İnsan ve Toplum Bilimleri Araştırmaları Dergisi
Journal of the Human and Social Science Researches
[2147-1185]

[itobiad], 2020, 9 (3): 2636/2661

The Relationship Between Nuclear Energy Consumption And Economic Performance: An Empiric Analysis on Selected Countries

Nükleer Enerji Tüketimi ve Ekonomik Performans Arasındaki İlişki: Seçilmiş Ülkeler Üzerine Ampirik Bir Analiz[1]

Türker ŞİMŞEK
Doç.Dr., Tokat Gaziosmanpaşa Üniversitesi İktisadi ve İdari Bilimler Fakültesi İktisad Bölümü
Assoc. Prof., Tokat Gaziosmanpaşa University Faculty of Economics and Administrative Sciences, Department of Economics
turker.simsek@gop.edu.tr / 0000-0001-7581-7590

Cihan USTA
Dr., Tokat Gaziosmanpaşa Üniversitesi Sosyal Bilimler Enstitüsü
PhD., Tokat Gaziosmanpaşa University, Social Sciences Institute Student in Economics
cihnusta@gmail.com / 0000-0001-8790-9505

Makale Bilgisi / Article Information

Makale Türü / Article Type	**:** Araştırma Makalesi / Research Article
Geliş Tarihi / Received	**:** 26.08.2020
Kabul Tarihi / Accepted	**:** 26.09.2020
Yayın Tarihi / Published	**:** 30.09.2020
Yayın Sezonu	**:** Temmuz-Ağustos-Eylül
Pub Date Season	**:** July-August September

Atıf/Cite as: Şimşek, T , Usta, C . (2020). The Relationship Between Nuclear Energy Consumption And Economic Performance: An Empiric Analysis on Selected Countries . İnsan ve Toplum Bilimleri Araştırmaları Dergisi , 9 (3) , 2636-2661 . Retrieved from http://www.itobiad.com/tr/pub/issue/56503/785764

İntihal /Plagiarism: Bu makale, en az iki hakem tarafından incelenmiş ve intihal içermediği teyit edilmiştir. / This article has been reviewed by at least two referees and confirmed to include no plagiarism. http://www.itobiad.com/

[1] This study is derived from the thesis of Cihan USTA, a graduate student of the Department of Economics, Institute of Social Sciences, Tokat Gaziosmanpasa University, entitled "The Relationship Between Nuclear Energy Consumption and Economic Performance: Panel Data Analysis" on 27.06.2019.

Nükleer Enerji Tüketimi ve Ekonomik Performans Arasındaki İlişki: Seçilmiş Ülkeler Üzerine Ampirik Bir Analiz

Öz

Gelişmekte olan ülkelerin kalkınması için, enerji üretimi önem arzetmektedir. Ülkelerin nükleer enerji geleceği ise o ülkede yaşayan insanların hoşgörülerini kazanmasına ve emniyetli bir şekilde bu hoşgörüyü devam ettirebilmesine bağlı bulunmaktadır. Özellikle sanayileşmiş ülkeler için bu önemli bir koşul olarak görülmektedir. Gelişmekte olan ülkelerde nükleer enerjiden endüstriyel anlamda faydalanılmasa bile tıbbi anlamda, radyoaktif muayene ve çeşitli alanlarda yararlanılmaktadır. Çalışmada nükleer enerji tüketiminde ilk sıralarda yer alan ülkelerde nükleer enerji tüketimi ile ekonomik performans arasındaki ilişkinin ekonometrik analizlerle ortaya konulması ve politika karar vericilere tavsiye niteliğinde önermelerde bulunulması amaçlanmıştır. Bu amaç doğrultusunda Dünya'da nükleer enerji tüketiminde ilk sıralarda yer alan Almanya, Amerika Birleşik Devletleri, Birleşik Krallık, Çin, Fransa, Güney Kore, Hindistan, Japonya, Kanada, Rusya ve Ukrayna gibi ülkelerde nükleer enerji tüketimi ile ekonomik performans arasında uzun veya kısa dönemli bir ilişkinin olup olmadığı panel veri yöntemleri ile araştırılmıştır. Analizde Dünya Bankası Kalkınma Göstergeleri ve BP Dünya Enerji İstatistikleri Raporları'ndan derlenen 1997-2017 dönemine ait normalize edilmiş yıllık veriler kullanılarak Havuzlanmış Ortalama Grup Tahmincisi (PMGE), Ortalama Grup Tahmincisi (MGE) ve Dinamik Sabit Etkiler (DFE) yöntemlerine başvurulmuştur. Stata programı aracılığıyla yapılan ekonometrik analiz sonucunda nükleer enerji tüketimi ekonomik performans üzerinde kısa dönemde etkili olmaz iken uzun dönemde Japonya dışında diğer ülkelerde nükleer enerji tüketiminin ekonomik performans üzerinde etkili olduğu sonucuna ulaşılmıştır. Panel veri yönteminde her bir ülke için ayrı ayrı sonuçlar sağlayan analizden çıkan bulguların politika karar vericiler tarafından dikkate alınarak uygun ekonomi politikalarının izlenmesi ekonomik performans ve etkinlik açısından önemli olacaktır.

Anahtar Kelimeler: Nükleer Enerji Tüketimi, Ekonomik Performans, Havuzlanmış Ortalama Grup Tahmincisi, Ortalama Grup Tahmincisi ve Dinamik Sabit Etkiler.

