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The Causality between Electricity Consumption and Gross Domestic Product: Evidence from 144 Countries

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ABSTRACT

This study investigates the causal relationship between electricity consumption and gross domestic product (GDP) in 144 countries during the period 1980-2006. Thus, the countries have been divided into four different groups according to their GDP. These groups are defined as high income (38 countries), upper middle income (25 countries), lower middle income (39 countries) and low income (42 countries). This study applies the most recently developed panel causality tests, including the Hurlin and Venet test (2001) and the Granger causality test. The results show strong evidence for bidirectional causality in high income group, low income group and full sample, but no evidence for causal relationships in upper middle income countries. The findings show that unidirectional causality links electricity consumption to GDP in lower middle income countries. The results of all tests are also found same. Generally, the findings show that causal relationships are homogenous across the investigated countries, but only the heterogeneous causality is defined in twelve countries (Bahamas, Bahrain, Greece, Ireland, Kuwait, Malta, Netherlands, Puerto Rico, Saudi Arabia, Singapore, Switzerland and United Arab Emirates in high income group) of all countries.

Key words: electricity consumption, economic growth, panel causality

Journal of Economic Literature (JEL) Classification Number: C01, C33, C82, P44, Q43

Mathematics Subject Classification Number: 62P20, 91B64, 91B76, 91B82, 91B99

1. INTRODUCTION

Energy production, consumption and efficient yield are some of the main elements that influence the development of countries and societies in the globalised world. The presentation of policies that use scientific research to facilitate efficient energy consumption will stimulate social development and revitalisation, as well as economic growth.

The current economic trend of rising GDP influences energy demand significantly. Energy consumption per person is quite high in countries where the income level per person is high. It is clear that there is a close relationship between GDP and energy consumption. An increase in any country's GDP results in increased energy use. Thus, the causal relationship between energy consumption and economic growth is an important issue for academic research, particularly regarding energy policies.

There are many studies that investigate the causality between energy consumption and economic growth but few that focus on the causality between electricity and growth. Furthermore, most of the energy-GDP causality studies have used time series data. Some examples of such studies are Murray and Nan, 1996; Yang, 2000; Soytas and Sari, 2003; Wolde-Rufael, 2004; Ghali and El-Sakka, 2004; Altınay and Karagöl, 2005; Lee and Chang, 2005; Yoo, 2005; Narayan and Smyth, 2005; Zamani, 2007; Chen et al., 2007; Ho and Siu, 2007; Abosedra et al., 2008; Narayan and Prasad, 2008; Ghosh, 2009; Odhiambo, 2009, and among others. These studies were conducted at the country level, and the time series sample has usually been small. Recently, energy causality work has been enhanced using panel data. Table 1 summarises the previous empirical findings on the causality between energy (electricity) consumption and GDP for a number of countries.

Table 1: Comparative survey of the empirical results from panel causality tests for various countries

Researcher	Countries	Period	Results
Lee(2005)	18 developing countries	1975-2001	Causality from energy to GDP
Mehrara (2007)	11 developing countries	1971-2002	Causality from GDP to energy consumption
Mahadevan-Asafu Adjaye(2007)	20 countries	1971-2002	Bidirectional causality between energy and GDP.
Lee-Chang(2008)	16 Asian countries	1971-2002	Causality from energy to GDP in the long run
Lee et al.(2008)	22 OECD countries	1960-2001	Bidirectional causality between energy and GDP.
Narayan- Smyth(2008)	G7 countries	1972-2002	Causality from energy to GDP
Narayan - Smyth(2009)	6 Middle Eastern Countries	1974- 2002	Bidirectional causality between energy and GDP
Nondo and Kahsai(2009)	19 African countries	1980-2005	Causality from energy to GDP
Sinha(2009)	88 countries	1975-2003	Bidirectional causality between GDP and energy
Ciarreta- Zarraga(2010)	12 European countries	1970-2007	Causality from electricity consumption to GDP
Apergis-Payne(2010)	20 OECD countries	1985-2005	Bidirectional causality between energy and GDP.
Narayan, Narayan Popp(2010)	93 countries	1980-2006	Causality from elec. to GDP (for all panels) Causality from GDP to elec. (except Africa- G6)

