Available online at www.HEFJournal.org

ISSN: 2785-2997

Journal of
Human, Earth, and Future

Vol. 3, No. 1, March, 2022

Analysis of Relationship between Economic Growth and Energy Consumption in Developed Countries

Okyay Uçan [1*], Hilal Budak [1], E. Dilara Aktekin [1]

[1] *Department of Economics, Faculty of Economics and Administrative Sciences, Niğde Ömer Halisdemir University, Niğde, Turkey*

Received 11 January 2022; Revised 24 February 2022; Accepted 27 February 2022; Published 01 March 2022

Abstract

This study examined the relationship between economic growth and energy consumption in the period 1986–2015 for 15 selected developed countries. In this study, in which the dynamic panel analysis method was used, cross-section dependence and homogeneity tests were taken into account. Accordingly, unit root and cointegration tests were decided. According to the cointegration test results, it has been determined that there is a long-term relationship between economic growth and energy consumption. The results obtained from the *Dumitrescu-Hurlin* causality test analysis show that there is a bidirectional causality relationship. As a result of the analysis, it has been concluded that economic growth and energy consumption are the causes of each other for the period of 1986–2015 in 15 selected developed countries.

JEL Classification: O40, O13, C23.

Keywords: Economic Growth; Energy Consumption; Panel Data Analysis.

1. Introduction

Economic growth is the indicator that economists make the most effort to explain. It is important to explain the sources of economic growth. Energy consumption, required for production activity, is closely related to economic growth. Empirical studies examining the relationship between economic growth and energy consumption have been conducted since the 1970s. Different results were obtained in these studies due to the differences between the countries examined. In their pioneering study, Kraft and Kraft (1978), found unidirectional causality running from economic growth to energy consumption for the US 1947–1974 period [1].

This study, which consists of five chapters, starts with the introduction, where general information is given. In Chapter 2, empirical literature on the energy consumption-economic growth link is given. Chapter 3 presents the data and econometric methodology. Chapter 4 includes an analysis and empirical results. In the last chapter, Chapter 5, the results of the study are presented.

2. Literature Review

Kraft and Kraft (1978) investigated the relationship between energy consumption and economic growth for the USA in the 1947–1974 period with the Sims Methodology. The result of the study reveals that there is a one-way

* Corresponding author: okyayu@hotmail.com

http://dx.doi.org/10. 28991/HEF-2022-03-01-06

causality relationship between economic growth and energy consumption [1]. Stern (1993) conducted the relationship between economic growth and energy use for the USA in the 1947–1990 period with VAR analysis. The result of the study reveals that there is a one-way causality relationship between economic growth and energy consumption [2].

Ghali & Al-Sakka (2004) analysed the relationship between energy consumption, economic growth, capital and labor for Canada over the period 1961–1997 using a cointegration and error correction model. The result of the study reveals that there is a bidirectional causality relationship between energy consumption and economic growth [3]. Altınay & Karagöl (2005) studied the relationship between electricity consumption and economic growth for Turkey in the 1950-2000 period using the Dolado–Lütkepohl and Granger causality method. The result of the study reveals that there is a one-way causality relationship between electricity consumption and economic growth [4].

Wolde-Rufael (2004) investigated the relationship between electricity consumption and economic growth for 19 African countries during the 1971–2001 period using the Granger causality method. While the result of the study shows that there is a one-way causality relationship between energy consumption and economic growth in Cameroon, Morocco, and Nigeria. It reveals that there is a one-way causality relationship between economic growth and energy consumption in Congo, Algeria, Egypt, Ivory Coast, and Ghana. It also shows that there is a bidirectional unidirectional causality relationship between economic growth and energy consumption for Gabon and Zambia [5].

Erbaykal (2007) researched the relationship between economic growth and energy consumption for Turkey in the period 1970-2003 by using ARDL and the cointegration method. The result of the study reveals that there is a cointegration relationship between the variables. While it shows that there is a positive relationship between economic growth and energy consumption in the short run, no significant relationship has been reached in the long run [6]. Mehrara (2007) investigated the relationship between energy consumption and economic growth for 11 selected oil-exporting countries in the 1971-2002 period using the panel cointegration analysis method. The result of the study reveals that there is a one-way causality relationship between economic growth and energy consumption [7].