The Relationship Between Nuclear Energy Consumption And Economic Performance: An Empiric Analysis on Selected Countries

Abstract

Energy production is important for the development of developing countries. The future of nuclear energy depends on the people living in that country gaining their tolerance and being able to continue this tolerance in a safe way. This is seen as an important condition, especially for industrialized countries. In developing countries, even if nuclear energy is not used in industrial terms, it is used in medical terms, radioactive examination and various fields. The aim of the study is to determine the relationship between nuclear energy consumption and economic performance in the countries that are ranked first in nuclear energy consumption by econometric analyses and to make recommendations to policy decision makers. For this purpose, it has been investigated whether there is a long or short term relationship between nuclear energy consumption and economic performance in countries (Germany, the United States, the United Kingdom, China, France, South Korea, India, Japan, Canada, Russia and Ukraine) that are in the first place in nuclear energy consumption in the world by using panel data methods. In the analysis, Pooled Mean Group Estimator (PMGE), Mean Group Estimator (MGE) and Dynamic Fixed Effects (DFE) methods are used using the normalized annual data for the period 1997-2017 compiled from the World Bank Development Indicators and BP World Energy Statistics Reports. As a result of the econometric analysis conducted through the Stata program, it has been concluded that nuclear energy consumption does not have an impact on economic performance in the short term, whereas nuclear energy consumption in other countries, except Japan, has an impact on economic performance in the long term. In the panel data method, it will be important for economic performance and efficiency to be followed by policy decision makers considering the findings from the analysis provided for each country separately.

Keywords: Nuclear Energy Consumption, Economic Performance, Pooled Mean Group Estimator, Mean Group Estimator and Dynamic Fixed Effects.

1.Introduction

Energy, which is one of the most important elements of our economy and daily life, has started to become important with the discovery of fire. The Industrial Revolution that started in England contributed to the production of more efficient, less costly and quality goods with less labour force by mechanizing energy (steam power). Developments such as developing technology, industrialization, urbanization and population growth have started to increase the demand for energy consumption. Since fossil resources (such as oil and coal) that meet the increasing demand for energy are limited, there have been period-by-period energy crises. These crises have led developed and developing countries to seek alternative energy sources. Alternative energy sources include renewable energy sources such as biomass, geothermal, hydrogen, wind, solar and nuclear energy. These resources are among the issues that countries are working on in terms of sustainable development.

Nuclear energy, which ranks among fossil and renewable energy sources in terms of obtaining clean and low cost energy, was first started to be used for civilian and military purposes in the 1950s. After the Chernobyl, Windscale, Three Mile Island and Fukushima nuclear energy accidents that led to worldwide disasters in the following years, people began to have doubts about the supply of nuclear-derived energy. But with evolving technology, international laws and treaties, many countries have benefited from nuclear energy, which has overcome a large part of the security problem.

Countries that are economically developed or targeted for development and do not want to be dependent on the external energy generally prefer to use the energy derived from nuclear power plants. In addition to obtaining energy from nuclear energy, which is considered to be important in the economic and political field, it is another important issue that countries take into consideration where different added values can be obtained. Apart from energy production, nuclear technology is also utilized in different fields such as medicine, agriculture and food.

The aim of the study is to determine the relationship between nuclear energy consumption and economic performance in the countries that are ranked first in nuclear energy consumption by econometric analyses and to make recommendations to policy decision makers. Nuclear energy is characterized by low production and high investment costs, unaffected by fluctuations in fuel prices, long operating life and regulatory costs. In this respect, it directly affects the economic performance. It is important to examine the relationship between nuclear energy and economic performance in developed countries. The findings can be considered for countries considering the transition to the nuclear program. For this purpose, firstly, after giving an introduction, the theoretical relationship between nuclear energy and economic performance is discussed. After the literature review is included in the third title and the analysis in the fourth title, the study is concluded with the conclusion section.

2.Nuclear Energy and Economıc Performance

Nuclear energy is defined as the type of energy released by fission, fusion, or radioactive decay of the atom, which is the smallest unit of matter (Erden, 1990: 109). Energy policies around the world are being revisited again and again to get rid of dependence on fossil fuels such as oil, natural gas and coal. The resulting energy crises have led countries to explore alternative energy sources, provide energy diversity and reduce energy dependence (Yildirim and Örnek, 2007: 1). Nuclear energy released as a result of studies with atomic nuclei, meets the needs of the society and is attracted by many countries since energy is obtained efficiently (Morali, 2004: 10). Nuclear power plants and technologies provide a variety of facilities besides obtaining energy. Nuclear technology has many areas of application such as industry, medical treatment, medical material sterilization, pathogen reduction, protection of foodstuffs and pest control in agriculture (Kiziltan, 2010: 35).

While discussing the economic performance of a country, the country's Real Gross Domestic Product (RGDP) is widely used in the literature. An increase in real gross domestic product means that production and economic growth have increased. Economic growth indicators will be considered as a measure of economic performance. Economic growth is expressed as the amount of output in the economy or the increase in real national income each year (Turan, 2008: 11). Economic growth has been an important issue both in industrialized countries and in industrializing countries. However, economic growth varies on a country basis. When the growth in developed countries is analyzed, production outputs or real gross domestic product increase is based on, while in developing countries both real real gross domestic product or increase in production output is taken as basis. Although economic development is a subject that includes economic growth, it also includes issues such as improving job opportunities, reducing the imbalances in income distribution, increasing literacy rates, modernizing economic and social institutions, human and political issues (Seyidoğlu, 2006: 829).

Today, energy is a factor used as input in almost every activity (Tuğrul, 2006: 27). The demand for electricity is increasing due to the increase in the population and urbanization, the increase in the need for electricity provided to households, the increase in the need for electricity through mechanization in the agricultural sector, and the increase in the need for electricity used in the production phase in the industry (Gülbahar and Kılınç, 2011:6).

Low energy costs and changes in output after production increase the gross domestic product and add positive effects to economic growth. For this reason, nuclear energy is among the factors that provide economic growth (Ferguson, 2015: 6). Energy production is important for the development of developing countries. The nuclear energy future of the countries depends on the people living in that country to gain their tolerance and to continue this tolerance safely. This is seen as an important condition especially for industrialized countries (Özden, 1983). In developing countries, even if nuclear energy is not used in an industrial sense, it is used in medical fields, radioactive examination and various fields (TAEK, 2005). The relationship between nuclear energy and economic performance is based on growth theories in the economic field. The low production cost of nuclear energy and not being affected by fuel price fluctuations affect the economic performance, in other words, the production positively. It is expected that an increase in the use of nuclear energy will positively affect the economic growth due to the efficiency and productivity.

