

4. THE ENERGY CONSUMPTION AND ECONOMIC GROWTH IN THE E7 COUNTRIES: COINTEGRATION IN PANEL DATA WITH STRUCTURAL BREAKS

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Abstract

Nowadays, the energy factor has become one of the most basic inputs for production. Especially the technological developments, the increase in the product range, the development of international trade and population growth have boosted the demand for energy to a great extent. The relationship between energy and economic growth is an important indicator for the direction of economic policies. In this context, this paper aims at examining the relationship between total energy consumption and economic growth in the E7 countries (Brazil, China, Indonesia, India, Mexico, Russia and Turkey) by using data for the 1990-2016 period. The results of the cointegration analysis with structural breaks suggest that the series move together in the long term. As a result of the analysis, a 1% increase in energy consumption leads to 0.123% increase in economic growth, based on the overall figures of the panel.

Keywords: energy, economic growth, panel cointegration, E7 countries

JEL Classification: F43, N70

1. Introduction

Energy is a significant element of daily life and it is a compulsory input for manufacturing and necessary for the development of the countries. In this regard, energy is found in the literature as one of the cornerstones of economic development (Ghosh, 2002: 125). With the changing and evolving conditions due to globalization, the economic implications of energy consumption have attracted the attention of all countries (Mucuk and Uysal, 2009: 107). The relationship between energy consumption and economic growth has become the primary focus point of economics and policy analysts (Kraft and Kraft, 1978; Yu and Choi, 1985; Cheng and Lai, 1997; Yang, 2000; Ghosh, 2002). Economic growth especially is one of the most important factors affecting the changes proposed in energy consumption earlier. Although many studies were conducted about the relationship between energy consumption

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and economic growth, a definitive conclusion about this relationship is still under question. The direction of causality is very important to policy makers. For instance, if the causality is from energy consumption to economic growth, policies to reduce energy consumption may affect economic growth negatively (Belke *et al.*, 2011: 782). However, the opposite situation could result in no impact of energy consumption on income.

Energy plays a critical role in economic growth for both developed and developing countries. In this sense, energy is regarded as one of the most prominent component of economic growth and it potentially affects all the economies (Dritsaki and Dritsaki, 2014: 309). Energy is not the only input leading to economic growth, but it is an extremely important input for it. Energy plays an important role both on the supply and the demand side of the economy. In terms of demand, energy maximizes the benefits of consumers, and in terms of supply, it is involved in production as a key factor as well as labor, capital and raw material. For these reasons, energy plays an important role in ensuring the social development and economic growth of the countries and improving the standards of living (Chontanawat *et al.*, 2006:1).

Increased infrastructure investments with industrialization bring high and continuous energy consumption. However, with the help of technological developments, efficiency and energy conservation occurs in the new investments. In addition, with the increase in energy prices as a public choice and restricting environmental factors, more efficient use of energy is supported. The shift in the form of production from industry to information-intensive sectors changes energy consumption. The increase in service activities and the shift to production of high-quality goods are considered as a factor that reduces energy intensity (Galli, 1998).

The relationship between energy and economic growth revives the existence of two basic ideas, which take place at the two extremes in the literature. In terms of economic growth, biophysical economics, which regards labor and capital production as secondary factors and considers energy as the main factor affecting growth, bases this view on three fundamental laws of thermodynamics. According to the biophysical approach, which sees the economy as a thermodynamic subsystem, the effect of energy on economic growth is very obvious (Cleveland *et al.*, 1984:890-895). In the study of Odum and Odum (1976), which is an important study in this context, the source of economic growth and economic relations were discussed with biophysical approach. In this study for the US economy, it was determined that there is a strong correlation between energy use and gross national product.

