceres D. 2001, Organic Farming and sustainability of agricultural systems, *Agricultural Systems,* 68, 21-40
[2] Trewavas, A. 2001, Urban myths of organic farming, Nature, 410, 409-410
[3] Gallastegui, I.G. 2002, The use of eco-labels: A review of the literature, *European Environment,* 12, 216-331
[4] AISBL, 2013, COSMOS-standard: Cosmetics organic and natural standard, AISBL, Brussels
[5] Gil J. M., Gracia A., Sanchez M. 2001, Market segmentation and willingness to pay for organic products in Spain, *International Food and Agribusiness Management Review,* 3, 207-226
[6] Krystallis A., Chryssohoidis G. 2005, Consumers' willingness to pay for organic food: Factors that affect it and variation per organic product type, *British Food Journal,* Vol 107, 320-343
[7] Akgüngör S., Miran B., Abay C. 2007, Consumer Willingness to Pay for Organic Products in Urban Turkey, *105th EAAE Seminar 'International Marketing and International Trade of Quality Food Products,* 2007

ICOVACS2015
International Conference on Value Chain Sustainability
12-13 March 2015
Marmara University, Institutes Building Conference Hall, Göztepe Campus

The Future of Mobile Banking

Gökçağ Polat [1]

Abstract

With new technology, the bond between banking services, online systems and the customer are increasing. Internet banking is a widely used contact method between the customer and the bank. It provides easy access, time saving for the customer and cost saving and ability to be in touch with the customer to the bank. Now with the usage of smart phones, internet banking takes one step further and allows the customer and the bank to be in touch in all times. A lot of banks have applications for android processors or iPhones. Social media also has an important effect on the increasing of usage rates. The aim of this study is to consider the future of mobile banking and also in this study the adaptation process of the banks to mobile banking will be examined. Mobile phone is more accessible than internet connection through personal computers and mobile phone operators have a wider coverage area. It provides sustainable customer relations for banks which they do not have any branches. For this research, expert opinion was taken. These experts are the banking professionals who have experience more than five years in marketing and alternative distribution channel departments of the banks.

Keywords: Internet Banking, Mobile Banking, Sustainable, Technology

Introduction

With new technology alternatives marketing channels became very important for banks. Banks are able to reach their customers through different channels like telephone, automated teller machine (ATM) and internet besides retail banking. The technology adds new dimensions to the classic banking systems. For example, over the last few years, self-service technologies have replaced the need for face-to-face interaction between banks and customers [1].

One of the self service applications is mobile banking. Mobile banking (m-banking) is making banking transactions on mobile devices like smartphones and tablets through applications. Mobile banking applications are tailored to all major mobile service providers and banks.

Although ATM, telephone, and internet banking offer effective delivery channels for traditional banking products, mobile banking as the newest delivery channel established by retail and microfinance banks in many developed and developing countries is likely to offer even more services and have significant effects on the market [2].

Traditional banking in rural areas does not work well [3, 4], because of poor transportation services, long distances, and the resulting high cost of delivery. Branchless banking, in which a resident of a village acts as an agent for a faraway bank, provides a way of connecting rural people to the banking world. It simplifies to reach customers and contribute to sustainable customer relations. It enables a host of services including simple withdrawals and deposits. It reduces two of the biggest problems to financial access: the cost of roll-out (the cost of having a physical presence) and the cost of low value transactions [4].

[1] Gökçağ Polat, Marmara University, Institute of Pure and Applied Sciences, Department of Engineering Management, Istanbul, Turkey, gokcagpolat@gmail.com

As the penetration of smartphones increases the tendency of the consumer to be online the usage of mobile banking also increases. Besides the branches, call centers or ATMs are not only touch points for banks. Banks invest in mobile banking applications to be more in touch with the customer in all times. By this way, banks provide sustainable customer relations. It is also time saving and more efficient for the customer and cost saving for the banks. Banks must also add value to their mobile banking applications to provide more powerful customer relations.

Mobile banking has advantages for customers. Through mobile banking, customers can make different banking transactions easily. Internet access cost is important but phone operators offer tariffs which include internet usage. People do not need high internet package to use mobile banking. They can buy the package which they need only and internet connection costs are even lower than internet usage costs from houses.