3.Literature Review

The relationship between economic growth and energy is becoming an increasingly important subject for researchers (Şimşek and Aydın, 2018: 729). In the studies in the literature, many analyzes have been made between economic growth and energy consumption, and various results have emerged. To better understand these results, growth, protection, neutrality, and feedback (hypotheses) have been developed (Şimşek and Yiğit, 2017: 122).

According to the growth hypothesis, the interaction between energy use and economic growth has a positive direction, and causality is from energy use to economic growth. A one-unit increase or decrease in energy use will also cause an increase or decrease in economic growth. According to the conservation hypothesis, he argues that causality is from economic growth to energy use. According to the nullity hypothesis, he argues that there is no causality, or too little to care about, neither from growth to energy use nor from energy use to growth. The feedback hypothesis is that causality is mutual, that is, from energy use to growth and from growth to energy use (Öztürk and Acaravcı, 2011: 2885; Şimşek and Yiğit, 2017: 122). The lietrature studies on the subject are given in Table 1.

Table 1: Literature Review

Author(s)	Sample and Period	Method	Results
Wolde Rufael (2010)	India (1969-2006)	Toda Yamamoto Granger Causality Test	NE→RGDP

Apergis et al. (2010)	USA, Germany, Belgium, UK, Bulgaria, Finland, France, South Korea, India, Netherlands, Spain, Sweden, Switzerland, Japan, Canada, Pakistan (1980-2005)	Panel Vector Error Correction Model	NE→RGDP: For Short Term NE↔RGDP: For Long Term
Wolde Rufael and Menyah (2010)	USA, UK, Canada, France, the Netherlands, Japan, Spain, Sweden, Switzerland (1971-2005)	Toda Yamamoto Granger Causality Test	NE→RGDP: Japan, Netherlands, Switzerland NE←RGDP: Canada, Sweden NE↔RGDP: USA, UK, France, Spain
Apergis and Payne (2010)	USA, Germany, Belgium, UK, Bulgaria, Finland, France, South Korea, India, Netherlands, Spain, Sweden, Switzerland, Japan, Canada, Pakistan (1980-2005)	Panel Vector Error Correction Model Panel Granger Causality	NE→RGDP: For Long Term NE↔RGDP: For Short Term
Menyah and Wolde Rufael (2010)	USA (1960-2006)	Toda Yamamoto Granger Causality Test	NE×RGDP
Lee and Chiu (2011a)	USA, United Kingdom, Canada, France, Japan (1965-2008)	Toda Yamamoto Granger Causality Test	NE←RGDP: Japan : NE↔RGDP: Canada, Germany, UK NE×RGDP: France, USA
Heo et al. (2011)	India (1969-2006)	Granger Causality Test	NE→RGDP
Lee and Chiu (2011b)	USA, United Kingdom, Canada, France, Japan (1971-2006)	Panel Cointegration Test Panel Granger Causality	NE←RGDP: For Long Term NE×RGDP: For Short Term

Nazlıoğlu et al. (2011)	USA, Germany, UK, Belgium, Canada, Czech Republic, Finland, France, Netherlands, Japan, Korea, Hungary, Spain, Sweden, Switzerland	Panel Granger Causality Toda Yamamoto Granger Causality Test	NE→RGDP: Hungary NE←RGDP: UK,Spain NExRGDP: Other Countries
Chu and Chang (2012)	USA, Germany, UK, Canada, France, Japan (1971-2010)	Bootstrap Panel Granger Causality Test	NE→RGDP: USA, UK, Japan NE×RGDP: Canada, France, Germany
Wolde-Rufael (2012)	Taiwan (1977-2007)	Toda Yamamoto Granger Causality Test	NE→RGDP
Aslan and Çam (2013)	Israel (1985-2009)	Granger Causality Test	NE→RGDP
Omri and Chaibi (2014)	USA, Argentina, Belgium, UK, Brazil, Bulgaria, Canada, Finland, France, Hungary, India, Japan, Netherlands, Pakistan, Spain, Sweden (1990-2011)	Dynamic Simultaneous Equation Panel Data	NE→RGDP: Belgium, Spain NE←RGDP: Bulgaria, Canada, Netherlands, Sweden NE↔RGDP: Argentina, Brazil, France, Pakistan, USA NE×RGDP: Finland, Hungary, India, Japan, Switzerland, UK
Chang et al. (2014)	USA, Germany, UK, Canada, France, Japan (1971-2011)	Panel Granger Causality Test	NE→RGDP: Germany NE↔RGDP: UK NE×RGDP: Canada, France, Japan, USA
Mbarek et al. (2015)	France (2001-2012)	Granger Causality Test	NE→RGDP

Omri et al. (2015)	USA, Argentina, Belgium, UK, Brazil, Bulgaria, Canada, Finland, France, Hungary, India, Japan, Netherlands, Pakistan, Spain, Sweden, Switzerland (1990-2011)	Dynamic Simultaneous Equation Panel Data	NE→RGDP: Belgium, Spain NE←RGDP: Bulgaria, Canada, Netherlands, Sweden NE↔RGDP: Argentina, Brazil, France, Pakistan, USA NE×RGDP: Finland, Hungary, India, Japan, Switzerland, UK
Ozcan and Arı (2016)	13 OECD Countries: Belgium, France, Canada, Germany, Netherlands, Spain, Sweden, UK, USA, Japan, Switzerland, Finland, South Korea, Czechia (1980- 2012)	Panel Cointegration Test Toda Yamamoto Granger Causality Test	NE↔RGDP
Saidi and Mbarek (2016)	USA, UK, Canada, France, Japan, Netherlands, Spain, Switzerland, Sweden (1990-2013)	Panel Granger Causality Toda Yamamoto Granger Causality Test	NE×GDP
Mbarek et al. (2017)	France (2001-2012)	Granger Causality Testi Vector Error Correction Model	NE↔GDP
Şimşek and Aydın (2018)	4 Developed Countries: United States, Russia, China, South Korea (1997-2016)	Panel FMOLS	NE→RGDP
Luqman et al. (2019)	Pakistan (1990-2016)	NARDL	NE×GDP

As can be seen from Table 1, there is no consensus on nuclear energy and economic performance in the studies in the related field. In addition to the studies claiming that there is a one-way and two-way relationship between them, there are studies that argue that there is no relationship between them. In this study, in addition to the determination of the causality relationship, which is generally made in the literature, it will be tried to determine how much nuclear energy affects the economic growth of each country in the countries included in the analysis. In addition to the general result obtained in the panel data analysis, the use of an econometric method that gives results separately in each country makes the study one of the few studies in the literature.