At the other extreme of this view, there is the neoclassical growth theory. Neo-classical growth theory is briefly based on the assumptions that in the stationary state, the growth rate is extrinsic, and the savings have no effect on this rate; that in the absence of technological development, the population growth rate determines the rate of input growth; and that the only element that may lead to an increase in the growth rate is technological development (Dornbusch and Fischer 1984:269-272). Energy, on the other hand, is regarded as an element that allows the use of technology in practice. But high-tech investments are also needed to make energy available by converting it. Countries make such investments not only to generate energy, but also to provide energy efficiency. As a result, the energy factor, which is available at low cost and can be used efficiently in the production process, will increase the level of national output over the technology. In contrast with these assumptions of neoclassical growth theory, internal growth models showed that energy can be one of the most effective factors in the economy with the public spendings (Barro, 1988), human capital, and as well as the contributions of neoclassical economists such as Hamilton (1983) and Burbridge and Harisson (1984) (Gbadebo ve Okonkwo, 2009: 48).

According to neoclassical economists such as Hamilton (1983), Burbridge and Harrison (1984), energy can play a major role in the economy. Capital (K), labor (L) and energy (E)

can be defined as separate inputs in the context of single-sector neoclassical production technology, assuming that the amount of energy used in the industry increases, the output and, thus, the GNP also increases. Therefore, the production function can be written as below (Ghali and Sakka, 2004:228):

$$Q=f(K,L,E) \quad (1)$$

In this regard, when economic growth is concerned, the relationship between the three basic production factors involved in the above production function gains importance. In a positive relationship between energy and economic growth, implementations for reducing energy consumption may adversely affect economic growth. Similar results can be valid in terms of capital and labor force. Another important point in directing economic policies is the relationship between the factors of production. At this point, in addition to differences among industries, it is generally expected to find complementarity between energy use and capital, and substitution relation between labor and capital (Stern and Cleveland, 2004: 20). The point to be taken into consideration here is that the relations between the factors of production can change in parallel with the structural characteristics of the countries. However, in the countries studied, especially the existence of the informal economy may cause the relationship between the variables to be out of expectation.

The purpose of this study is to analyze the effect levels of energy consumption and economic growth relationship with panel data analysis covering the period between 1990 and 2016 in the E7 countries sample (Brazil, China, Indonesia, India, Mexico, Russia and Turkey). The fundamental reasons of why this period was selected and why these countries were involved in the study are that data for some of these countries in 1980s are not available, and that the E7 countries showed great developments over the last two decades and they became one of the most powerful economies in the world. The gap between the E7 countries and the G7 countries (US, Japan, Germany, Great Britain, Italy, France, and Canada) is closing by each passing day. In a report filed by the international consulting company Pricewaterhouse-Cooper (PwC), it was underlined that the economic growth of the E7 countries might overtake the economically-developed and industrialized G7 countries by 75% by 2020 (PwC, 2010). Additionally, Pricewaterhouse-Cooper (PwC) claims that the majority of global economy has gathered in China, India and the other developing economies. China and India stand out by their innovative actions and this constitutes the driving force for growth in other E7 countries. Especially, the growth performance of China is basically rooted in technological advances, innovation, and energy (Göçer, 2013: 122).

In literature, no empirical study conducted about the aforementioned countries and the period was found. Therefore, this study is expected to contribute to the literature as it involves contemporary issues of the economics, and the second section reviews the studies conducted before in literature. In the third section, information regarding data and data resources are given and panel cointegration results are discussed. In the last section, policy proposals and the results are provided.

2. Literature Review

Since the late 1970s, developed countries revealed the fact that material welfare based on the intensive use of natural resources is threatened by the energy crisis (1973-79 oil crisis). This awareness triggered many scholars who studied the relationship between energy consumption and economic growth (Esseghir and Khouni, 2014:218). The relationship between energy consumption and economic growth is significant in empirical, theoretical,

and political terms (Odhiambo, 2009: 618). Energy is a must for the continuation of economic growth. Moreover, it is a striking fact that the energy demand of the countries with higher income per person is more than that of the other countries. On this issue, the study conducted by Kraft and Kraft (1978) for the period between 1947 and 1974 in the US sample revealed that it was unidirectional causality from energy consumption to economic growth. In this regard, the relationship between energy consumption and economic growth was the topic of many theoretical and empirical studies.

There are two different arguments on the relationship between energy and growth in the literature. According to the pro-energy approach, the effect of energy on economic growth is obvious and energy is the main input factor, such as labor and capital. In other words, energy is one of the most effective factors in economic growth. However, the neoclassical approach argues that the effect of energy consumption on economic growth is not significant. Since energy costs constitute only a little part of GDP, the effect of energy on economic growth will also be little (Aytaç, 2010: 483; Bulut vd. 2014:4).