For example, Lee et al. (2008) found evidence of bidirectional causality between GDP and energy in a sample of 22 developed countries. Mehrara (2007) examined the causal relationship between the per capita energy consumption and per capita GDP in a panel of 11 selected oil-exporting countries. This study found unidirectional causality between economic growth and energy consumption in these countries. Using data from Central America, Apergis and Payne (2008) found evidence of bidirectional causality between energy consumption and GDP. Narayan et al. (2010) searched the causality for the different seven regions. In all groups, they found that GDP causes electricity. In Narayan et al.(2010), the grouping was made according to regional specifications. Countries in the groups and the number of them are different from our study. The all groups in our study created according to the classification in the World Development Report 2007.

The purpose of most of these studies is to test for causality between energy consumption and GDP using a Granger causality test in the panel data. When the Granger causality test is applied in the panel data framework, two important inferential issues arise, both of which concern the potential heterogeneity of the individual cross-sections. Econometricians only recently modified these Granger tests to incorporate panel data. For this reason, we applied two different methods for causality tests in panel data models, to examine the causality between electricity consumption and GDP. In this purpose, we used Granger causality test (the three step procedure of unit root test, co-integration test and panel VECM/VAR) and Hurlin Venet(2001) test (This method tests whether homogeneous causality and it treats the autoregressive and regression coefficients as constants[1]). The aim of this study is to investigate the causal relationships between electricity consumption and GDP for 144 countries. These countries are examined in four subgroups using panel contents. In this paper, the data is expanded to 144 countries which are larger than Narayan et. al.(2010). In addition, we applied Hurlin Venet(2001) and Granger Causality three step procedure in a new panel causality context.

The rest of the paper is structured as follows: Section 2 explains the panel methodology; Section 3 describes the data, and Section 4 summarises empirical results. Conclusions are given in Section 5.

2. METHODOLOGY

The direction of the causality between electricity consumption and GDP is studied using the Granger causality and Hurlin and Venet (2001; HV hereafter) tests.

2.1. The Granger Causality Test

The Granger Causality test indicates the direction of the causal relationship between the variables examined. Firstly, the panel unit root and panel co-integration should be investigated. If co-integration is not found between the variables, the standard Granger Causality test is implemented as follows:

[1] See more detail, Dietrich (2009) and Erdil and Yetkiner (2005).

$$\Delta Y_{i,t} = \theta_{1i} + \sum_{k=1}^{p} \theta_{11ik} \Delta Y_{i,t-k} + \sum_{k=1}^{p} \theta_{12ik} \Delta X_{i,t-k} + u_{1i,t}$$

$$\Delta X_{i,t} = \theta_{2i} + \sum_{k=1}^{p} \theta_{21ik} \Delta X_{i,t-k} + \sum_{k=1}^{p} \theta_{22ik} \Delta Y_{i,t-k} + u_{2i,t}$$

The hypothesis,

$$Ho : \theta_{12ik} = 0 \qquad Ho : \theta_{22ik} = 0$$

In this test, if θ_{12ik} and/or θ_{22ik} in the equations are not equal to zero, it can be determined that there is causality between X and Y. In the equations, if co-integration is found, a panel-based error correction model (PVECM) is determined using the in the Granger causality analysis. Therefore, the following equations are estimated:

$$\Delta Y_{i,t} = \theta_{1i} + \lambda_{1i} ECT_{it-1} + \sum_{k=1}^{p} \theta_{11ik} \Delta Y_{i,t-k} + \sum_{k=1}^{p} \theta_{12ik} \Delta X_{i,t-k} + u_{1i,t}$$

$$\Delta X_{i,t} = \theta_{2i} + \lambda_{2i} ECT_{it-1} + \sum_{k=1}^{p} \theta_{21ik} \Delta X_{i,t-k} + \sum_{k=1}^{p} \theta_{22ik} \Delta Y_{i,t-k} + u_{2i,t}$$

where *ECT* is the error correction term that is obtained from the error term (e_{it}) of a co integrating equation:

$$Y_{it} = \beta_{it} X_{it} + e_{it} \qquad\qquad e_{it} \sim I(0)$$

If θ_{12ik} and/or θ_{22ik} and λ_{1i} and/or λ_{2i} in equations are not equal to zero, it can be determined that there is a causal relationship in the long-run. For this aim, the significance of parameters is investigated by the joint F test in equations. If θ_{12ik} and λ_{1i} are not equal to zero, X causes Y, as same, θ_{22ik} and λ_{2i} are not equal zero, Y causes X.

