Intelligent Approach Based on Group Method of Data Handling to Predict Economic Growth Through Entrepreneurship and Innovativeness with Time Series

Özlem Şenvar[1](✉) and Melis Zeren[2]

[1] Department of Industrial Engineering, Marmara University, Istanbul, Turkey
ozlem.senvar@marmara.edu.tr, ozlemsenvar1@gmail.com
[2] Institute of Pure and Applied Sciences, Marmara University, Istanbul, Turkey

Abstract. Entrepreneurship and innovativeness are the key factors for determination of economic viability along with preservation of sustainability. Entrepreneurship with innovation is a crucial part of economic improvement and growth and substantial for the steady dynamism of the modern economy. Since entrepreneurship and innovation generate value for the economy through creative destruction, their impacts on GDP growth (annual %) can be examined through anticipatory capacities. Brexit is expected to have serious consequences of generating international entrepreneurship and business opportunities for companies worldwide. This study aims to anticipate economic growth through entrepreneurial activities and innovativeness before and after the Brexit decision. In this study, New Business Density and R&D Expenditure (% of GDP) are handled to make anticipations regarding annual GDP Growth (%) via time series forecasting algorithm. We consider Iceland, Ireland and the UK before and after Brexit decision. Iceland and Ireland are taken into account due to their close relationships with the UK.

Keywords: Entrepreneurship · Innovativeness · Economic growth · Anticipation · Group Method of Data Handling (GMDH)

1 Introduction

The global economy is characterized by pervasive, profound technological differentiation and accompanying social changes. For example, the recent event, Brexit, is anticipated to have profound economic consequences both for the UK and the rest of the world. Anticipations about the local impact of Brexit are suggested via two different consequences: the bad scenario and the good scenario. Brexit was officially initiated when the UK government notified its exit from the European Union on 29 March 2017, after the 23 June 2016 plebiscite.

C. Kahraman et al. (Eds.): INFUS 2022, LNNS 504, pp. 982–989, 2022.
https://doi.org/10.1007/978-3-031-09173-5_112

Some researchers suggest that the consequences of economic nationalism will be negative, both socially and economically. Other scientists suggest that the results of independence will be positive for the UK economy. For example, Dhingra et al. (2017) predict the average effects of Brexit on the UK to be negative due to the spatial and sectoral specialization of economic areas. The UK's overall GDP is anticipated to decline while some sectors are expected to be better off (Felbermayr et al. 2017).

Research on the effects of Brexit is generally made on financial indicators such as FDI, inflation, market integration, tariff barriers etc. Nevertheless, not many studies show regard to entrepreneurship and innovation. We propose that besides the negative effects of Brexit, there might be positive impacts on the UK economy via fostered economic activities. Accelerated economic activities also mean new businesses registered and new innovative endeavors with new ideas and inventions. The economy might compensate for the negative impacts through proliferating new businesses and innovations. The impact of Brexit might not be as negative as the pessimistic view foresees.

This study handles new business density and R&D Expenditure (% of GDP) are handled to make anticipations regarding annual GDP Growth (%) via time series forecasting algorithm.

New Business Density, measured by new registrations per 1,000 people between ages 15 and 64, is fundamentally the prevalence rate of individuals in the working-age population who are actively involved in starting a business as new entrepreneurs or owner-managers of new firms. And following the World Bank and OECD, we employ Research and Development Expenditure (% Of GDP) as the indicator for innovativeness. R&D spending as a percentage of Gross Domestic Product is referred to as the current and capital expenditure on R&D carried out by all resident research institutes, companies, government laboratories and universities, etc., in a country. It involves R&D funded by foreign investments but excludes domestic funds made outside of the domestic country (OECD 2019).

The organization of this research paper is given as follows: In section two, we consider related literature. The next section introduces the Group Method of Data Handling, displaying also the relevant algorithm. The fourth section reveals the results of the research demonstrating the output tables and prediction graph. And finally, the fifth section discusses the conclusions of this research, including suggestions for future research.

2 Literature Review

Traditional literature states that entrepreneurship fosters innovation and innovations promote economic growth. Furthermore, economic growth stimulates further innovation and also encourages entrepreneurial activity. Beugelsdijk (2007) subsequently relates entrepreneurial culture to innovativeness and economic growth in 54 European regions. Tang and Koveos (2004) employ Global Entrepreneurship Monitor (GEM) data to reveal the impact of entrepreneurship, as defined by new business generation, in confluence with innovation, on economic growth at the macro level. Galindo and Méndez-Picazo (2013) analyze the relationship between innovation and economic growth following the Schumpeter approach with the consideration of entrepreneurship activity. Wong et al.

(2005) utilize overall Total early-stage Entrepreneurial Activity (TEA), necessity TEA, high growth potential TEA and opportunity TEA as separate determinants by employing an augmented Cobb–Douglas production function to explore economic growth.