In the literature, some of the studies on the relationship between energy consumption and economic growth (Cheng and Lai, 1997; Ghali and El-Sakka, 2004; Haipen, 2005; Narayan and Smith, 2008; Apergis and Payne, 2009b; Oztürk *et al.*, 2010; Apergis and Danuletiu, 2012) have found that there is a unidirectional causality from energy consumption to economic growth. Moreover, they have found that in the long term there is a cointegration between energy consumption and economic growth. There are also some studies which claim that there is a bidirectional causality and cointegration relationship between energy consumption and economic growth (Asufu-Adjaye, 2000; Apergis and Payne, 2009a; Kaplan *et al.*, 2011; Esseghir and Khouni, 2014; Naser, 2015).

In a study by Yemane (2004), the relationship between per capita electricity consumption and GDP was examined in seventeen African countries for the period 1971-2001. In nine countries, a long-term relationship between variables; in six countries, a unidirectional causality from per capita GDP to per capita electricity consumption; and in three countries, the existence of a reverse directional causality has been detected. Soytaş and Sarı (2006) used Granger causality and vector error correction model (VECM) for the G7 countries using data for the 1960-2004 period. It was found that it was bidirectional causality from energy consumption to economic growth in Canada, Italy, England and Japan. In France and USA, there is causality from energy consumption to economic growth. Moreover, the direction of the causality is from economic growth to energy consumption in Germany. They have found that energy consumption strongly influences economic growth.

Jobert and Karanfil (2007) conducted Cointegration and Granger Causality tests for the relationship between energy consumption and economic growth in Turkey between 1960 and 2003. They have not identified a relationship between energy consumption and growth. A study analyzing the relationship between capital formation, energy consumption and economic growth in the G7 countries for the 1972-2002 period was carried out by Narayan and Smyth (2008). In the study, panel cointegration and long-term structural break estimation methods were used. The results of the study have uncovered that it was cointegration between fixed capital investments, energy consumption and economic growth. In addition, fixed capital investments and energy consumption positively affects economic growth on long term. While 1% increase in fixed capital investments increases economic growth by 0.1-0.28%, 1% increase in energy consumption increases economic growth by 0.12-0.39%.

Shahbaz *et al.* (2013) researched the relationship of financial development, energy consumption and economic growth in Lebanon for the period 1993M1-2010M12. It has been

concluded that it was a cointegrated relationship between the variables, and that financial development and energy consumption contributed to the economic growth of the sample country. Also, energy consumption positively affects economic growth, and financial development has a key role in terms of economic growth.

3. Empirical Analysis

3.1. Data Set

The E7 countries, which constitute the study sample of this paper, are among the most promising economies in the last two decades. Data for the period between 1990 and 2016 about energy consumption and economic growth were used. Oil, gas, coal and hydropower energy data was calculated up to provide total energy consumption and this data was obtained from the BP world energy statistics database. On the other hand, economic growth data was taken from Penn World Table (Version 8.1) database. In the study, energy consumption and economic growth are denoted as ENERGY and GDP (Gross Domestic Product), respectively.

3.2. Testing Horizontal Cross-sectional Dependence

It is obvious while conducting panel data analysis that if there is horizontal cross-sectional dependence between the series the analysis results are not regarded as coherent (Breusch and Pagan, 1980; Pesaran, 2004). Therefore, it is essential to test whether there is cross-sectional dependence before engaging in the analysis in a study. Based on the analysis results, first or second generation panel unit root tests and cointegration analysis are conducted.