Huang et al. (2008) prepared an analyses the relationship between energy consumption and economic growth for 82 countries in the 1972-1992 period using the Panel VAR model and the GMM method. In the study, four different country groups are investigated, namely the lower income group, the lower middle income group, the upper middle income group and the high income group. The result of the study reveals that there is a one-way causality relationship from economic growth to energy consumption in countries belonging to the upper middle income group. It also shows that there is no causal relationship between energy consumption and economic growth in low-income countries [8].

Chiou-Wei et al. (2008) examined the relationship between economic growth and energy consumption for the period 1954-2006 with linear and nonlinear Granger causality tests for the USA and newly industrialized Asian countries. For the Philippines and Singapore, causality from economic growth to energy consumption was determined. It is concluded that there is causality from energy consumption to economic growth for Taiwan, Hong Kong, Malaysia and Indonesia. There is no relationship between economic growth and energy consumption for the USA, Thailand and South Korea [9]. Apergis & Payne (2010) investigated the relationship between energy consumption and economic growth for eleven countries in the Commonwealth of Independent States, using panel cointegration test and error correction model, during the period 1991-2005. The result of the study reveals the existence of unidirectional causality from energy consumption to economic growth in the short term, and bidirectional causality between energy consumption and economic growth in the long term [10].

Apergis et al. (2010) conducted the relationship between CO_2 emissions, nuclear energy consumption, renewable energy consumption and economic growth for 19 developed and developing countries in the 1984-2007 period using a panel error correction model. The result of the study reveals that there is a bidirectional causality relationship between energy consumption and economic growth [11]. Apergis & Payne (2010) study carried out the relationship between renewable energy consumption and economic growth for the 1985-2005 period of twenty OECD countries. It has been concluded that there is a positive relationship between economic growth, renewable energy consumption and gross capital formation. A bidirectional causality was found between energy consumption and economic growth [10].

Pirlogea & Cicea (2012) investigated the relationship between economic growth and energy consumption for Turkey in the 1970-2008 period using the Granger causality method. The result of the study reveals that there is a one-way causality relationship from economic growth to energy consumption [12]. Belke et al. (2011) researched the relationship between economic growth and energy consumption for 25 OECD countries during the 1981-2007 period using the Granger causality method. The result of the study reveals that there is a bidirectional causality relationship between energy consumption and economic growth [13].

Adom et al. (2021) examined the relationship between economic growth and energy consumption for 95 countries using a panel causality test by dividing countries into four income groups. A long-run causality from economic growth to energy consumption was found for high- and low-income countries. For lower-middle and upper-middle-income countries, it was concluded that there is bidirectional causality between economic growth and energy consumption in the long run [14].

Erdoğan & Gürbüz (2014) conducted the relationship between economic growth and energy consumption for Turkey in the 1970-2009 period using the Granger causality method. The result of the study reveals that there is no causal relationship between energy consumption and economic growth [15]. Solarin & Shahbaz (2015) examined the relationship between Malaysia's economic growth, natural gas consumption, foreign direct investment, capital and trade openness for the period 1971-2012. It has been determined that there is cointegration between the variables. It has been concluded that natural gas consumption, foreign direct investment, capital formation and trade openness have positive effects on economic growth [16].

Azam et al. (2015) studied the relationship between energy consumption and economic growth for the ASEAN-5 countries in the 1980-2012 period. Johansen cointegration test and Granger causality test were applied. It has been concluded that there is a long-term and significant relationship between economic growth and energy consumption for ASEAN-5 countries [17]. Tang et al. (2016) conducted the relationship between energy consumption and economic growth for Vietnam during the 1971-2011 period using the Granger causality method. The result of the study reveals that there is a one-way causality relationship from energy consumption to economic growth [18]. Appiah (2018) investigated the relationship between energy consumption, economic growth and CO_2 emissions for Ghana during the period 1960-2015 using ARDL, Johansen cointegration test and Toda-Yamamoto causality method. The result of the study reveals that there is a one-way causality relationship from energy consumption to economic growth [19].