2.2. Hurlin and Venet Test

Hurlin and Venet (2001) proposed an extension of the Granger (1969) causality definition to panel data models with a fixed coefficient. Their model uses a time-stationary VAR representation, adapted to a panel data context. The following model is used for this aim:

$$Y_{it} = \sum_{k=1}^{p} \gamma^{(k)} Y_{it-k} + \sum_{k=0}^{p} \beta_i^{(k)} X_{it-k} + v_{it}$$

where $p \in \mathrm{N}*$, $v_{it} = \alpha_i + \varepsilon_{it}$ and ε_{it} is $i.i.d.(0, \sigma_\varepsilon^2)$. Therefore, the slope coefficients of $X_{i,t}$ are tested to be zero for all individuals *i* and all lags *k*. Hurlin and Venet use four different causality relationship hypotheses. First, they indicate that the Homogenous Non-Causality hypothesis (HNC) implies that, conditional to the specific error components of the model, no individual causality relationships exist. The hypothesis of the HNC test is defined as:

$$Ho: \beta_i^{(k)} = 0 \qquad \forall_i = 1,...,N; \forall_k = 1,..., p$$
$$H_1: \exists(i,k) / \beta_i^{(k)} \neq 0$$

The test statistic is used as follows:

$$F_{HNC} = \frac{(RSS_2 - RSS_1)/(Np)}{RSS_1 /[NT - N(1+p) - p]}$$

where RSS_2 denotes the restricted sum of squared residuals obtained under the null hypothesis, and RSS_1 denotes the unrestricted sum of squared residuals of the model. The F_{HNC} statistic has a Fischer distribution with Np and NT-N(1+p)-p degrees of freedom. If the HNC hypothesis is not rejected, it implies that variable *X* is not causing *Y* in all cross-section units. The non-causality results are then totally homogeneous and the testing procedure will go no further. If the HNC hypothesis is rejected, Homogeneous Causality (HC) should be examined.

Second, the model denotes the HC hypothesis. The hypothesis implies that N causality relationships for the coefficients of the lagged explanatory variable $X_{i,t-k}$ are identical for each lag k, and different from zero. The hypothesis of the test is defined as follows:

$$Ho: \beta_i^{(k)} = \beta^{(k)} \qquad \forall_i \in [1, N]; \forall_k \in [1, p]$$
$$H_1: \beta_i^{(k)} \neq \beta_j^{(k)} \qquad \exists(i, j) \in [1, N], \exists k \in [1, p]$$

The F statistic is computed as follows:

$$F_{HC} = \frac{(RSS_3 - RSS_1)/ p(N-1)}{RSS_1 /[NT - N(1+p) - p]}$$

where RSS_3 denotes the restricted sum of squared residuals obtained under the null hypothesis. If the HC hypothesis is rejected, it means that there is no homogeneous causality relationship from *X* to *Y* for all cross section units. It does not mean that there is no causality from the variable X to the variable Y but only that the causal relationship is non-homogenous. Thus, the Heterogeneous Non-Causality (HENC) test should be applied in the next step. The two last cases correspond to heterogeneous processes. They are the HENC and Heterogeneous Causality (HEC) hypothesis.