Horizontal cross-sectional dependence between the series was analyzed by CD tests developed by Pesaran (2004). Pesaran (2004) CD test can only be used with the cases in which cross-section is larger than time and time is larger than cross-section ($N > T$, $T > N$). CD test is deviant when the national average is different from zero but panel average is zero. The LM test proposed by Pesaran, Ullah, and Yamagata (2008) adds variance and average to test statistics to eliminate this deviation, and it improves the equation. The LM test is as follows:

$$CDLM1 = T \sum_{i=1}^{N-1} \sum_{j=i+1}^N \rho_{ij}^2 \sim X^2 \frac{N(N-1)}{2} \quad (2)$$

It was improved to the following equation later on:

$$LM_{adj} = \left(\frac{2}{N(N-1)} \right)^{1/2} \sum_{i=1}^{N-1} \sum_{j=i+1}^N \rho_{ij}^2 \frac{(T-K-1) \mu_{Tij}^2 - \mu_{Tij}}{v_{Tij}} \sim N(0,1) \quad (3)$$

In this equation, μ_{Tij} represents average, while v_{Tij} stands for variance.

The test statistics obtained from the equation show the standard normal distribution asymptotically (Pesaran *et al.*, 2008).

Hypothesis:

H_0 = no cross-sectional dependence

H_1 = there is cross-sectional dependence

According to the test results, as the probability value is smaller than 0.05, H_0 hypothesis was rejected for 5% significance level and it was concluded that there was cross-sectional dependence between the units forming the panel (Pesaran *et al.*, 2008).

In this study, cross-sectional dependence of the series and co-integration equation was tested by Gauss codes and LM_{adj} tests separately, and the results are given in Table 1.

Table 1

Testing Horizontal Cross-sectional Dependence

Variable	Energy	GDP	Cointegration Equation
Tests	Test statistics and p-value		
LM (Breusch and Pagan, 1980)	43.353(0.003)	45.574(0.001)	128.520(0.000)
CDLM1 (Pesaran, 2004)	3.449(0.000)	3.792(0.000)	16.591(0.000)
CDLM (Pesaran, 2004)	-3.190(0.001)	-2.579(0.005)	0.998(0.159)
LM_{adj} (Pesaran <i>et al.</i> , 2008)	3.345(0,000)	1.340(0.090)	14.517(0.000)

Based on the figures in the table, as the results of the co-integration variables and equations are lower than 0.05, the H_0 hypothesis was rejected and it was concluded that it was cross-sectional dependence in the series and co-integration equation. This means that shocks experienced in one of the countries' total energy consumption and economic growth have an impact on the others. Moreover, after determining that it was cross-sectional dependence, it was decided that it was necessary to conduct second generation panel unit root and co-integration analysis on the series. While identifying the co-integration relationship between the series, it is obligatory to use co-integration analysis that regards cross-sectional dependence. Hence, second generation panel unit root tests and panel co-integration analysis are conducted in the rest of this paper.

3.3. Panel Unit Root Analysis

The most significant factor to consider while conducting panel unit root analysis is to check whether horizontal cross-sections forming the panel are independent of one another.

First-generation panel unit root tests are based on the fact that each of the horizontal section units that form panel data analysis are independent of each other and a shock experienced in one of the countries that are involved in the panel has an equal impact on all cross-sections. Considering that world countries cannot be independent of each other in the global world, a shock initiated in each of the horizontal section units can most probably result in different levels of effects on different units. To eliminate this problem, second-generation panel unit root tests were developed to end the dependence of horizontal section units.

As horizontal cross-sectional dependence was identified among the countries that are in the panel test for the variables of this study, CADF test of Pesaran (2007) of second-generation panel unit root tests was used. The CADF test displays test results of the overall figures in the panel while testing each country in the panel. One of the features of the CADF test is that it may be used under conditions of $T > N$ and $T < N$. The results were compared with Pesaran's (2007) CADF critical table values and the existence of unit root is decided. The hypothesis of the unit root test is established as follows:

$$Y_{i,t} = (1 - \phi_i)\mu_i + \phi_i Y_{i,t-1} + u_{i,t} \quad i = 1, 2, \dots, N \text{ ve } t = 1, 2, \dots, T \quad (4)$$

$$u_{i,t} = \gamma_i f_t + \varepsilon_{i,t} \quad (5)$$

f_t stands for unobservable common effects of each country in the panel, $\varepsilon_{i,t}$ while expresses the error term of each country. The unit root hypothesis can be written as follows:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \gamma_i f_t + \varepsilon_{it} \quad i = 1, 2, \dots, N \text{ and } t = 1, 2, \dots, T$$