Özcan & Öztürk (2019) prepared the relationship between renewable energy consumption and economic growth in 17 developing countries. As a result of the study, while energy consumption has no effect on economic growth for 16 developing countries' economies, there is a positive effect for Poland [20]. Meyer & Sanusi (2019) studied the relationship between gross fixed capital formation, employment and economic growth for South Africa. He concluded that there is a long-run relationship between the variables and there is bidirectional causality between economic growth and employment. Economic growth is the determinant of gross fixed capital formation [21]. Topolewski (2021) empirically examined the relationship between economic growth and energy consumption of 37 European countries. It has been concluded that for European countries, the increase in production is the determinant of energy consumption and there is a one-way positive relationship from economic growth to energy consumption [22].

Yasmeen et al. (2021) investigated the relationship between economic growth, natural resources, gross capital formation and energy consumption for the period between 1990-2018 for Pakistan. It has been determined that there is a negative relationship between natural resources and economic growth. It has been concluded that capital formation is not effective on economic growth [23].

3. Data and Methodology

In this paper, it is investigated the economic growth and energy consumption. The data set used for the analysis of the relationship between energy consumption and economic growth and explanatory information about the variables are shown in Table 1. A bivariate model was used in the empirical analysis. In the analysis applied, Gauss 16 and Stata 14.1 econometrics package programs were used.

Table 1. Description of Variables

Variables	Explanation	Source
LGDP	Logarithmic GDP per capita (ABD $)	WDI, 2021
LEC	Logarithmic Energy Consumption (kg oil equivalent per capita)	WDI, 2021

The logarithm of the variables shown in Table 1 was taken and the model was created. The model created is shown in Equation 1:

$$LGDP_{it}= \beta_{0it}+\beta_1 LEC_{it}+ \varepsilon_{it} \quad (i=1,2,\ldots,15;\ t=1986,1988,\ldots\ldots,2015) \tag{1}$$

Data from selected fifteen developed countries were used, including Australia, Austria, Belgium, Denmark, Finland, France, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, the USA and Switzerland (Figure 1). While the i-index represents the countries in the model, the t index represents the time. Homogeneity and cross-section dependency tests were performed to estimate the model. According to the results of the analysis, the tests to be used were decided.

A dynamic panel data analysis procedure was followed in the study. This procedure allows group and time effects to be viewed simultaneously. Cross-section dependency and homogeneity tests were applied before estimating the cointegration relationship between energy consumption and economic growth. The Slope Homogeneity Test (Δ test) created by Pesaran & Yamagata (2008) was used to analyze the homogeneity of the variables in the model [24]. In order to determine whether there is interdependence between units in the model [25], LM (Lagrange Multiplier) test,

CD (Cross Section Dependent) test and CD_{LM} test [26] and Pesaran et al. (2008) LM_{adj} (Bias Adjusted Cross Sectional Dependence Lagrange Multiplier) tests were used. According to the results of the analysis, it was determined that the PANICCA test, one of the second generation panel unit root tests, should be applied [27]. The long-term relationship between the variables is analyzed by the panel cointegration test created by Westerlund & Edgerton (2007) [28]. The cointegration coefficients of the variables in the model were analyzed with the CCE (Common Correlated Effect) estimators created by Pesaran (2006) and taking into account the cross-sectional dependence [29].