A lot of banks see the mobile banking as the most important trend in future. According to the Banks Association of Turkey Report mobile banking user number was 8 million 853 thousand in third quarters of 2014 [5]. According to Financial Empowerment in the Digital Age research, Turkey is the leader at using mobile banking in first half of the year 2014 in European Countries. This research also say number of mobile banking users who use internet increased from 49% to 56% in Turkey [6]. The number of mobile banking users increases but at the same time the number of internet and mobile fraud increases. According to research made from Ernst and Young, 68% of smartphone users do not use mobile banking because of the security reasons [7]. Fraudulent capture the password of customers and they can attain customers' accounts. So fraud is an important issue for customers as they perceive fraud as an important threat. To overcome fraud problems banks try to increase their security precautions and give information to consumers to protect them against fraud.

The purpose of this research is to consider the future of mobile banking and also in this study banks' precautions to mobile banking fraud was examined. For this aim questions were asked banking professionals in order to get more detailed information about the present and future mobile banking.

The significance of the paper is to emphasize the importance of mobile banking in future with developing technology according to both banks and customers.

Literature Review

Internet banking is defined as the use of banking services through the computer network (the Internet), offering a wider range of potential benefits to financial institutions due to more accessibility, user friendly use of the technology and lower transaction costs [8].

Pikkarainen, Pikkarainen, Karjaluoto, and Pahnila highlighted two main reasons for the development and proliferation of internet banking. First, the cost savings by the banks compared with the traditional channels; second, the reduction of branch networks and, therefore, the costs with staff [9]. Jayawardhena and Foley also identified the benefit of increasing the customer base, because using multiple distribution channels (branch networks, Internet banking, mobile banking, etc.) amplifies market coverage by enabling different products to be targeted at different demographic segments [10].

Internet banking offers many advantages both for the banks and customers. First the advantage of it for banks is the potential savings from the cost of maintaining a traditional branch network, and it creates an opportunity

to increase the consumer base by reaching a differentiated target group from the traditional bank customers [11].

The development of electronic banking to mobile banking the services of bank have actually upgraded with the introduction of different kind of innovative functions and practices, the question arise, whether the technology will be adopted by the customer on same footing? Or the technological advancement would discover easy way for acceptance by the user as compare to the internet? Many researchers take this question. Customers are now more interested in new channel and less willing in doing transactions physically; they are less loyal to traditional moves and methods and more demanding for superior service quality [12]. The increasing circulation of mobile technology and WAP-enabled strategy has brought very visible development in electronic banking [13].

Many of the determinants valid for electronic banking are also valid for banking through mobile devices [14]. Time saving, and freedom from the place and time constraints, immediacy or service speed, compatibility and convenience with life style are the factor that stimulate the use of technology in service, while complication of service like perceived cost, service ignorance of electronic devices, perceived credibility, perceived trust are factors which require a brief touch for better understanding as comparative issues in both technologies while increasing features of mobile phones and increasing numbers of mobile users making this device as big channel and vast potential for service sector [15].

Banks are investing in mobile technology and security, developing smartphone applications, adding new features such as remote deposit of checks, and educating consumers. Consequently mobile banking adoption among consumers has been much faster than the adoption of online banking more than a decade ago [16].

Internet and mobile Internet banking services are the most innovative and profitable banking services introduced by commercial banks in Turkey. According to Turkish banking Association's (TBB) statements Isbank offered the first internet banking service in 1997 to its customers and were followed by Garantibank in the same year. And for year 2004 it's reported that 22 banks in Turkey were offering internet banking services to their customers. According to a recent statistic about the Internet Banking usage in Turkey made by Turkish Banking Association, there are 15 million users registered for retail banking and approximately 1 million users for corporate banking. This makes 16 million for overall registered users of which are 17% active for retail banking and 47% for corporate banking.

Fraud encompasses a range of irregularities and illegal acts characterised by intentional deception or misrepresentation, which an individual knows to be false or does not believe to be true. Fraud is perpetrated by a person knowing that it could result in some unauthorised benefit to him or her, to the organization, or to another person, and can be perpetrated by persons outside and inside the organization. Fraud perpetrated to the detriment of the organization is conducted generally for the direct or indirect benefit of an employee, outside individual, or another organization [17].