$H_0: \beta_i = 0$ for all i (Series Not Stationary)

$H_0: \beta_i < 0, i = 1, 2, \dots, N_1, \beta_i = 0 i = N_1 + 1, N_2 + 2, \dots, N.$ (Series Stationary)

Additionally, the average of the countries of unit root test statistics was calculated and Cross-Sectionally Augmented IPS (CIPS) of unit root test statistics for the whole panel is found (Pesaran, 2007). CIPS statistics:

$$CIPS = N^{-1} \sum_{i=1}^N CADF_i \quad (6)$$

Unit roots of each country in the panel data analysis (CADF), the overall of panel (CIPS), and critical values developed by Pesaran (2007) are found in Table 2.

Table 2

Panel Unit Root Test

Countries	Variables	Test Statistics			
		Energy	ΔEnergy	GDP	ΔGDP
Brazil		-2.1586	-2.1134	-1.5193	-3.5110**
China		-1.7179	-1.4218	-1.7875	-2.9962***
Indonesia		-4.5820*	-4.0955**	-2.5571	-3.6161**
India		0.4667	-0.2673	-3.3271***	-3.2317**
Mexico		-0.8538	-3.7566**	-4.2040*	-4.1658*
Russia		-0.6083	-2.0161	-2.5289	-4.3728*
Turkey		-2.5343	-3.7893*	-2.6331	-3.6666**
Panel (CIPS)		-1.7129	-2.4943**	-2.6510*	-3.6515*

Note: * expresses the stationary of significance level of the series. * shows that the series are stationary in 1% significance level, ** shows that they are stationary in 5% significance level, and *** shows that they are stationary in 10% significance level. Only intercept critical values for the countries are 1% -4.11; 5% -3.36, 10% -2.97, while they are 1% -2.57; 5% -2.33; 10% -2.21 for the overall of panel. Δ shows that the difference of variables were subtracted. A fixed model was used as a test model.

According to Pesaran's (2007) CADF unit roots test analysis that was conducted to check for stationary status of the series in the study, it was concluded that energy and GDP series are stationary in level, while they were stationary in 1% significance level when they were applied the first difference.

3.4. Testing the Homogeneity of Cointegration Coefficients

Homogeneity test is useful for testing the homogeneity of slope coefficient of co-integration equation. The study conducted by Swamy (1970) was improved by Pesaran and Yamagata (2008).

$$Y_{it} = \alpha + \beta_i X_{it} + \varepsilon_{it} \quad (7)$$

The equation above is a co-integration equation, and β_i tests if there is difference between horizontal cross-sections of the slope coefficient. Hypotheses of the homogeneity test are as follows:

$$H_0: \beta_i = \beta \quad \text{Slope coefficients are homogeneous.}$$

$$H_0: \beta_i \neq \beta \quad \text{Slope coefficients are not homogeneous}$$

Pesaran and Yamagata (2008) created two different test statistics to test these hypotheses:

$$\text{For Large Samples: } \hat{\Delta} = \sqrt{N} \left(\frac{N^{-1}\bar{S}-k}{2k} \right) \sim X_k^2$$

$$\text{For Small Samples: } \hat{\Delta}_{adj} = \sqrt{N} \left(\frac{N^{-1}\bar{S}-k}{v(T,k)} \right) \sim N(0,1)$$

In the equation above, N stands for the number of horizontal cross-sections, S expresses Swamy test statistics, k explains the number of explanatory variables, and $v(T, k)$ stands for standard error.

Table 3

Homogeneity Test Results

	Test Statistics	Probability Value
$\hat{\Delta}$	14.922	0.000
$\hat{\Delta}_{adj}$	15.792	0.000

Because the calculated probability values of the tests are higher than 0.05, the H_0 hypothesis was accepted. In the co-integration equation, it was inferred that the constant term and slope coefficients were homogeneous. Based on the analysis results, reviews of co-integration equation which will be held for the whole panel are valid and reliable (Pesaran and Yamagata, 2008).