4.Data Set and Econometric Model

In the study, 11 countries that consume nuclear energy the most are included in the analysis. These countries are Germany, the United States (USA), the United Kingdom, China, France, South Korea, India, Japan, Canada, Russia and Ukraine. Whether there is a long or short term relationship between nuclear energy consumption and economic performance in these countries will be analyzed using the Stata 15 program. Real gross domestic product (RGDP) indicator is obtained from the World Bank Economic Development Indicators database by taking the examples such as Odularu and Okonkwu (2009), Mucuk and Demirsel (2009) and Arslan (2011) included in the literature as an indicator of economic performance. Nuclear Energy Consumption (NE) data has been compiled as million tons of oil equivalent unit from the reports prepared by British Petroleum (BP) for statistical analysis of world energy. The period between 1997 and 2017 has been considered and the data compiled annually are included in the analysis to obtain more reliable results. The model used in econometric analysis is shown in equation (1):

$$RGDP_{it} = \alpha_i + \partial_{it} + NE_{it} + \varepsilon_{it} \qquad (1)$$

In Equation (1) i=1,...,N show each country in the panel data analysis; t=1,...,T show the period of time. α shows the probability of country-specific constant effects, deterministic trends, and the ε parameter also shows predictive residues that express deviations from the long-term relationship.

In order to achieve more reliable results in Panel data analysis, cross-section dependence between variables must be investigated. It is emphasized by Pesaran (2004) that there can be correlations between cross-sections in panel models where the horizontal section size (N) is small and the time size (T) is large. In the study, the cross-section dependence and homogeneity should be considered as N=11, T=20 or N<T. Misleading and inconsistent results can be obtained if horizontal cross-sectional dependence is not taken into

account (Chudik and Pesaran, 2013). Table 2 shows the cross section dependency test results.

Table 2: Cross Section Dependency Test Results

Test	Test Value	Probability Value / Critical Value
Pesaran CD_{LM}	28.199	p=0.0000
Friedman R	50.543	p=0.0000
Frees Q	0.2760	Critical Values According to Frees Q Distribution α = 0.10 : 0.1294 α = 0.05 : 0.1695 α = 0.01 : 0.2468
Breusch Pagan LM	190.595	p=0.0000

When the cross-section dependence test results in Table 2 are examined, the zero hypothesis is not accepted that there is no dependency between countries. In other words, according to the Pesaran CDLM, Friedman R, Frees Q and Breusch Pagan LM test results, dependency is determined between countries. In this case the Pesaran Panel unit Root Test is recommended to be used because it allows heterogeneous autoregressive coefficients (Apergis and Payne, 2010: 546). The results of the Pesaran Panel Unit Root Test or Cross Section Augmented Dickey Fuller Test (CADF), a second generation unit root test, are included in Table 3.

Table 3: Pesaran Panel Unit Root Test Results

		Variables	CADF		*Variables*	CADF
Level	*Constant*	RGDP	3.20567 (0.9993)	*First Differences*	RGDP	-5.18000*** (0.000)
		NE	0.15203 (0.5604)		NE	-5.51789*** (0.000)
	Constant + Trend	RGDP	-0.49604 (0.3099)		RGDP	-4.95863*** (0.000)

		NE -0.00680 (0.4973)		NE -4.72192*** (0.000)

The values shown in parentheses represent the probability value. *** , ** and * indicate the significance level of %1,%5, and %10, respectively.

According to Pesaran CADF unit root test results, while RGDP and NE variables are not stationary at level, it is observed that the variables are stationary at 1% significance level when first degree differences are taken. Therefore, econometric analysis will be continued by taking the first differences of these variables. Before proceeding to the panel data cointegration and causality analyzes to be carried out in the study, whether the slope coefficients have homogeneity for each unit is tested with the help of the delta test, which is introduced to the literature by Pesaran and Yamagata (2008).

Tablo 4: Delta Test Results

Test	Delta Test Statistics	p value
Δ	15.285	0.000
Δ_{adj}	16.516	0.000

The null hypothesis in the delta test, which was introduced to the literature by Pesaran and Yamagata (2008), is "The Slope Coefficients are Homogeneous". When the table showing the delta test result is examined, it is seen that the null hypothesis cannot be rejected. Therefore, it is concluded that the slope coefficients in the model created for this study are homogeneous.

Although there are permanent shocks that affect the system in econometric analysis, testing whether there is a long-term relationship between the variables will increase the strength of the test. For this purpose, Westerlund Panel Cointegration test is performed. This test is based on four statistics and therefore contains a flexible structure; This cointegration test is preferred in the study, since the error correction model has advantages such as permitting heterogeneity in long- and short-term parameters and resistive critical values resulting in self-extraction if there is correlation between units (Tatoğlu, 2012: 240). Table 5 shows the Westerlund Panel Cointegration Test results.

Table 5: Westerlund Panel Cointegration Test Results

Statistical	**Value**	**Z-Value**	**p- Value**

G_t	-3.812	-7.532	0.000
G_a	-16.351	-5.600	0.000
P_t	-13.834	-8.828	0.000
P_a	-21.676	-12.520	0.000

The lag length according to the Akaike information criterion is 1; the antecedent length (in the range of 0-1) is 0.09 as determined by the program.

According to G_t, G_a, P_t and P_a test statistic values, z values and probability values results in Table 3, H_0 hypothesis that there is no cointegration is rejected. Probability (p) values less than 0.05 indicate that there is a long-term cointegration relationship between Real Gross Domestic Product and Nuclear Energy Consumption variables. In the Westerlund panel cointegration test, Pt and Pa statistics should be taken into account if the panel is homogeneous. In addition, in Chang (2004), it is suggested to use resistive probability values in case of cross-section dependency. Therefore, in this study, it is necessary to look at the resistant probability values of the "Pt" and "Pa" statistics because the panel is homogeneous and the series have cross-sectional dependence.