The third step of the procedure involves testing the HENC hypothesis. HENC assumes a non-homogeneous causal relationship between the variables. The hypothesis is defined as follows:

$$Ho: \exists i \in [1, N] / \forall k \in [1, p] \beta_i^{(k)} = 0$$

$$H_1 : \forall i = 1,..., N, \exists k \in [1, N] / \beta_i^{(k)} \neq 0$$

To test the HENC hypothesis, the F statistic is computed as follows:

$$F_{HENC} = \frac{(RSS_{2,i} - RSS_1)/p}{RSS_1 /[NT - N(1+2p) - p]}$$

where $RSS_{2,i}$ denotes the restricted sum of squared residuals obtained under the null hypothesis for individual *i*. A second procedure of this test consists of testing the joint hypothesis for a causal relationship in a subgroup of individuals. It is defined as follows:

$$Y_{it} = \sum_{k=1}^{p} \gamma^{(k)} Y_{it-k} + \sum_{k=0}^{p} \beta_i^{(k)} X_{it-k} + v_{it} \text{ with } \begin{cases} \beta_i^k \neq 0 \, for & i \in I_c \\ \beta_i^k = 0 \, for & i \in I_{nc} \end{cases}$$

$$n_c = \dim(I_c)$$
$$n_{nc} = \dim(I_{nc})$$

where the I_c and I_{nc} index sets represent subgroups for which there exists a causal relationship and no causal relationship, respectively. To test the HENC hypothesis, test statistics are computed as follows:

$$F_{HENC} = \frac{(RSS_4 - RSS_1)/n_{nc}p}{RSS_1 /[NT - N(1+p) - n_c p]}$$

where RSS_4 is the restricted sum of squared residuals obtained under the null hypothesis for the subgroups. If the HENC hypothesis is not rejected, this implies that there exists a subgroup of individuals for which the variable X does not cause the variable Y. However, if the HENC hypothesis is rejected, it implies that there exists the causal relationship between X and Y for all subgroups of the panel and the HEC hypothesis is explored. The HEC hypothesis implies that there exists a heterogeneous causal relationship between the variables *X* and *Y*, for the *i* cross section unit.

3. DATA

This study uses data from 144 countries during 1980-2006. These countries are divided into four different groups according to GDP in the World Bank's World Development Report, 2007. The World Bank classifies countries into four categories, namely low income (LIC), lower middle income (LMC), upper middle income (UMC), and high income countries (HIC). We have included 42 low income, 39 lower middle income, 25 upper middle income and 38 high income countries. Data used in this analysis were obtained from the databases of the International Energy Agency (IEA), Energy Statistics, and World Bank. The definitions of the variables examined are presented in Table 2. The list of countries can be appeared in the Appendix.

Table 2: The Definition of Variables

Variables	Definition
LEC	Natural Logarithms of EC [a]
LGDP	Natural Logarithms of GDP [b]

[a] Electricity consumption (Billion kilowatts)
[b] Real Gross Domestic Product (Base year: 2005)

4. EMPIRICAL RESULTS

First, we identified the order of integration of the series using unit root tests. We tested for unit roots using the panel-based methods proposed by Levin, Lin and Chu (2002, hereafter LLC)[2]. Table 3 presents the results of the LLC panel unit root test.

Table 3: The Results of Panel Unit Roots Test

Countries	Variables	LLC* Level	LLC* First Difference
LIC	LEC	-1. 67*	
	LGDP	-0.41	-18.33*
LMC	LEC	-0.29	-18.27*
	LGDP	-0.27	-15.94*
UMC	LEC	-3.47*	
	LGDP	-1.08	-12.37*
HIC	LEC	-1.00	-21.01*
	LGDP	-0.43	-15.94*
FULL SAMPLE	LEC	-3.06*	
	LGDP	-1.03	-31.51*

note: * denotes the rejection of the null hypothesis of unit root at the 5% level.

The unit root statistics are reported for the level and first difference series of LEC and LGDP. The results of the panel unit root test indicate the series that are integrated into one (1) in the high income group and lower middle income group. The test results suggested that the LEC and LGDP contain a panel unit root, and we proceeded on this basis to test for panel co-integration in the high income group and lower middle income group. In the second step of our estimation, we examined the long-run relationship between LEC and LGDP in high income group and lower middle income group using the panel co-integration technique developed by Pedroni (1995, 1999). Pedroni (1999) refers to

[2] For a detailed discussion on panel unit root tests, see Levin et al. (2002).

