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# Relationship between Energy Consumption and Real Gross Domestic Production in Turkey: A Co-integration Analysis with Structural Breaks

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**ABSTRACT**

Energy is one of the most fundamental requirements for a sustainable economy in many of the emerging countries. Being one of these emerging countries, Turkey has inadequate energy sources and this increases its foreign source dependency for energy. Likewise, experiencing negative energy shocks decreases the economic growth rate. Analyzing the relationship between energy consumption and economic growth by taking into account the structural changes caused by internal shocks and external shocks experienced in the country is of great importance for the Turkish economy. In this study, the long term relationship between energy consumption and real gross domestic production in the period between 1960 and 2012 has been investigated by employing co-integration methods and the vector error correction model. Results of our study show that there is a long term relationship between the series and one-way causality from real gross domestic production to energy consumption. These findings clearly state that economic growth has an important role in energy consumption.

**Keywords:** Energy Consumption, Economic Growth, Co-integration Test with Multiple Structural Breaks
**JEL Classifications:** C32, O4, Q43

## 1. INTRODUCTION

From the perspective of realizing economic and social development, energy is one of the most important inputs in the production process. Therefore, there exists a relationship in a positive direction between energy consumption and economic growth. This relationship between energy and economic growth and the scarcity of world energy resources determine the relations between countries both from economic and politics points of view. Increases in energy prices due to the oil crises experienced in the 1970s have emphasized the importance of energy in developed and developing countries, making the relationship between energy consumption and economic growth in developing countries and the direction of this relationship unquestionably significant for economists as well as policy-makers.

The energy consumption in Turkey has increased particularly with the foreign expansion process that started in the 1980s, when the agriculture sector lost its value to the manufacturing and services sectors. The manufacturing and services sectors rely heavily on non-renewable (primary) energy sources such as oil and natural gas. The Turkish economy has been generating some portion of renewable (secondary) energy sources and is consequently able to meet increasing demand for energy. For non-renewable (primary) energy sources, however, like many other developing countries, Turkey is dependent on foreign sources; increases in economic growth yield an increase in energy consumption and foreign source dependency. In fact, Turkey's foreign source dependency was 52% in 1990 and 68% in 2000, but in 2011, when the primary energy production met 28% of the consumption, foreign source dependency rose to 72% (World Energy Council). 1 year later in 2012, the share of imports in Turkey's primary energy consumption, (in other words, foreign source dependency for energy), was 71.5% and it increased to 73.5% in 2013 (Republic of Turkey Ministry of Energy and Natural Resources). With increasing economic growth in Turkey comes increasing energy consumption, and, correspondingly, increased foreign dependency for energy. Furthermore, uncertainties in global energy prices affect the economic indicators and, especially, economic growth negatively. This situation unveils the relevance of empirical analysis of the relationship between economic growth and energy consumption in the Turkish economy. The objective of this study is to analyze the relationship between energy consumption and real gross domestic production (GDP), as well as the direction of this relationship in both the short and long terms in Turkey, using annual data for the period of 1960-2012. The difference between this study and existing studies in economics literature, (hence its contribution to empirical literature), is that it takes into account the structural changes caused by internal and external shocks experienced in the analysis period in Turkey, and analyzes the relationship between the two variables in question. In this study, the long-term relationship between the variables has been first investigated with the Johansen co-integration test, which does not take the structural changes into account. Subsequently, the same relationship has been analyzed by employing the Maki co-integration test with multiple structural breaks in which structural breaks are taken into account. The short and long term causality between the series has been analyzed by the vector error correction model (VECM). The rest of the study has been organized as follows: The second section elaborates on empirical studies in the literature, the third explains the data set, the fourth explains the econometric method and empirical findings, and in the final section describes findings.

## 2. EMPIRICAL LITERATURE

The relationship between energy consumption and GDP has been analyzed by many researchers for developed and developing countries by using different methods and data sets. The relationship between these two variables was first studied by Kraft and Kraft (1978). Using causality analysis developed by Sims for the period of 1947-1974, they found a one-way causal relationship from GDP to energy growth. The same study was conducted by Yu and Hwang (1984) using the data for 1947-1979 and no causal relationship was found between energy consumption and GDP.