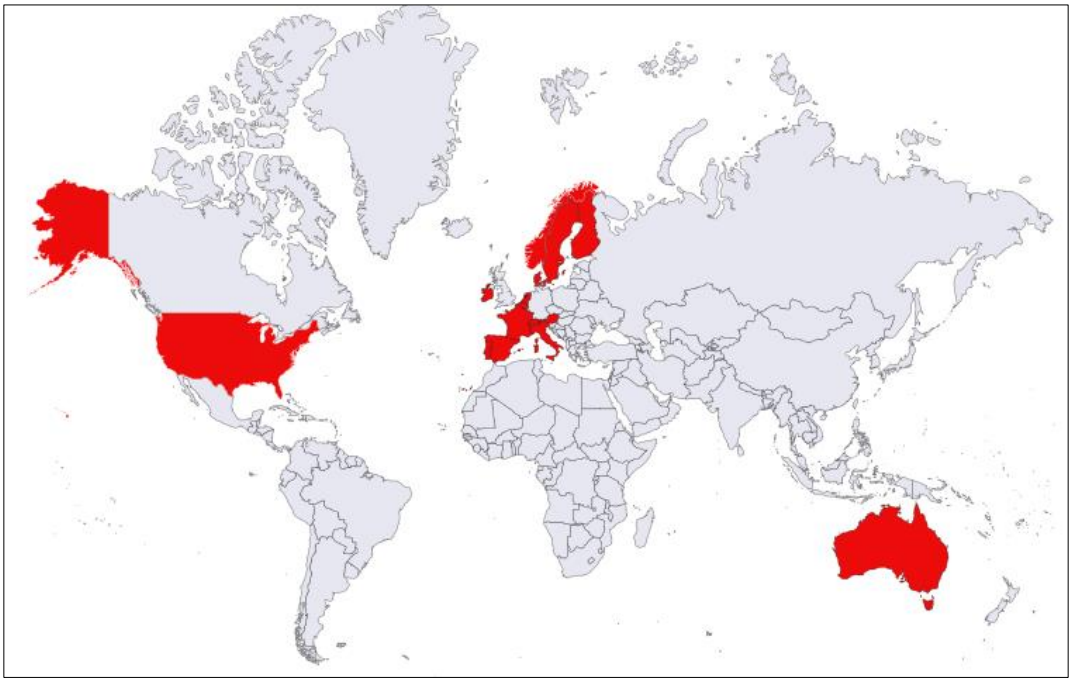

Figure 1. Fifteen selected developed countries

4. Empirical Results

In panel data analysis, it is necessary to determine the stationarity of the series in order to avoid the spurious regression problem. In order to decide which unit root test will be used for the stationarity of the series, it is necessary to determine the cross-section dependence test and the homogeneity test.

In this study, the Slope Homogeneity Test (Δ test) created by Pesaran and Yamagata (2008) was applied to determine homogeneity [24]. The hypotheses of the test are as follows:

H_o: The slope coefficients are homogeneous.

H_1: The slope coefficients are not homogeneous.

Homogeneity test results are shown in Table 2.

Table 2. Homogeneity Test Results

Tests	Test Statistic Probability Value	Probability Value
Delta Tilde	11.981	0.000***
Delta Tildeadj	12.629	0.000***

Note: **** indicates that it is statistically significant at the 1% level.*

According to the results in Table 2, it was found that the model was heterogeneous. Accordingly, the test results show that the selected countries are different from each other. In order to determine whether there is interdependence between units in the model [25], LM (Lagrange Multiplier) test, CD (Cross Section Dependent) test and CDLM test [26] and Pesaran et al. (2008) LM_{adj} (Bias Adjusted Cross Sectional Dependence Lagrange Multiplier) tests were used [27]. The hypotheses of the test are as follows:

H_o: No Cross Section Dependency

H_1: Cross Section Dependency

Cross Section Dependency test results are shown in Table 3.

Table 3. Cross Section Dependency Test Results

Tests	Test Statistic	Probability Value
CD_{LM1} [25]	365.710	0.000***
CD_{LM2} [26]	29.625	0.000***
CD_{LM3} [26]	15.133	0.000***
LM_{adj} [27]	30.603	0.000***

Note: **** indicates that it is statistically significant at the 1% level.*

According to the results in Table 3, it was found that the model was cross section dependency. Therefore study following section, second generation panel unit root test and panel cointegration analysis methods, which take into account the horizontal cross section dependency, were used. As a result of these analyses, the PANICCA test, which is one of the second generation panel unit root tests, which takes into account heterogeneity and cross-section dependence, was applied.

The results of the analysis applied in the study show that the PANICCA test, one of the second generation panel unit root tests, should be applied. The hypotheses of the PANICCA test are as follows:

H_0: Series are not stationary.

H_1: Series are stationary.

Unit root test results are shown in Table 4.