Methodology

Questions about mobile banking were asked to five banking professionals who are Individual Internet Executive, Mobile Services Executive, Alternative Distribution Channel Specialist, Head of Anti-money Laundering and IT Auditor of different banks and one consultant who gives consultancy to banks by face to face in depth interview method. These people have more than five years' experience in their areas. Questions are:

- What are the main differences between internet and mobile banking?
- What does mobile banking bring as innovative to customers life or banking sector?
- Do you think that there is any security problem with mobile banking? What are the security problems?

- Why do banks give importance to mobile banking?
- Is there any effect of social media on mobile banking usage?
- What do you think about the future of mobile banking?
- What can banks do to remove customers' worries?

These questions were chosen to see the effects of mobile banking over banks and sustainable customer relations. Most of the researches about mobile banking are focused on customers' behavior. On this paper I wanted to research the mobile banking under the aspects of banks. Experts' opinions were received by the questions if there is contribution or not to sustainable customer relations of mobile banking. While asking these questions to Individual Internet Executive and Mobile Services Executive, these professionals answered the questions together.

Findings

Firstly asked "what are the main differences between internet and mobile banking?" All banking professionals said mainly both of them includes similar applications. But, mobile technology grows more quickly than internet technology both in Turkey and in the World. For this reason banks give more importance to mobile banking investment. Mobile banking is not an alternative channel; it is now a basic service channel. Banks have a lot of customers from all parts of Turkey. Some small towns do not have enough banking opportunities and internet infrastructure. But banks reach easily to all of their customers through mobile banking. In the near future all services done from internet banking will be also possible via mobile banking.

The consultant said that processes in banking sector started to be similar among competitors. Different thing is only advertisements. With new innovative products people now are more mobile and to follow the agenda are more online. Internet banking was the one of the first step of adaptation to changing world conditions. But it was not enough to provide sustainable customer relations while smartphone user numbers were increasing sharply. So mobile banking started to be important one step further than internet banking for banks. To get new customers and to be in first place in market, banks should make more investment to their mobile banking applications.

Second question is "what does mobile banking bring as innovative to customers life or banking sector?" Mobile Services Executive, Alternative Distribution Channel Specialist and Individual Internet Executive said customers think that mobile banking simplifies the financial management. Because customers always have smartphones with them and they easily check their financial statements with mobile banking applications. Also, banks expand their customer network easier than traditional banking. Fingerprint technology is slowly entering our lives for mobile banking. It will simplify the usage and it will strengthen the security. To enter a person's bank account, you will need his fingerprint.

Head of Anti-money Laundering and IT Auditor said customers do a lot of banking transactions by mobile banking except withdrawal, deposit, credit card delivery and transactions which need wet signature like mortgage.

Consultant said that banking sector had a new platform through the mobile banking. Banks compete to have best mobile banking application. Customers want from banks user friendly applications.

Third question is "do you think that there is any security problem with mobile banking? "What are these security problems?" These questions were asked only to Head of Anti-money Laundering and IT Auditor as these questions are mainly of interest to these two experts.

Head of Anti-money Laundering said that mobile banking technology develops but also some new fraud transactions improve with the technology. Banks make investment to prevent cyber-attack. To use mobile banking customers have to have user name and a unique password. After entering these values a security message is sent to customer's mobile phone. Banks strengthen their security precautions. Smartphones may receive some cyber-attacks but customers prevent that by using only secure and certificated applications.

IT Auditor said customers should never follow a banking link sent to them in a text message or e-mail. These links can probably lead customers to fake websites and if customers enter their user name and password to this websites, customers' accounts become an open target to cyber-attack. Not to be exposed to fraud, consumers should not share their all mother's maiden name, credit card and debit card password, credit card security number, internet branch password and internet banking login and disposable password.