As a result of Westerlund Panel Cointegration, long-term relationships between the relevant variables are detected, long-term and short-term relationships can be demonstrated by different methods in the literature. As mentioned earlier, the Pooled Mean Group Estimator (PMGE), Mean Group Estimator (MGE) and Dynamic Fixed Effects (DFE) methods can be used in both short term and long term parameter estimation. In the study, the estimation results of these methods will be included, and the final estimation method will be decided with the tests to be carried out for which one should be preferred. Table 6 gives the results of the Pooled Mean Group Estimator (PMGE).

Table 6: Pooled Mean Group Estimator Results

D.RGDP	Coefficient	Standard Error	z	p>IzI	[95% Confidence Interval]	
ec NE	0.2986275	0.1205924	2.47	0.013	0.06227	0.53498

SR ec	-0.1784912	0.0543061	-3.28	0.005	-0.04964	0.35152
NE D1.	0.0243715	0.0271847	0.89	0.370	-0.02890	0.07765
Constant Term	0.1536479	0.0096794	15.87	0.000	0.13467	0.17261

Log-likelihood value = 151.4888 is calculated by the program.

According to the results in Table 6, the error correction parameter was found to be -0.178. A long-term relationship between two variables can be said to be negative and statistically significant. This error correction parameter refers to the speed at which short-term deviations that occur if the series is not stationary come to equilibrium in the next period. According to this statement, approximately 18% of the imbalances formed in one period will be recovered in the next period and will be brought closer to equilibrium in the long term. In addition, the long-term parameter of nuclear energy consumption is found to be a positive value of 0.29 and is statistically significant at 5% significance level. However, the short-term parameter is found to be 0.02 and is statistically insignificant. Thus, according to the Pooled Mean Group Estimator method, nuclear energy consumption does not have a statistically significant relationship on economic performance in the short term. In the long run, a 1% increase in nuclear energy consumption leads to an increase of about 0.3% (0.298) on economic performance.

Another method that can be used to estimate short and long term relationships between nuclear energy consumption and economic performance is the Mean Group Estimator (MGE) method. The estimation results for this method are shown in Table 7.

Table 7: Mean Group Estimator Results

D.RGDP	Coefficient	Standard Error	z	p>IzI	[95% Confidence Interval]	
ec NE	0.2063145	0.3539581	0.58	0.560	-0.48743	0.90005
SR ec	-0.1031454	0.0653936	-1.57	0.115	-0.23131	0.02502

NE D1.	-0.0086361	0.0353788	-0.24	0.807	-0.07797	0.0607
Constant Term	0.1324688	0.0191305	6.92	0.000	0.09497	0.16996

When the results in Table 7 are examined, it is observed that the error correction parameter is negative (-0.103) but not statistically significant (p=0.115). This indicates that there is no long-term relationship between nuclear energy consumption and economic performance according to the Mean Group Estimator method. As to be noted, the short and long term parameters of the nuclear energy consumption variable are statistically insignificant.

Another method in the literature that can be used to determine short-and long-term relationships between nuclear energy consumption and economic performance is the Dynamic Fixed Effects Estimator (DFE) method. The forecast results for this method are also shown in Table 8.

Table 8: Dynamic Fixed Effects Estimator Results

D.RGDP	Coefficient	Standard Error	z	p>IzI	[95% Confidence Interval]	
ec NE	0.232194	0.0785642	2.95	0.034	0.18743	0.37425
SR ec	-0.028239	0.0166399	-1.70	0.090	-0.06085	0.00437
NE D1.	0.0721499	0.03288	2.19	0.028	0.00770	0.13659
Constant Term	0.1698702	0.0176328	9.63	0.000	0.13531	0.20442

According to the Dynamic Fixed Effects Estimator results in Table 8, error correction parameter is negative (-0.0282) and statistically significant at 10% significance level. This shows that there is a long-term relationship between nuclear energy consumption and economic performance variables. In the light of this information, approximately 2.8% of the imbalances that occur in one period will improve in the next period and will approach the long term balance. In addition, short and long term parameters of nuclear energy consumption are statistically significant and positive marked at 5% significance level. In the long term, 1% increase in nuclear energy consumption increases economic performance by 0.23%.

After the results of the Pooled Mean Group (PMG), Mean Group (MG) and Dynamic Fixed Effects (DFE) estimators are obtained, the Hausman test, which is often used in the relevant literature, will be applied to determine which estimator to choose. The Hausman test will allow selection between MG and PMG estimators and between MG and DFE estimators. When the long-term parameter in the Pooled Mean Group and Dynamic Fixed Effects estimator is homogeneous with constant or other expression for all countries; The Mean Group varies for all units in the estimator, meaning it is heterogeneous. Therefore, the results of the Hausman test applied to test long-term homogeneity are given in Table 9.

Table 9: Hausman Test Results

Estimators	Chi-Square Value	Probability (p) Value
MG, PMG	0.050	0.8267
MG, DFE	0.000	0.9922

When the Hausman Test results in Table 9 are examined, it is concluded that the H_0 hypothesis could not be rejected and the Pooled Mean Group Estimator is more effective in the test applied first between the MG and PMG estimators. In the Hausman test between MG and DFE estimators, the H_0 hypothesis is similarly adopted and it is found that the Dynamic Fixed Effects estimator is more effective than the Mean Group estimator. In other words, if probability values are greater than 0.05, PMG and DFE estimators should be used against the MG estimator. Thus, it is concluded that long term parameters do not change from unit to unit, that is, they are homogeneous.

In the econometric analysis, the results obtained by the Pooled Mean Group estimator and Dynamic Fixed Effects estimator can be used. In the study, the Pooled Mean Group Estimator, whose error correction parameter is statistically significant at 1% significance level and the predictive results can be obtained on the basis of units, will be prioritized. The results of the Pooled Mean Group Estimator for the countries are given in Table 10.