Table 4. Unit Root Test Results

Unit Root Test		LGDP	LEC
		Level	
		Constant and Trend	Constant and Trend
PANICCA	Pa	1.696 (0.955)	1.815 (0.965)
	Pb	2.236 (0.987)	2.450 (0.992)
	PMSB	3.174 (0.999)	3.538 (0.999)

According to the PANICCA unit root test results, the series are not stationary at the level. Series contain unit root. The fact that the series contain a unit root at the level necessitates the cointegration test. The cointegration test ensures that the spurious regression problem is eliminated [29]. In this study, the LM test created by Westerlund & Edgerton (2007) was applied to determine whether there is a cointegration relationship between the variables [27]. Since there is a cross-section dependency in the model, the bootstrap part is taken into account. The hypotheses of the LM test are as follows:

H_0: There is a cointegration relationship.

H_1: There is no cointegration relationship.

The cointegration test results are shown in Table 5.

Table 5. Cointegration Test Results

	LM Statistics	Asymptotic p-value	Bootstrap p-value
LM_N^+	23.038	0.000	1.000

Note: *Bootstrap probability values are obtained from a 1000 replication distribution. The delay value is taken as 1. Fixed and trending models are used.*

According to the cointegration test results, the null hypothesis cannot be rejected. . It has been found that there is a long-term relationship between economic growth and energy use variables.

After the cointegration relationship was determined, the cointegration coefficients were analyzed with the CCE (Common Corelated Effect) estimators created by Pesaran (2006) [28] and taking into account the cross-section dependence. The results of the cointegration coefficient estimators are shown in Table 6.

Table 6. Common Corelated Effect (CCE)

	Coefficient	Std. E.	p-value
CCE	0.240	0.065	0.000***
Country Results			
Australia	0.111	0.173	0.518
Austria	-0.165	0.137	0.230
Belgium	0.122	0.105	2.244
Denmark	0.209	0.081	0.010**
Finland	0.673	0.179	0.000***
France	0.396	0.127	0.002***
Ireland	0.761	0.211	0.000***
Italy	0.302	0.103	0.003***
Netherlands	-0.098	0.131	0.452
Norway	0.067	0.104	0.516
Portugal	0.321	0.055	0.000***
Spain	0.136	0.127	0.286
Sweden	0.418	0.127	0.001***
U.S.A.	0.134	0.131	0.307
Switzerland	0.219	0.118	0.063*

Note: *"***" sign means 1%, "**" sign 5% and "*" sign 10% significance.*

According to the findings obtained from the cointegration coefficient estimators, it was determined that the panel result was statistically significant as a developed country group. According to the estimation results, a 1% increase in energy consumption increases economic growth by 0.2%. When the estimation results are evaluated on a country basis, it has been determined that there is a positive relationship between energy consumption and economic growth in Denmark, Finland, France, Ireland, Italy, Portugal, Sweden and Switzerland. Energy consumption of countries differs according to their energy demand elasticities. The energy consumption of countries differs according to their energy demand elasticities [30]. Energy demand elasticity is higher in Ireland than in other selected countries in this study.

Table 7. Dumitrescu-Hurlin Panel Causality Test Results

Null Hypothesis	W Statistic	Z-bar Statistic	p-value
GDP → EC	1.679	1.861	0.062*
EC → GDP	4.075	8.421	0.000***

Note: *The *** sign indicates significance at the %1 and the * sign at the 10% level.*

According to Table 7, there is a 10% significance level panel causality relationship from economic growth variable to energy consumption. In addition, there is a panel causality relationship at 1% significance level from energy consumption to economic growth variable.

5. Conclusion

The relationship between economic growth and energy consumption is an issue that maintains its importance for developed countries. This study looked at the relationship between economic growth and energy consumption in 15 developed countries from 1986 to 2015. Cross-section dependence and homogeneity tests were considered in this work, which used the dynamic panel analysis method. Unit root and cointegration tests were chosen. Based on the results of the cointegration test, it has been determined that there is a long-term relationship between economic growth and energy consumption. The results obtained from the Dumitrescu-Hurlin causality test analysis show that there is a bidirectional causality relationship. There are many empirical studies in the literature on the relationship between energy consumption and economic growth. However, in these studies, it was not possible to reach a definite conclusion about whether there was a relationship between the two variables. In this study, it was examined whether there is a relationship between economic growth and energy consumption for 15 selected developed countries. As a result of the analysis, it has been concluded that economic growth and energy consumption are the causes of each other for the period of 1986–2015 in 15 selected developed countries. The significant positive relationship between energy consumption and economic growth supports the theoretical expectation. The increase in energy consumption,

as an indicator of industrialization and technological progress, has a positive effect on economic growth. Therefore, cheaper energy sources should be encouraged. Policies should be supported to avoid dynamics that negatively affect energy consumption.