Fourth question is "what can banks do to remove customer's worries about security?" Alternative Distribution Channel Specialist, Individual Internet Executive and Mobile Services Executive said that a lot of security programs are used to prevent fraud. Education is given by banks about how customers can use this security programs efficiently. Public Wi-Fi areas aren't very secure. If customers want to control their bank accounts, they do not use public wireless. Banking applications are more secure than connecting from websites of the banks.

IT Auditor and Head of Anti-money Laundering said that banks buy new more powerful security programs to prevent cyber-attack. To have a customer's banking account, you must have both customer's phone and his password. A lot of tests were done to see the security defects. Firstly, new features of mobile banking were used to willing customers. If there is not any problem, these features open to all customers' usage.

Consultant said that every bank has their own security packages and different security precautions. To open mobile banking operations, some banks want a user name and password and after that a disposal security code sent to customer's phone. This code is entered to screen and then customer can use banking application safety. Some banks want customer number to reach bank's mobile application and a photo which was chosen by customer that was seen before. Consumers understand the page's security through the accuracy of the photo.

Fifth question is "why do banks give importance to mobile banking?" Mobile Services Executive and Individual Internet Executive said that mobile banking is still developing platform and customers started to prefer this platform more than the other channels. Banks want sustainable customer relations and for this mobile banking is an efficient platform. Also, customers want faster and cheaper service. Making financial transactions from mobile phones are also faster and cheaper than making these transactions from the branches.

Other banking professionals and consultant said the same thing as; people need to be more mobile than before. For these reasons consumers want to make their banking transactions easily and quickly while they are travelling.

Sixth question is whether there is any effect of social media on mobile banking usage? Banking professionals said that Turkey is one of countries with highest number of social media users. All banks have social media accounts and customers can follow the banks' new products. Banks make campaigns to increase mobile banking usage and customers know these campaigns although they are not going to banks' branches.

Consultant said that lots of young people control their social media accounts when they get up. Banks have advertisements on social media page to attract young people especially. Some banks present their customers

money transfer opportunities through Facebook and consumers can see their total assets and credit card statements with detailed graphs.

Seventh question is "what do you think about the future of mobile banking? "Mobile Services Executive and Individual Internet Executive said that branchless banking's importance will increase and mobile banking is one of the branchless banking concepts. Mobile banking is relatively new compared to the other banking services. Mobile banking usage rates increase steadily. Turkey is one of the leader countries among the other European countries which use the mobile banking. Customers started to use cash less than the last years.

Alternative Distribution Channel Specialist said that in future, internet and mobile banking won't be only an alternative and especially will be channels used by young people. Y generation likes using technology, more comfortable with mobile banking .

IT Auditor and Head of Anti-money Laundering said that banks try to minimize systematic defects to provide more customer satisfaction. In future, mobile banking will be more secure and people won't hesitate to use mobile banking applications

Consultant said that mobile banking is important and also simplifies the life but increase in mobile fraud worries the customers. Banks should improve their security prevention. Young people prefer mobile banking mostly. If banks do not take precaution to minimize the fraud, older generations will not start to use mobile banking. People who live in countryside and meet new with technology have difficulty in using mobile banking but it is easier than internet usage. Via mobile banking, banks decrease their costs to meet customers. Some education programs can be given about mobile banking to attract these people who live in countryside. Also, banks want to decrease their costs and they will want price to make transactions which done in branches. With this way, people will start to use mobile banking. If customers continue to come to branches to make transactions, banks will take from them transaction cost. Population will have mobile banking usage habit and bank branches will need fewer employees to carry on their daily processes.

Discussion and Conclusion

Results and managerial implications

With developing technology and trends, alternative distribution channels come into question for banks. Especially mobile banking investments will increase in future.

Bank's main aim is to maximize profits. There are a lot of banks in the market and profit margins are decreasing day by day. Mobile banking will provide some advantages to banks. Banks will have advantage to do their jobs with fewer employees and less cost.

According to answers which were taken from banking professionals and consultant and past researches, traditional banking and internet banking are not so much popular any more, now mobile banking shows a rising trend. With investment and new features, mobile banking will have a more important place in banking sector. The rising of mobile banking will provide sustainable customer relations for banks. Because it allows the customer and the bank to be in touch in all times. But also consumers should pay attention to security. They do not use public Wi-Fi areas while using their bank accounts and should not follow fake links to protect themselves from cyber-attack.