seven different statistics for co-integration tests. These are the panel v-statistics, panel rho-statistics, panel PP-statistics, panel ADF-statistics, group rho-statistics, group PP-statistics and group ADF-statistics. These tests are based on two types – the "within dimension" approach and the "between dimensions" approach. The results of the Pedroni panel co-integration test are reported in Table 4

Table 4: The results of Panel Co-integration Tests between LEC and LGDP

Countries	Panel co-integration tests	No deterministic trend	Deterministic intercept and trend	No deterministic intercept or trend
HIC	Panel v-Statistic	0.603527	13.85001*	-2.735868
	Panel rho-Statistic	-5.849537*	-0.621125	1.636410
	Panel PP-Statistic	-14.75312*	-3.844598*	0.149564
	Panel ADF-Statistic	-14.79193*	-5.172824*	2.902065
	Group rho-Statistic	-0.261914	2.059692	4.700273
	Group PP-Statistic	-5.066282*	-1.850056	-0.251952
	Group ADF-Statistic	-6.528938*	-3.340191*	-0.319588
LMC	Panel v-Statistic	5.142935*	3.210874*	-2.603797
	Panel rho-Statistic	0.428332	3.491435	2.956735
	Panel PP-Statistic	-3.901984*	-2.438119*	3.142663
	Panel ADF-Statistic	-4.276700*	-7.043147*	3.002793
	Group rho-Statistic	2.548470	4.878853	5.252104
	Group PP-Statistic	-4.216804*	-2.847745*	0.059095
	Group ADF-Statistic	-6.371783*	-6.498364*	1.331042

notes: * denotes the rejection of the null hypothesis of no co-integration at the 5% level
the variance ratio test is right-sided, while the others are left-sided.

The results of the panel co-integration test showed that there is a long-run relationship between LEC and LGDP in the high income level and lower income level. These results will be used for investigating the Granger causality test. Before estimating equations, the appropriate lag lengths are selected using the Schwartz criteria for both variables in each of four groups and full sample. We held same the lag-length and variables used in the Granger Causality Test and HV test, because it is difficult to compare the results from those two tests. The lag length of the variables in the models is selected using Schwartz criteria and it is found as two.

After defining the appropriate lag lengths, we applied the three-step Granger Causality procedure (Panel unit root, panel co-integration and PVECM) in the high income level and lower middle income level. We used Granger causality analysis taking account panel VAR in low income, upper middle income and full sample, too. The results of Panel Granger causality tests are presented in Table 5.

Table 5: Results of Panel Granger Causality Test

Countries	Dependent Variable	Source of Causation (independent variable)				
		Short- run		Long-run		
HIC		**ΔLGDP**	**ΔLEC**	**ECT**	**Joint (ECT and LGDP)**	**Joint (ECT and LEC)**
	ΔLGDP	-	56.39*	0.004608	-	54.72*
	ΔLEC	35.36*	-	0.005951	35.24*	-
LMC		**ΔLGDP**	**ΔLEC**	**ECT**	**Joint (ECT and LGDP)**	**Joint (ECT and LEC)**
	ΔLGDP	-	5.77	- 0.000706	-	5.72
	ΔLEC	29.21*	-	0.016770	28.07*	-
UMC		**ΔLGDP**	**LEC**			
	ΔLGDP	-	3.84			
	LEC	3.75	-			
LIC		**LGDP**	**LEC**			
	LGDP	-	13.51*			
	LEC	41.82*	-			
FULL SAMPLE		**ΔLGDP**	**LEC**			
	ΔLGDP	-	21.66*			
	LEC	88.06*	-			

notes: * denotes the rejection of the null hypothesis of no causality at the 5% level. Δ refers first differences.

In the high income group, we found that there is both a long-run and short-run causal relationship between LEC and LGDP. In lower middle income group, we found that there is the unidirectional causality from LGDP to LEC. We also investigated the short-term causality in the upper middle income, low income countries and full sample. According to the results, it can be seen that there is bidirectional causality in the low income and full sample. Moreover, in the upper middle income group, the results of the test indicate that there is no causal relationship between electricity consumption and GDP.

Second, we applied the HV causality test. The HNC and HC tests have recently been provided to econometrics literature for this purpose. This test takes into consideration homogeneity. Table 6 shows the results of these tests.