It is desirable to predict economic growth, understand the current and past economic performance of countries, and make plans for the future (Stimson et al. 2006). There are numerous ways to prognosticate the future, and simple protrusions of recent trends, for illustration, tell us both veritably little about the present and not important about the future. On the other hand, analytical forecasting modeling that attempts to sort out the main influences that are likely to shape the future can deepen our understanding of the mechanisms driving economic growth. Although the forecasts involve errors, a good model allows analysts to review a forecast's strengths and limitations and to identify specific shortcomings that contributed to the gap between predictions and ultimate outcomes.

Technology forecasting is handled as foresight, which is equivalent to a bundle of systematic efforts to look ahead and to choose more effectively. Foresight considers that there is not a single future. That is to say, depending on action or non-action at present, many futures are possible, but only one of them will happen. In particular, technology and innovation policies select a desirable future and facilitate realizations. Foresight is the process involved in systematically attempting to look into the longer-term future of economic growth, innovation, and entrepreneurship with the aim of identifying the areas of strategic research and the emerging policies as well as technologies likely to yield the greatest economic and social benefits (Howland and Voss 2003). Adams et al. (2009) emphasize anticipation with its epistemic value of a virtue emerging through actuarial saturation as the sciences of the actual are displaced by speculative forecasts.

3 Group Method of Data Handling (GMDH)

The Group Method of Data Handling (GMDH) was introduced by Ivakhnenko (1968). GMDH can be applied to perform time-series prognosticating problems. For (giving level) considerably noisy data, GMDH algorithms based on external criteria are better than statistical methods and neural networks Lepoutre et al. (2013). Therefore, GMDH is a good method to solve the problem of noisy time series prediction (Howland and Voss 2003; Yang et al. 2009).

GMDH can be considered as an alternative to the conventional statistical approach. It determines the model of the optimal complexity from the given class of models based on experimental data. GMDH employs two or more subsets from an existing dataset for model creation, selection, and validation. It takes into account in-definiteness concerning features of source data automatically (Fig. 1).

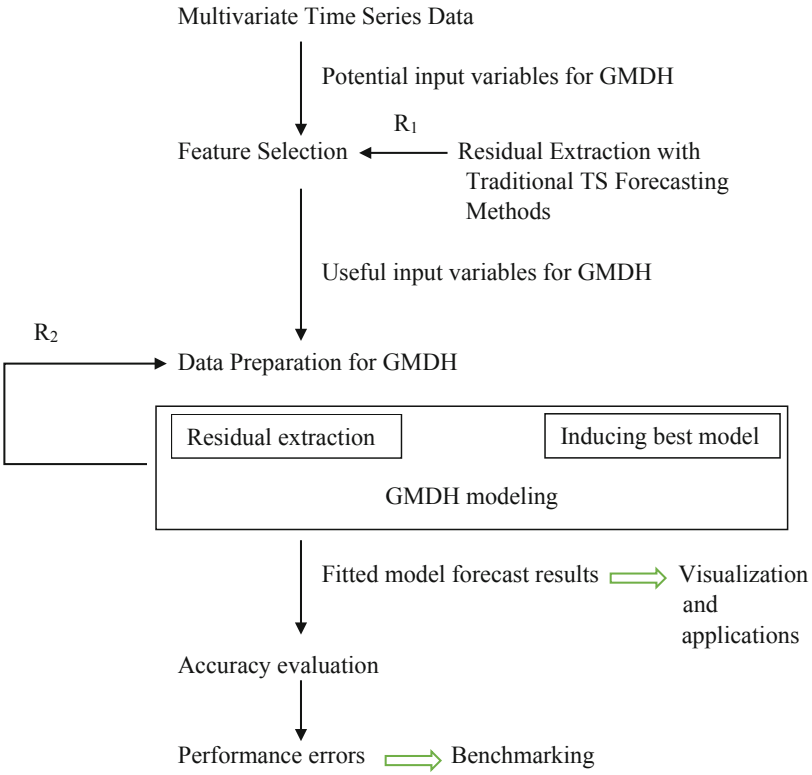

Fig. 1. The Operational Flow of the Residual-Feedback GMDH Method (Fong et al. 2012).

4 Applications and Results

This study shows evidence that entrepreneurship has a positive and significant effect (alpha = 0.10) and innovation has a negative and significant effect on GDP Growth (Annual %) after Brexit in the UK. In Ireland, the same goes for the time interval before Brexit. In Iceland, entrepreneurship and innovation don't seem to have a statistically significant impact on annual GDP growth.

Additionally, GDP Growth (Annual %) shows a negative correlation with entrepreneurship activities and a positive correlation with innovation. However, entrepreneurship and innovation exhibit a small negative correlation with each other in the UK. The same goes for Ireland, but Iceland shows opposite correlative results.

Table 1, 2, 3, 4, 5, and 6 exhibit the results of time series and correlation analyses.

Figure 2 shows the results of annual GDP Growth (%) forecasts made via the GMDH time series algorithm. Evidence shows that the GDP growth of the UK tends to have a negative slope until 2029 and a steep increase right after that year. These results might be related to the negative effects of Brexit on economic growth through entrepreneurship and innovation.