The result of paper is investing in mobile banking and user number will increase in future. Also, fraud attempting to mobile banking will continue but it will be difficult to capture consumers' accounts if they take enough precautions.

This research has contributed to past researches because questions were asked different people from different banks. This study would make a significant contribution in understanding the behavior of banks and customers about mobile banking.

However, the rise of the mobile banking covers wide range of subjects and future researches can have different approaches to mobile banking. So future of banking sector, changes at branch numbers and mobile application features can be reviewed for further studies.

References

[1] Eriksson, K., & Nilsson, D. (2007). Determinants of the continued use of self-service technology: The case of Internet banking. Technovation, 27, 159–167.
[2] Safeena, R., Date, H., Kammani, A., Hundewale, N., 2012. Technology adoption and Indian consumers: study on mobile banking. Int. J. Comput. Theory Eng. 4 (6), 1020–1024.
[3] Gautham Ivatury. Using technology to build inclusive financial systems. In CGAP Focus Note 32, Washington D.C., 2006.
[4] Gautham Ivatury and Ignacio Mas. Early experiences with branchless banking. InCGAP Focus Note 46, Washington D.C., 2008.
[5]Internet ve Mobil Bankacılık İstatistikleri http://www.tbb.org.tr/tr/banka-ve-sektor-bilgileri/istatistiki-raporlar/eylul--2014---internet-ve-mobil-bankacilik-istatistikleri/1375 [accessed on 31.10.2014]
[6] ING International Survey. (2013). Finacial Empowerment in the Digital Age
[7] Ernst & Young News – Releases http://www.ey.com/TR/tr/Newsroom/News-releases [accessed on 25.10.2014]
[8] Aladwani, A. M. (2001). Online banking: A field study of drivers, development chal-lenges, and expectations. International Journal of Information Management, 21(3),213–225
[9] Pikkarainen, T., Pikkarainen, K., Karjaluoto, H., & Pahnila, S. (2004). Consumer accep-tance of online banking: An extension of the technology acceptance model.Internet Research, 14(3), 224–235.
[10] Jayawardhena, C., & Foley, P. (2000). Changes in the banking sector – The case ofInternet banking in the UK. Internet Research, 10(1), 19–30.
[11] Yereli, A. (2002). "Elektronik Bankacılık ve Türkiye Uygulaması", Yayınlanmamış Doktora Tezi, Celal Bayar Üniversitesi, Manisa.
[12] Norizan Mohd Kassim, Abdel Kader Muhammad Ahmad Abdulla, 2006; The influence of attraction of internet banking: an extension to the trust relationship commitment model; international Journal of Bank Marketing 24, 6 p. 424-442
[13] Mohd Abbas S. Z., R. A. Rehman, Manhenthiran, S. (2009), "Ultimate Ownership and Performance of Islamic Financial Institutions in Malaysia", Asian Finance Association Conference, July 2009
[14] Dennis F. Galletta; Yogesh Malhotra, (1999) "Extending The Technology Acceptance Model to Account for Social Influence: Theoretical Bases and Empirical Validation", proceedings of 32nd Hawaii international conferenc4e on system sciences, 1999
[15] Laukkanen, T. (2007) Internet vs. mobile banking: comparing customer value perceptions Business Process Management Journal Vol. 13 No. 6, 2007 pp. 788-797
[16] Sunil Gupta and Kerry Herman, "Bank of America: Mobile Banking," Harvard Business School Case, 2012.
[17] Vona, L.W.(2008).Fraud Risk Assessment: Building a Fraud Audit Program. Canada: John Wiley&Sons, Inc.