Table 10: Pooled Mean Group Estimator Results for Countries

D.RGDP	Coefficient	Standard Error	z	p>IzI	[95% Confidence Interval]	
ec NE	0.2986275	0.120592	2.48	0.013	0.06227	0.534984
USA ec	-0.1233472	0.040345	3.05	0.011	-0.28242	0.075727
NE D1.	0.1125677	0.074946	1.50	0.133	-0.03432	0.259460
Constant Term	-3.424104	1.35383	-2.53	0.011	-6.0775	-0.77062
UK ec	-0.127799	0.053998	-2.37	0.018	-0.23363	-0.02196
NE D1.	0.0329399	0.02507	1.31	0.189	0.08202	0.016212
Constant Term	0.1618334	0.029368	5.51	0.000	0.104272	0.219394
Germany ec	-0.4906323	0.296467	-1.65	0.098	-1.07169	0.090433
NE D1.	-0.0004729	0.199359	-0.00	0.998	-0.39121	0.390264
Constant Term	0.1754902	0.064308	2.73	0.006	0.049448	0.30153

Japan ec	-0.0099106	0.073763	-0.13	0.893	-0.15448	0.134663
NE D1.	-0.0643139	0.229175	-0.28	0.779	-0.51349	0.384862
Constant Term	0.1475682	0.088347	1.67	0.095	-0.02559	0.320726
Canada ec	-0.3619517	0.213550	-1.69	0.090	-0.78050	0.056599
NE D1.	0.0663307	0.044801	1.48	0.139	-0.02147	0.15414
Constant Term	0.1662114	0.023666	7.02	0.00	0.119826	0.21259
Russia ec	-0.051310	0.015670	-3.27	0.001	-0.08202	-0.02059
NE D1.	0.078239	0.199719	0.39	0.695	-0.31320	0.46968
Constant Term	0.1092108	0.050959	2.14	0.032	0.009331	0.20909
S.Korea ec	-0.1737212	0.051217	-3.39	0.001	-0.27410	-0.07333
NE D1.	0.0359338	0.06797	0.53	0.597	0.169153	0.097285

Constant Term	0.1582614	0.021998	7.19	0.000	0.115145	0.201377
China ec	0.1039267	0.016832	6.17	0.000	0.070935	0.136918
NE D1.	0.061992	0.056487	1.10	0.272	0.172706	0.048722
Constant Term	0.1757431	0.011777	14.9	0.000	0.152658	0.198827
Ukraine ec	-0.1915563	0.094934	-2.02	0.044	-0.37762	-0.00548
NE D1.	0.1735821	0.10327	1.68	0.093	-0.02882	0.375991
Constant Term	-4.619845	1.199999	3.85	0.000	-6.97180	-2.26789
France ec	-0.0872915	0.035287	-2.47	0.013	-1.56452	-0.18130
NE D1.	0.0829243	0.058156	1.42	0.217	-0.01442	0.180277
Constant Term	0.1725589	0.030471	5.66	0.000	0.112836	0.232281
India ec	0.101286	0.019492	5.20	0.000	0.063081	0.139490

NE D1.	0.0449549	0.028367	1.58	0.113	-0.01064	0.100553
Constant Term	0.1647876	0.008764	18.8	0.000	0.147609	0.181965

As shown in Table 10, a single long term parameter is estimated. This parameter value is calculated as 0.298. However, error correction parameters, short-term parameters and constant parameters vary by country. According to the results obtained, even if the error correction parameter is negative only in Japan, it is not statistically significant. In other words, there is no significant long-term relationship between nuclear energy consumption and economic performance in this country. By contrast, Russia, South Korea, China and India are at 1% significance level; Error correction parameters in the USA, Great Britain, France and Ukraine at 5% significance level and in Canada and Germany at 10% significance level are significant and negative. Therefore, there is a long-term relationship between nuclear energy consumption and economic performance variables in these countries. When the short-term parameters of these countries are analyzed, the parameters of the countries other than Ukraine are statistically insignificant. In Ukraine, the short term parameter is statistically significant at the 10% significance level. This can be attributed to the relatively low level of development of the country compared to other countries and to its shrinking economy as a result of the recent political and economic crises. In general, it is possible to conclude that nuclear energy consumption is not effective in the short term on economic performance in the countries involved in the analysis and which consume the most nuclear energy in the world. Also in Germany, Canada, France and South Korea, the error correction parameter is relatively high compared to other countries. In these countries, the rate of short-term deviations approaching long-term equilibrium is higher than in other countries. If the findings regarding the short-and long-term relations between the relevant variables are examined and policy decision makers apply policies in the light of this information, it will be expected that economic efficiency will be achieved and thus economic performance will be positively affected. In the final phase of the analysis section, the PairWise Dumitrescu Hurlin panel causality test is applied to look at whether there is a causality relationship for the countries generally covered in the relevant variables. Table 11 below shows the results of the Pairwise Dumitrescu Hurlin Panel Causality test.

Table 11: Pairwise Dumitrescu Hurlin Panel Causality Test Results

Zero Hypotheses:	W-Stat.	Zbar-statistic	Prob. Value (p)
NE does not homogeneously cause RGDP	4.91631	3.09140	0.0020
RGDP does not homogeneously cause NE	4.99484	3.18550	0.0014

When the causality results in Table 11 are analyzed, a bidirectional Granger causality relationship is determined between nuclear energy consumption and real gross domestic product, which is the proxies of economic growth, in 11 countries, which are considered at 1% significance level. This finding shows that the Feedback Hypothesis in the literature is valid for the countries included in the analysis.