6. Declarations

6.1. Author Contributions

O.U., H.B., and E.D.A. contributed to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available in the article.

6.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

6.4. Institutional Review Board Statement

Not applicable.

6.5. Informed Consent Statement

Not applicable.

6.6. Declaration of Competing Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

7. References

[1] Kraft, J., & Kraft, A. (1978). On the Relationship between Energy and GNP. The Journal of Energy and Development, 3(2), 401–403.

[2] Stern, D. I. (1993). Energy and economic growth in the USA. A multivariate approach. Energy Economics, 15(2), 137–150. doi:10.1016/0140-9883(93)90033-N.

[3] Ghali, K. H., & El-Sakka, M. I. T. (2004). Energy use and output growth in Canada: A multivariate cointegration analysis. Energy Economics, 26(2), 225–238. doi:10.1016/S0140-9883(03)00056-2.

[4] Altinay, G., & Karagol, E. (2005). Electricity consumption and economic growth: Evidence from Turkey. Energy Economics, 27(6), 849–856. doi:10.1016/j.eneco.2005.07.002.

[5] Wolde-Rufael, Y. (2004). Disaggregated industrial energy consumption and GDP: The case of Shanghai, 1952-1999. Energy Economics, 26(1), 69–75. doi:10.1016/S0140-9883(03)00032-X.

[6] Erbaykal, E. (2007). Türkiye'de Enerji Tüketiminin Ekonomik Büyüme Üzerindeki Etkisi. Beykent Üniversitesi Sosyal Bilimler Dergisi, 1(1), 29–44.

[7] Mehrara, M. (2007). Energy consumption and economic growth: The case of oil exporting countries. Energy Policy, 35(5), 2939–2945. doi:10.1016/j.enpol.2006.10.018.

[8] Huang, B.-N., Hwang, M. J., & Yang, C. W. (2008). Causal relationship between energy consumption and GDP growth revisited: A dynamic panel data approach. Ecological Economics, 67(1), 41–54. doi:10.1016/j.ecolecon.2007.11.006.

[9] Chiou-Wei, S. Z., Chen, C. F., & Zhu, Z. (2008). Economic growth and energy consumption revisited - Evidence from linear and nonlinear Granger causality. Energy Economics, 30(6), 3063–3076. doi:10.1016/j.eneco.2008.02.002.

[10] Apergis, N., & Payne, J. E. (2010). Renewable energy consumption and economic growth: Evidence from a panel of OECD countries. Energy Policy, 38(1), 656–660. doi:10.1016/j.enpol.2009.09.002.

[11] Apergis, N., Payne, J. E., Menyah, K., & Wolde-Rufael, Y. (2010). On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. Ecological Economics, 69(11), 2255–2260. doi:10.1016/j.ecolecon.2010.06.014.

[12] Pirlogea, C., & Cicea, C. (2012). Econometric perspective of the energy consumption and economic growth relation in European Union. Renewable and Sustainable Energy Reviews, 16(8), 5718–5726. doi:10.1016/j.rser.2012.06.010.

[13] Belke, A., Dobnik, F., & Dreger, C. (2011). Energy consumption and economic growth: New insights into the cointegration relationship. Energy Economics, 33(5), 782–789. doi:10.1016/j.eneco.2011.02.005.

[14] Adom, P. K., Agradi, M., & Vezzulli, A. (2021). Energy efficiency-economic growth nexus: What is the role of income inequality? Journal of Cleaner Production, 310, 127382. doi:10.1016/j.jclepro.2021.127382.