3. 5. Multiple Structural Break Cointegration Test

Multiple structural break cointegration test was developed by Basher and Westerlund (2009). This test analyzes cointegration relationship considering the structural breaks in the periods where it was cross-sectional dependence. The characteristic of this test is that it examines co-integration relationship of the series of which stationary status is not fixed, but can only be found after the first difference. The other feature of this test is that it allows breaks in stationary and trend. Developed test statistic equation (8) is given below:

$$Z(M) = \frac{1}{N} \sum_{i=1}^N \sum_{j=1}^{M_i+1} \sum_{t=T_{ij-1}+1}^{T_{ij}} \frac{S_{it}^2}{(T_{ij}-T_{ij-1})^2 \hat{\sigma}_i^2} \tag{8}$$

In this equation, $S_{it} = \sum_{s=T_{ij-1}+1}^t \widehat{W}_{st}$. In addition, \widehat{W}_{st} is residual vector obtained by a valuer of least squares method $\hat{\sigma}_i^2$ on the other hand is the long-term variance valuer of \widehat{W}_{st} . $Z(M)$ becomes the following equation when it was simplified by horizontal cross average:

$$Z(M) = \sum_{t=T_{ij-1}+1}^{T_{ij}} \frac{S_{it}^2}{(T_{ij}-T_{ij-1})^2 \hat{\sigma}_i^2} \sim N(0,1) \tag{9}$$

This test statistic shows the standard normal distribution. The hypotheses of this test are:

H_0 : There is cointegration relationship between the series.

H_1 : There is no cointegration relationship between the series for some horizontal sections

While examining co-integration relationship, if there is no cross-sectional dependence between the countries in the panel, the calculated LM test statistics for 5% significance level is compared with 1.645 critical values or asymptotic probability value is compared with 0.05. If there is cross-sectional dependence, bootstrap probability value is compared with 0.05 at 5% significance level. If the probability value is over 0.05, H_0 is accepted and it is decided that there is co-integration relationship between the series. Co-integration test results are shown in Table 4.

Table 4

Multiple Structural Break Cointegration Test Results

	LM test statistic	Asymptotic probability value	Decision	Bootstrap Probability Value	Decision
Breaks are not taken into account:					
Stationary	2,080	0,019***	Co-integration	0,589*	Co-integration Available
Stationary and Trend	3,655	0,000	No Co-integration Available	0,001	Co-integration Available
Breaks are taken into account:					
Stationary	1,802	0,036**	Co-integration Available	0,166*	Co-integration Available
Stationary and Trend	2,457	0,007	No Co-integration	0,757*	Co-integration Available

Note: Probability values were obtained from 1000 samples using Bootstrap.

Based on the figures in the table, considering horizontal cross-sectional dependence and structural breaks it is crucial in identifying the existence of co-integration relationship. In relation to cross-sectional dependence and co-integration equations between the countries, it was found out that it was co-integration relationship between the series in the whole panel. In the case when structural breaks are not taken into account in stationary and stationary-trend, it was concluded that there was no co-integration relationship. Moreover, considering the stationary and stationary-trend breaks, there was co-integration relationship between the series.

Table 5

Date of Fluctuations

Countries	Number of Fluctuations	Fluctuation Date
Brazil	1	2000
China	1	2008
Indonesia	1	1999
India	1	2009
Mexico	0	-
Russia	1	1999
Turkey	1	2002

As Table 5 shows, there are structural breaks that occur in countries other than Mexico. It can be inferred from the table that Brazil went through a currency devaluation of 8% in January 1999 (Ferreira and Tullio, 2002:144); that Indonesia struggled with the Asian Financial Crisis in 1997 and faced a great devaluation of the currency in January 1998; that right after the Asian Financial Crisis, Russia encountered a financial crises in 1998, and its national currency was devaluated especially after the second quarter of the same year; that in February 2001 Turkey has abandoned the stabilization policy based on the exchange rate as a result of a speculative attack against the national currency and a financial crisis started due to leaving the exchange rate to fluctuate; that with the stock market crash in India in

2009 the value of the national currency increased; and that in 2008 the value of the national currency rose in China, and these incidents have been influential on the structural breaks.