Firstly, we investigated HNC test and we found that the null hypothesis was rejected bidirectional in the low income, high income and full sample, only one-way in lower middle income. In addition, the null hypothesis can not be rejected in upper middle income group at the 5% level. Its mean is that no causality between electricity consumption and GDP in the upper middle income group. Secondly, HC test is used for investigating whether the homogeneous causality for low income, high income groups and full sample. It is found that the causality is homogeneous between electricity and GDP in low income, lower middle income and full sample, because the null hypothesis of HC test is accepted. However, we rejected the null hypothesis of HC test from LEC to LGDP in high income group. Thus, Heterogeneous Causality was investigated in high income group by HENC Test. Table 7 displays the results of HENC test.

Table 6: The results of HV Test

Test	Countries / Variables	LIC	LMC	UMC	HIC	FULL SAMPLE
HNC	From LGDP to LEC	1.75*	1.75*	-0.45	1.99*	3.16*
	From LEC to LGDP	2.33*	0.56	1.50	2.79*	1.51*
HC	From LGDP to LEC	0.06	0.95	-	1.17	3.28
	From LEC to LGDP	0.07	-	-	6.69*	0.01

Notes: * denotes the rejection of the null hypothesis at the 5% level according to tests.
The critical values are 1.73, 1.52, 1.41 for HNC test (1%, 5 %, 10%)
The critical values are 1.50, 1.36, 1.29 for full sample (1%, 5%, 10%)
The critical values are 2.15, 1.78, 1.60 for HC test (1%, 5%, 10%)

Table 7: Test results for Heterogeneous Causality (HENC) from LEC to LGDP

High Income Countries	Test Results	High Income Countries	Test Results
Antigua and Barbuda	0.005	**Japan**	1.130
Australia	0.653	**Kuwait**	**6.162***
Austria	0.216	**Luxembourg**	1.100
Bahamas	**5.285***	**Malta**	**3.849***
Bahrain	**3.867***	**Netherlands**	**3.937***
Belgium	1.333	**New Zealand**	1.136
Brunei	2.927	**Norway**	0.011
Canada	0.347	**Portugal**	2.432
Cyprus	0.285	**Puerto-Rico**	**9.271***
Denmark	1.665	**Saudi Arabia**	**11.041***
Finland	2.747	**Singapore**	**4.656***
France	1.331	**South Korea**	0.595
Germany	0.980	**Spain**	1.362
Greece	**4.111***	**Sweden**	0.191
Hong Kong	0.285	**Switzerland**	**6.345***
Iceland	1.737	**Taiwan**	0.718
Ireland	**3.638***	**United Arab Emirates**	**4.267***
Israel	2.876	**United Kingdom**	0.096
Italy	0.142	**United States**	0.544

note: * denotes the rejection of the null hypothesis at the 5% level according to HENC test.

According to test results for Heterogeneous Causality (HENC), the unidirectional causality from LEC to LGDP can be observed for only twelve high income countries: Bahamas, Bahrain, Greece, Ireland, Kuwait, Malta, Netherlands, Puerto Rico, Saudi Arabia, Singapore, Switzerland and United Arab Emirates. Other high income countries have homogenous causality relationship from LEC to LGDP. Generally, test results indicate to be homogenous causality between LEC and LGDP in OECD countries (except Greece, Netherlands and Switzerland).

In this paper, the causality relation between Electricity consumption and Gross domestic product is investigated. This purpose, Granger causality test and Hurlin Venet test are applied. A summary of the results of these causality tests is presented in Table 8.

Table 8: Summary of the Causality Tests

Panel Causality Tests	HIC	UMC	LMC	LIC	FULL SAMPLE
Granger Causality Test	EC↔GDP	No Causality	EC←GDP	EC↔GDP	EC↔GDP
Hurlin-Venet Test	EC↔GDP	No Causality	EC←GDP	EC↔GDP	EC↔GDP

Notes: ↔ indicates bidirectional causality
← indicates unidirectional causality

According to the table, Granger Causality test and Hurlin-Venet Causality test results are found same. Generally, the results of all panel causality tests show bidirectional homogeneous causality between electricity consumption and economic growth in the high income, lower income and full sample groups. However, of all high income group countries, twelve countries (Bahamas, Bahrain, Greece, Ireland, Kuwait, Malta, Netherlands, Puerto Rico, Saudi Arabia, Singapore, Switzerland and United Arab Emirates.) have heterogeneous causal relationship according to HENC test. On the other hand, it is found unidirectional homogeneous causality between electricity consumption and GDP (from LGDP to LEC) in lower middle income group, too. The results of all tests indicate no causal relationship between variables in upper middle income group.