[15] Erdoğan, S., and Gürbüz, S. (2014). Türkiye'de Enerji Tüketimi Ve Ekonomik Büyüme İlişkisi: Yapısal Kırılmalı Zaman Serisi Analizi. Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, (32), 79-87.

[16] Solarin, S. A., & Shahbaz, M. (2015). Natural gas consumption and economic growth: The role of foreign direct investment, capital formation and trade openness in Malaysia. Renewable and Sustainable Energy Reviews, 42, 835–845. doi:10.1016/j.rser.2014.10.075.

[17] Azam, M., Khan, A. Q., Bakhtyar, B., & Emirullah, C. (2015). The causal relationship between energy consumption and economic growth in the ASEAN-5 countries. Renewable and Sustainable Energy Reviews, 47, 732–745. doi:10.1016/j.rser.2015.03.023.

[18] Tang, C. F., Tan, B. W., & Ozturk, I. (2016). Energy consumption and economic growth in Vietnam. Renewable and Sustainable Energy Reviews, 54, 1506–1514. doi:10.1016/j.rser.2015.10.083.

[19] Appiah, M. O. (2018). Investigating the multivariate Granger causality between energy consumption, economic growth and CO_2 emissions in Ghana. Energy Policy, 112, 198–208. doi:10.1016/j.enpol.2017.10.017.

[20] Ozcan, B., & Ozturk, I. (2019). Renewable energy consumption-economic growth nexus in emerging countries: A bootstrap panel causality test. Renewable and Sustainable Energy Reviews, 104, 30–37. doi:10.1016/j.rser.2019.01.020.

[21] Meyer, D. F., & Sanusi, K. A. (2019). A Causality Analysis of the Relationships between Gross Fixed Capital Formation, Economic Growth and Employment in South Africa. Studia Universitatis Babes-Bolyai Oeconomica, 64(1), 33–44. doi:10.2478/subboec-2019-0003.

[22] Topolewski, Ł. (2021). Relationship between energy consumption and economic growth in European countries: Evidence from dynamic panel data analysis. Energies, 14(12), 3565. doi:10.3390/en14123565.

[23] Yasmeen, H., Tan, Q., Zameer, H., Vo, X. V., & Shahbaz, M. (2021). Discovering the relationship between natural resources, energy consumption, gross capital formation with economic growth: Can lower financial openness change the curse into blessing. Resources Policy, 71, 102013. doi:10.1016/j.resourpol.2021.102013.

[24] Pesaran, M. H., & Yamagata, T. (2008). Testing slope homogeneity in large panels. Journal of Econometrics, 142(1), 50–93. doi:10.1016/j.jeconom.2007.05.010.

[25] Breusch, T. S., & Pagan, A. R. (1980). The Lagrange Multiplier Test and its Applications to Model Specification in Econometrics. The Review of Economic Studies, 47(1), 239. doi:10.2307/2297111.

[26] Pesaran, M. H. (2020). General diagnostic tests for cross-sectional dependence in panels. Empirical Economics, 60(1), 13–50. doi:10.1007/s00181-020-01875-7.

[27] Pesaran, M. H., Ullah, A., & Yamagata, T. (2008). A bias-adjusted LM test of error cross-section independence. Econometrics Journal, 11(1), 105–127. doi:10.1111/j.1368-423X.2007.00227.x.

[28] Westerlund, J., & Edgerton, D. L. (2007). A panel bootstrap cointegration test. Economics Letters, 97(3), 185–190. doi:10.1016/j.econlet.2007.03.003.

[29] Pesaran, M. H. (2006). Estimation and Inference in Large Heterogeneous Panels with a Multifactor Error Structure. Econometrica, 74(4), 967–1012. doi:10.1111/j.1468-0262.2006.00692.x.

[29] Damodar N. Gujarati, Dawn C. Porter, Ümit Şenesen (Çevirmen), Gülay Günlük Şenesen (2018). Temel Ekonometri 5. Basımdan Çeviri (Ekonomik Baskı), Literatür Yayınları, İstanbul, Turkey.

[30] Dumitrescu, E. I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. Economic Modelling, 29(4), 1450–1460. doi:10.1016/j.econmod.2012.02.014.