MARMARA ÜNİVERSİTESİ YAYINEVİ



ICOVACS2015

AUTHOR INDEX

MARMARA ÜNİVERSİTESİ

A

A. Güldem Cerit, 436, 444
Ahmet Ekerim, 155, 493
Ahmet Ürkmez, 340
Aida Meskarian, 376
Alev Taşkın Gümüş, 456
Ali Fuat Güneri, 390
Ali Nezhadmohammad Alarlough, 117
Alireza Bafandeh Zendeh, 308, 376
Alper Özpınar, 349
Asuman Çelik Küçük, 241
Ayşe Ayçim Selam, 406-415
Ayşe Hande Erol Bingüler, 21
Ayşenur Erdil, 155, 493
Aysun Akpolat, 215

B

B. Gültekin Çetiner, 398
Bahar Sennaroğlu, 70, 149
Banu Çalış, 183
Barış Egemen Özkan, 83
Batuhan Kocaoğlu, 357

C

Çaglar Üçler, 290
Can Atalay, 29
Canan Ağlan, 276
Cansu Yıldırım, 469
Celil Durdağ, 300
Cem Çağrı Dönmez, 106, 126
Ceren Deniz Tatarlar, 436
Çiğdem Alabaş-Uslu, 76

D

Davoud Norouzi, 376
Duygugül Can, 444

E

Ebru Beyza Bayerçelik, 383
Ecenaz Demirci, 208
Emel Şeyma Küçükaşçı, 349
Emine Çobanoğlu, 233, 502
Erkan Çelik, 456
Ersin Şahin, 300
Esra Dağ, 487
Eyüp Anıl Duman, 262
Ezgi Uzel, 215
Ezgi Yolver, 368

F

Fadime Üney-Yüksektepe, 174
Filiz Çetin, 76
Fulya Taşel, 383

G

Gökçağ Polat, 506
Gökhan Kalem, 83
Göknur Arzu Akyüz, 248
Gonca Telli Yamamoto, 317
Gülfem Tuzkaya, 276
Gülgün Kayakutlu, 70
Güner Gürsoy, 248

H

Harun Karga, 340
Hikmet Erbıyık, 493
Huseyin Avni Es, 262
Hüseyin Selçuk Kılıç, 276

I

İlayda Ülkü, 164,174
İlknur Yardımcı, 49
İnci Elif Sağlam, 193
İrem Düzdar, 70

J
Jun Matsui, 241

K
Koray Altıntaş, 225,233

L
Lamia Gülnur Kasap, 49
Luis Martin-Domingo, 290
Lütfi Apilioğulları, 461

M
Mahmure Övül Arıoğlu Akan, 406, 415
Mahnaz Rabiei, 117
Masoud Askarnia, 308
Mehmet Miman, 487
Meltem Yavuz, 422
Mete Gündoğan, 398
Mete Han Topgul, 262
Morteza Mahmoudzadeh, 308
Muhammet Bilge, 97
Muhammet Gül, 390
Murat Bilsel, 255
Murat Kaykusuz, 317
Mustafa Ağaoğlu, 21

N
Nejla Karabulut, 324
Nesli Çankırı, 59
Nevin Balıkçı, 208

O
Oğuzcan Ünver, 502
Oğuzhan Erdinç, 340, 429
Okan Tuna, 215
Okay Işık, 97

Ö
Özalp Vayvay, 29, 49, 142, 164, 225, 255
Özgür Karamanlı Şekeroğlu, 317
Özlem Sanrı, 215
Özlem Şenvar, 149
Öznur Yurt, 469

P
Pınar Miç, 476

R
Rıfat Kamaşak, 422
Rosalba Prisinzano, 126

S
Samet Gürsev, 29
Semih Özel, 255
Serkan Gürsoy, 59
Serol Bulkan, 21, 41, 174
Sinan Apak, 383

T
Takuji Miyashita, 241
Tolga Ulusoy, 106
Tuğba Efendigil, 193
Tuğba Türk, 225

U
Umut R. Tuzkaya, 368

Y
Yıldırım Kılıçarslan, 97

Z
Zeynep Ceylan, 41, 164
Zeynep Tuğçe Şimşit, 142

MARMARA ÜNİVERSİTESİ YAYINEVİ

ICOVACS 2015

International Conference on
Value Chain Sustainability

12-13 March 2015

Marmara University,
Institutes Building Conference Hall,
Göztepe Campus

MARMARA ÜNİVERSİTESİ

www.icovacs.com

MARMARA ÜNİVERSİTESİ YAYINEVİ