5.Conclusion

Energy is among the most basic elements used to help fulfill vital needs for human beings, as well as increasing the level of production and welfare since the first person. Today, energy is kept at the center of the socio-economic development and economic performance indicators of countries. When we look at the usage process of energy in the production structure, it is seen that traditionally, in other words, fossil energy sources are used. However, with the increase in the economy and welfare level observed in the countries over time, the emergence of renewable energy sources caused traditional energy sources to be replaced by alternative energy sources. The spread of industrialization and mechanization and the acceleration of the urbanization process further increased the demand for energy. Countries that have oil reserves with the oil crisis that took place in the 1970s, imposed an embargo against the countries that supply oil and negatively affected the economies and social lives of the countries. In order to get rid of this crisis environment and to reduce foreign dependency on energy, research and development studies have been carried out in search of alternative energy sources and new energy sources have been used. Considering the diversity of energy sources, it is seen that the cost factor as well as environmental effects are an important factor in energy selection. Compared to alternative energy sources, nuclear energy, which is described as new and generally used in electricity generation, provides more energy in terms of volume and unit compared to other energy sources. Nuclear energy has been seen as an alternative energy source against the problems after the oil crisis. Even though doubts about the use of nuclear energy have started to occur with nuclear accidents in the history of nuclear energy, it is one of the top energy sources preferred by developed countries, as security levels are increased with international treaties and tracking systems.

The aim of this study is to explain the relationship between nuclear energy and economic performance with the help of panel data analysis, and to propose policy-making appropriate and environmentally friendly policies for sustainable development in order to be successful in economic growth targets. For this purpose, annual data of 11 countries (Germany, United States, China, France, India, Japan, United Kingdom, Canada, South Korea, Russia, Ukraine), which consumed nuclear energy for the period 1997-2017 are included in the analysis. . In order to obtain reliable results, firstly, the null hypothesis is rejected by looking at horizontal cross-section dependency and homogeneity. Pesaran CADF unit root test, which is the second generation unit root test, was used since it was determined that there is a horizontal cross-section dependency between the units. As a result of the unit root test, it is observed that the variables included in the analysis are not stationary at the level, but were stationary when the first degree differences are taken. As a result of the Westerlund Panel Cointegration Test conducted to test whether there is a long-term relationship between real gross domestic product, which is the indicator of nuclear energy consumption and economic performance, the existence of a long-term relationship between the variables is determined. As a result of Westerlund Panel Cointegration test, there is a long-term relationship between the variables, and the short and long-term relationships have been tested by the Pooled Mean Group Estimator (PMGE), Mean Group Estimator (MGE) and Dynamic Fixed Effects (DFE) methods that are generally preferred in the literature. After obtaining the results of these methods, Hausman Test, which is frequently used in the related literature, is applied for which estimator to choose and it is concluded that PMG and DFE estimators should be used. In the study, the Pooled Mean Group Estimator, whose error correction parameter is statistically significant at 1% significance level and the predictive results can be obtained on the basis of units, is prioritized. According to the results of this estimator, no significant long-term relationship has been found between nuclear energy consumption and economic performance in Japan. This unavailable relationship may be related to the fact that after the Fukushima Daiichi nuclear disaster in 2011, they turned to renewable energy sources and wanted to shut down their nuclear power plants in recent years. On the other hand, Russia, South Korea, China and India have 1% significance level; Error correction parameters were significant and negative at 5% significance level in USA, Great Britain, France and Ukraine and 10% significance level in Canada and Germany. In other words, there is a long-term relationship between nuclear energy consumption and economic performance variables in these countries. Looking at the short-term parameters of these countries, the parameters of other countries outside of Ukraine are statistically insignificant. In Ukraine, the short term parameter is statistically significant at the 10% significance level. This can be attributed to the relatively low level of development of the country relative to other countries and to its economy, which has shrunk as a result of the recent political and economic crises.

In general, it can be concluded that nuclear energy consumption is not effective on economic performance in the short term, but there is a positive relationship between these two variables in the long term. In addition, the error correction parameter in Germany, Canada, France and South Korea is relatively high compared to other countries. The rate of deviations occurring in the short term in these countries to approach the long-term balance is higher than in other countries. If the findings obtained for the short and long term relations between the relevant variables of the countries are examined and economic policy makers apply policies in the light of this information, it will be expected that economic efficiency will be effected and thus economic performance will be affected positively. Increasing the number of empirical studies will contribute to the relevant literature by taking into account the analysis of non-linear econometric methods, expanding the field of application, increasing the number of variables and observations included in the analysis.

References

Apergis, N. & Payne, J. E. (2010). A Panel Study of Nuclear Energy Consumption and Economic Growth. Energy Economics, 32, pp. 545-549.

Apergis, N., Payne J. E., Menyah K. & Yemane, W., R. (2010). On The Causal Dynamics Between Emissions, Nuclear Energy, Renewable Energy And Economic Growth. Ecological Economics, 69, pp. 2255-2260.

Aslan, A. & Çam, Seçil. (2013). Alternative and Nuclear ConsumptionEconomic Growth Nexus for Israel: Evidence Based on Bootstrap-Corrected Causality Tests. Progress in Nuclear Energy, 62, pp. 50-53.

Chang, Y. (2004). Bootstrap Unit Root Tests in Panels with Cross Sectional Dependency, Journal of Econometrics, 120(2), 263-293.

Chang, T. & Gatwabuyege, F., Gupta,R., Inglesi-Lotz,R., Manjezi, N.C., Simo-Kengne, B.D. (2014). Causal Relationship Between Nuclear Energy Consumption and Economic Growth in G6 Countries: Evidence From Panel Granger Causality Tests. Progress in Nuclear Energy, 46, pp. 187-193.

Chu, H. P. & Chang, T. (2012). Nuclear Energy Consumption, Oil Consumption and Economic Growth in G-6 Countries: Bootstrap Panel Causality Test, Energy Policy, 48,762-769.

Chudik, A. & Pesaran, M. H. (2013). Large panel data models with cross-sectional dependence: a survey. CAFE Research Paper, (13.15).

Erden, B. (1990). Çağımız ve Çevre Kirliliği. Ankara: Kadıoğlu Publishing.

Ferguson, C. D. (2015). Nükleer Enerji Herkesin Bilmesi Gerekenler. Ankara: Ankamat Publishing.

Gülbahar, N. & Kılınç, M.Y. (2011). Enerji Güvenliği ve Türkiye. In 6. International Advanced Technologies Symposium (IATS'11), pp. 16-18.

Heo, J.-Y., Yoo, S.-H. & Kwak S.J. (2011). The Causal Relationship Between Nuclear Energy Consumption and Economic Growth İn India. Energy Sources, pp.111-117.