Table 1. Time series analysis of Iceland before and after Brexit

Iceland-time series before Brexit			**R-squared: 0.0061**
Dependent variable: GDP growth (annual %)			
Variable	**Coefficient**	**p-value**	
New business density	0.0178	0.974	
R&D expenditures (% of GDP)	−0.737	0.894	
const	4.628	0.769	
Iceland-time series after Brexit			**R-squared: 0.7609**
New business density	0.892	0.350	
R&D expenditures (% of GDP)	−0.864	0.419	
onst	−5.229	0.602	

Table 2. Correlation analysis for Iceland

Iceland-correlation analysis			
	GDP growth (annual %)	**New business density**	**R&D expenditures (% of GDP)**
GDP growth (annual %)	1.0000		
New business density	0.3534	1.0000	
R&D expenditures (% of GDP)	−0.6000	0.3849	1.0000

Table 3. Time series analysis of Ireland before and after Brexit

Ireland-time series before Brexit			**R-squared: 0.3925**
Dependent variable: GDP growth (annual %)			
Variable	**Coefficient**	**p-value**	
New business density	0.8772	0.087*	
R&D expenditures (% of GDP)	−16.6660	0.066*	
const	22.7994	0.067*	
Ireland-time series after Brexit			**R-squared: 0.5969**
New business density	−4.2747	0.806	
R&D expenditures (% of GDP)	−29.0794	0.612	
const	−219.8975	0.613	

Table 4. Correlation analysis for Ireland

Ireland-correlation analysis			
	GDP growth (annual %)	**New business density**	**R&D expenditures (% of GDP)**
GDP growth (annual %)	1.0000		
New business density	−0.7464	1.0000	
R&D expenditures (% of GDP)	0.6329	−0.9394	1.0000

Table 5. Time series analysis of UK before and after Brexit

UK-time series before Brexit			**R-squared: 0.3172**
Dependent variable: GDP growth (annual %)			
Variable	**Coefficient**	**p-value**	
New business density	−0.2131	0.283	
R&D expenditures (% of GDP)	−8.7565	0.575	
const	17.0201	0.483	
Ireland-time series after Brexit			**R-squared: 0.9946**
New business density	0.2019	0.071*	
R&D expenditures (% of GDP)	−0.5161	0.063*	
const	9.2409	0.054*	

Table 6. Correlation analysis for UK

UK-correlation analysis			
	GDP growth (annual %)	**New business density**	**R&D expenditures (% of GDP)**
GDP growth (annual %)	1.0000		
New business density	−0.7499	1.0000	
R&D expenditures (% of GDP)	0.6709	−0.0181	1.0000

Table 7 reveals accuracy levels of the GMDH predictions with an R-square of 0.9809 and a correlation of 0.9912.

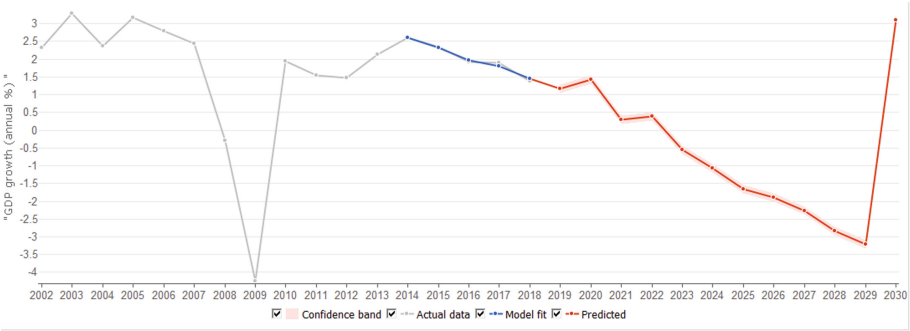

Fig. 2. UK-GDP growth (annual %) forecasts of UK via GMDH ALGORITHM

Table 7. Accuracy of GMDH predictions

Postprocessed results	Model fit
Number of observations	5
Max. negative error	-0.0869479
Max. positive error	0.0685035
Mean absolute error (MAE)	0.0502809
Root mean square error (RMSE)	0.0580862
Residual sum	-2.70894E-14
Standard deviation of residuals	0.0580862
Coefficient of determination (R^2)	0.980962
Correlation	0.991299

5 Conclusion

From theoretical and empirical points of view, the relationship between innovations, entrepreneurship and economic growth has been analyzed frequently in the literature. As a matter of fact, greater entrepreneurship and innovation enhance economic activity.

The risk management function affects both innovation and entrepreneurship. Predicting economic growth by taking into account innovation and entrepreneurship is vital for proactive policymaking on economic growth. In this regard, anticipating pitfalls in terms of innovative entrepreneurship must be considered by decision-makers for robust strategic planning for economic growth. This study analyzes the UK's economic growth before Brexit and economic growth potential after Brexit for a period of 12 years. It implements time series and correlation analysis and employs the GMDH algorithm to make anticipations about the future economic performance of the UK.

Evidence shows that the UK's economic growth should carry a steep downslope after Brexit and this result might be related to the decaying of innovative activities. The decay of innovation might well be connected to the newly imposed barriers to international trade and immigration. Consequently, consistent with the literature, Brexit is anticipated

to have negative impacts on the economic growth of the United Kingdom. Future research might regard different state-of-the-art machine learning algorithms employing varying innovation metrics along with a broader country set.

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