5. CONCLUSIONS

This study investigates the causal relationship between electricity consumption and GDP in 144 countries during 1980-2006, using panel causality tests called the Granger causality and HV tests. These causality tests yield strong evidence for bidirectional homogenous causality in high income group (except twelve countries), low income group and full sample. In addition, it is found to be the heterogeneous causal relationship in Bahamas, Bahrain, Greece, Ireland, Kuwait, Malta, Netherlands, Puerto Rico, Saudi Arabia, Singapore, Switzerland and United Arab Emirates in high income group. In upper middle income countries, it is identified that there is no causal relationship. This implies that electricity consumption and GDP are probably determined by some other factors. According to the Granger causality and HV test results, we had some evidence of unidirectional homogeneous causality between electricity consumption and GDP in lower middle income countries.

Electricity is very important input for an economic structure. It is used in producing of a country with together other energy sources, extensively. Long-term use of electricity has caused to be the most important factor affecting national income it. While the increase of electricity consumption is increasing the national income, increase in production brings more employment and growth with together it, too. If the developed economies notice to industrialization more, energy use will increase day by day. Thus, our results might help to design appropriate electricity consumption and growth policies in the countries.

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APPENDIX

The Countries in Groups

Low Income	Lower Middle Income	Upper Middle Income	High Income
Bangladesh	Albania	Argentina	Australia
Benin	Angola	Barbados	Austria
Bhutan	Bolivia	Belize	Belgium
Burkina Faso	Brazil	Botswana	Canada
Burundi	Bulgaria	Chile	Denmark
Central African Republic	Cameroon	Costa Rica	Finland
Chad	Cape Verde	Dominica	France
Comoros	China	Equatorial Guinea	Germany
Congo Brazzaville	Colombia	Gabon	Greece
Cote Divoire	Congo Kinshasa	Grenada	Iceland
Ethiopia	Ecuador	Hungary	Ireland
The Gambia	Egypt	Lebanon	Italy
Ghana	El Salvador	Libya	Japan
Guinea	Fiji	Malaysia	Korea South
Guinea Bissau	Guatemala	Mauritius	Luxembourg
Haiti	Guyana	Mexico	Netherlands
India	Honduras	Oman	New Zealand
Kenya	Indonesia	Panama	Norway
Laos	Iran	Poland	Portugal
Madagascar	Jamaica	Romania	Spain
Malawi	Jordan	Seychelles	Sweden
Mali	Kiribati	South Africa	Switzerland
Mauritania	Lesotho	Turkey	United Kingdom
Mongolia	Maldives	Uruguay	United States
Mozambique	Morocco	Venezuela	Antigua and Barbuda

Low Income	Lower Middle Income	Upper Middle Income	High Income
Nepal	Nicaragua		Bahamas
Niger	Paraguay		Bahrain
Nigeria	Peru		Brunei
Pakistan	Philippines		Cyprus
Papua New Guinea	Samoa		Hong Kong
Rwanda	Sri Lanka		Israel
Sao Tome and Principe	Suriname		Kuwait
Senegal	Swaziland		Malta
Sierra Leone	Syria		Puerto Rico
Solomon Islands	Thailand		Saudi Arabia
Sudan	Tonga		Singapore
Tanzania	Trinidad and Tobago		Taiwan
Togo	Tunisia		United Arab Emirates
Uganda	Vanuatu		
Vietnam			
Zambia			
Zimbabwe			

note: These groups are defined according to World Development Report 2007 as follows: low income (< $875), under middle income($876-3,465), upper middle income ($3,466-10,725), high income($10,726 <)