Kızıltan, O. (2010). Nükleer Enerjinin Türkiye'de Enerji İhtiyacını Karşılamadaki Rolü. *Unpublished Master Thesis.* Istanbul: Istanbul University Institute of Social Sciences, Department of Economics.

Lee C. C. & Chiu, Y. B. (2011a). Nuclear energy consumption, oil prices, and economic growth: Evidence from highly industrialized countries. Energy Economics, 33(2), pp. 236-248.

Lee C. C. & Chiu, Y.B. (2011b). Oil Prices, Nuclear Energy Consumption and Economic Growth: New Evidence Using a Heterogeneous Panel Analysis. Energy Policy, 39(4), pp. 2111-2120.

Luqman, M., Ahmad, N. & Bakhsh, K. (2019). Nuclear Energy, Renewable Energy And Economic Growth in Pakistan: Evidence from Non-Linear Autoregressive Distributed Lag Model. Renewable energy, 139, pp.1299-1309.

Mbarek, M. B., Khairallah, R. & Feki R. (2015). Causality Relationships Between Renewable Energy, Nuclear Energy And Economic Growth in France. Environment Systems and Decisions, 35(1), pp.133-142.

Mbarek, M.B., Nasreen, S. & Feki, R. (2017). The Contribution of Nuclear Energy To Economic Growth in France: Short and Long Run, Quality and Quality, 51: pp. 219-238.

Menyah, K. & Wolde-Rufael, Y. (2010). Co2 Emissions, Nuclear Energy Renewable Energy and Economic Growth in The US. Energy Policy, 38(6), pp. 2911-2915.

Moralı, D. (2004). Radyoaktif Kapitalizm-Nükleer *Santrallere Marksist Tutum.* İstanbul: Tarih Bilinci Publishing.

ISSN: 2147-1185

Nazlıoğlu, S., Lebe F. & Kayhan S. (2011), Nuclear Energy Consumption And Economic Growth in OECD Countries: CrossSectionally Depend Heterogeneous Panel Causality Analysis.

Omri A., Chaibi A., (2014). Nuclear Energy, Renewable Energy, And Economic Growth in Developed And Developing Countries: A Modelling Analysis From Simultaneous-Equation Models, No 2014-188, Working Papers, Department of Research, Ipag Business School.

Omri, A., Mabrouk, N. B. & Tmar A. S. (2015). Modeling The Causal Linkages Between Nuclear Energy, Renewable Energy And Economic Growth in Developed And Developing Countries. Renewable and Sustainable Energy Reviews, 42,pp.1012-1022.

Ozcan, B. & Ari, A. (2016). Nuclear Energy-Economic Growth Nexus in OECD Countries A Panel Data Analysis. Atw Internationale Zeitschrift fuer Kernenergie, 61(1), pp.13-21.

Ozden, N. (1983). Nükleer Çağın İlk 40 Yılı. İstanbul: Nuclear Energy Institute Publications.

Oztürk, I., Acaravcı, A. (2011). Electricity Consumption and Real GDP Causality Nexus: Evidence From Ardl Bounds Testing Approach For 11 Mena Countries. *Applied Energy*, pp.2885-2892.

Pesaran, M. H. (2004). General Diagnostic Tests for Cross Section Dependence in Panels. Cambridge Working Papers in Economics, 435.

Pesaran, M. H. & Yamagata, T. (2008). Testing Slope Homogeneity in Large Panels, Journal of Econometrics, 142(1), 50-93.

Saidi, K. & Mbarek M. B. (2016). Nuclear Energy, Renewable Energy, CO_2 Emissions, and Economic Growth for Nine Developed Countries: Evidence From Panel Granger Causality Tests. Progress in Nuclear Energy, 88, pp. 364-374.

Seyidoğlu, H. (2006). İktisat Biliminin Temelleri. Güzem Can Publishing.

Şimşek, T. & Aydın, H. İ. (2018). Gelişmiş Ülkelerde Nükleer Enerji Tüketimi Ve Ekonomik Büyüme İlişkisi Üzerine Panel Veri Analizi, Suleyman Demirel University Journal of Faculty Of Economics and Administrative Sciences, 23.

Şimşek, T. & Yiğit, E. (2017). BRICT Ülkelerinde Yenilenebilir Enerji Tüketimi, Petrol Fiyatları, CO_2 Emisyonu, Kentleşme ve Ekonomik Büyüme Üzerine Nedensellik Analizi. Eskişehir Osmangazi Üniversitesi İktisadi ve İdari Bilimler Dergisi, 12(3), 117-136.

TAEK. (2005) Türkiye Atom Enerjisi Kurumu. Retrieved from http://www.taek.gov.tr/tr/2016-06-09-00-43-55/135-gunumuzde-nuk leer-enerji-rapor/832-bolum-08-uluslararasinukle erduzenlemeler-ve-nukleer-silahlarin-yayilmasinin-onlenmesi.html Access Date: December 2018.

Tatoğlu, F. Y. (2012). Panel veri ekonometrisi. Beta Publisher.

Tuğrul, A. B. (2006). Türkiye'nin Nükleer Enerji Seçeneği. Sürdürülebilir Kalkınma için Nükleer Enerji, pp. 28-40. İstanbul: Tasam Publisher.

Turan, T. (2008). İktisadi Büyüme Teorisine Giriş. İstanbul: Yalın Publisher.

Yıldırım, M. & Örnek, İ. (2007). Enerjide Son Seçim: Nükleer Enerji. Gaziantep University Journal of Social Sciences, pp. 32-44.

Wolde-Rufael, Y. (2010). Bounds Test Approach to Cointegration and Causality Between Nuclear Energy Consumption and Economic Growth in India. Energy Policy, 38(1), pp. 52-58.

Wolde-Rufael, Y. (2012). Nuclear Energy Consumption and Economic Growth in Taiwan. Energy sources, 7(1), pp. 21-27.

Wolde-Rufael, Y. & Menyah, K. (2010). Nuclear Energy Consumption and Economic Growth in Nine Developed Countries. Energy Economics, 32(3), pp.550-556.