3.6. Estimating the Long-Term Cointegration Coefficients

In this part of the study, after the estimation of the existence of co-integration relationship between the series, Common Correlated Effects (CCE) method developed by Pesaran (2006) was used for the estimation of long-term co-integration coefficients.

$$Energy_{it} = \beta_{0i} + \beta_{1i}GDP_{it} + \varepsilon_{it} \quad (10)$$

This long-term co-integration estimator developed by Pesaran (2006) is consistent as $N, T \rightarrow \infty$, jointly, as long as a certain rank condition concerning the factor loadings is satisfied. In this case, the asymptotic distribution of the CCE estimator is derived if $\sqrt{T/N} \rightarrow 0$ as $N, T \rightarrow \infty$, jointly. The results of the estimator conducted with CCE method are given in Table 6.

Table 6

Long-Term Estimation of Cointegration Coefficients

Countries	Coef.	t-ist.	Prob.
Brazil	0.309	6.40	0.000*
China	11.240	2.70	0.000*
Indonesia	0.449	2.54	0.011**
India	1.033	0.55	0.061***
Mexico	0.148	2.75	0.006*
Russia	0.579	4.03	0.000*
Turkey	0.012	0.15	0.090***
Panel	0.123	1.92	0.054***

Note: * shows 1%, ** shows 5%, and *** shows 10% significance levels.

As one may see in Table 6 a 10% increase in energy consumption in the whole panel results in 0.123% increase in economic growth. It is clearly seen in the sample of E7 countries, which showed great development in the recent years, that increases occurring in energy consumption have positive and meaningful effects on economic growth. This reveals that these countries which experienced a strong economic development process need more energy resources to keep this sustainable. The obtained result is in line with the findings of Shahbaz *et al.* (2013) and Narayan and Smyth (2008).

4. Conclusions

Today, energy consumption constitutes the basis of economic growth and one of the most important infrastructure inputs for economic development. The increase in energy demand and the development of economic activities in the world leads to a steady increase in interest in energy. The results obtained in empirical studies gave different results according to the energy policies applied in the countries, the period studied, the econometric methods and the variables used. The purpose of this study was to analyze the effect levels of energy consumption and economic growth relationship covering the period between 1990 and 2016 in the E7 countries (Brazil, China, Indonesia, India, Mexico, Russia and Turkey). All in all, this study used the total energy consumption and economic growth data in relation to the E7 countries and conducted panel data analysis. Firstly, the CD tests developed by Breusch and Pagan, (1980); Pesaran, (2004) and Pesaran, and Ullah and Yamagata (2008) were

used to test horizontal cross-sectional dependence of the series, and it was decided that it was horizontal cross-sectional dependence among the countries. After this analysis, the stationary status of the series was controlled using CADF unit roots test, which is one of the second generation unit roots tests, developed by Pesaran (2007). It was observed that the series were stationary by the first difference. Then, the multiple structural break cointegration test developed by Westerlund (2009) was used and it was noticed that the series were correlated on long term. After testing the existence of co-integration between the series, the long-term cointegration estimator developed by Pesaran (2006) was tested by the CCE method. The analysis results suggested that 1% increase in energy consumption in the whole panel resulted in 0.169% increase in economic growth. The results obtained in this study show in a similar way to the other studies in literature that there is long-term correlation between energy consumption and economic growth. The findings obtained support the studies of Narayan and Smyth (2008), Apergis and Danuletiu (2012) and Esseghir and Khouni (2014). Consequently, it may be comfortably claimed that energy consumption increases experienced by the E7 countries, which are expected to develop even further in the next years, could have the potential to increase economic growth. The E7 countries, like the G7 countries, are a group of developing countries with a population that is growing fast and integrated with the international economy, and have the goal of becoming a promising economy in the world. In this context, in these countries the energy demand is high in terms of both production and consumption, and this demand will continue to rise in the coming period to reach their development goals. Considering that the energy demand will increase with economic growth, in order to contribute to the supply of energy demand at the desired time and amount, countries need to mobilize their own energy sources and use existing energy sources effectively and efficiently. Therefore, providing low-cost and sustainable energy resources, especially in the production process, is of great importance in terms of social prosperity.

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