Erol and Yu (1987) analyzed the relationship between energy consumption and GDP for the period of 1952-1982 covering the UK, France, Italy, Germany, Canada and Japan. They found a one-way relationship from energy consumption to GDP for Canada, a bi-directional relationship for Japan, and a one-way causality relationship from GDP to energy consumption for Germany and Italy. For France and the UK, they were unable to identify a causal relationship between the two variables.

Stern (2000) analyzed the relationship between energy consumption and GDP for the USA by using the Johansen co-integration and Granger causality tests. He found a long term relationship between the variables and a one-way causal relationship from energy consumption to GDP.

Asafu-Adjaye (2000) analyzed the long-term relationship between energy consumption and income by using the Johansen co-integration test and they examined the causality relationship by using the VECM for India, Indonesia, Philippines, and Thailand. Their findings showed that there was a one-way causal relationship from energy to income in the short term for India and Indonesia and a bi-directional causal relationship from energy to income for Thailand and Philippines.

Using data from the 1955 to 1996 period, Aqeel and Butt (2001) analyzed the causal relationship between energy consumption and economic growth and energy consumption and employment. He analyzed the relationship between GDP and total energy consumption and various components of energy consumption (oil, gas, and electricity) using Hsiao's Granger causality test. Results of this study showed that economic growth caused both total energy consumption and oil consumption; but, economic growth and gas consumption did not affect each other.

Using the vector autoregressive model, Chontanawat et al. (2006) analyzed the relation between energy and GDP for 30 OECD member countries and 78 non-OECD countries. When non-OECD member countries were compared to developing countries, they found that there was causal relationship from total energy consumption to GDP and from GDP to energy consumption in developed OECD countries.

For Beijing, Yong-xiu et al. (2007) analyzed the long-term relationship between total energy consumption and GDP by using the Johansen co-integration test, and investigated the direction of the causality between the two variables aided by the Granger causality test. The empirical findings showed that there is a long-term relationship between the two variables and there exists a Granger causal relationship from GDP to energy consumption.

Hye and Riaz (2008) used data between 1971 and 2007 to analyze the direction of a causal relation between energy consumption and economic growth in Pakistan. They used the bound testing approach to analyze the relationship between the variables in question and they employed the Granger causality test to determine the direction of the causality. Their findings showed that in the short term there was a bi-directional causal relationship between economic growth and energy consumption, whereas there was one-way causality from economic growth to energy consumption in the long term. They stated that in the long run, energy consumption did not cause economic growth; high energy prices increased costs and caused a negative effect on economic growth.

Hou (2009) analyzed the causal relationship between energy consumption and economic growth for the period of 1953-2006 in China. In this study, the researcher used Johansen co-integration and Hsiao's Granger causality tests and reached the conclusion that there was a bi-directional causality between the variables.

Abaidoo (2011) used 3-monthly data for the period of 39 years and employed the Sims test, which is based on the Granger causality definition, to analyze the causal relationship between energy consumption and economic growth for Ghana. Using the Granger causality test, he showed the existence of a one-way causal relationship from economic growth to energy consumption.

Binh (2011) analyzed the energy consumption-growth relation in Vietnam. He analyzed the relationship between per capita energy consumption and per capita GDP for the period of 1976-2010 by using the Johansen co-integration test and employed the VECM for the causality test. Results showed that there was a long-term relationship between the two variables and a one-way causality from per capita GDP to per capita energy consumption.

Abid and Sebri (2012) analyzed the long-term relationship between economic performance in the general economy (for sectors such as manufacturing, transportation, and housing) and energy consumption for the period of 1980-2007 in Tunisia by using the Johansen co-integration test and employed the VECM to analyze the causality relationship. They concluded that energy had an important effect on economic performance in the general economy.

Adhikari and Chen (2013) analyzed the long-term relationship between energy consumption and economic growth for 80 developing countries for the period between 1990 and 2009. Their analysis methods were the panel unit root test, the panel co-integration test, and the panel dynamic least squares test. They separated the 80 countries into three groups with respect to income levels. The empirical results revealed that as in the case of each of the country groups, there was a long term co-integration relationship between energy consumption and growth for all panel countries, as well.

Using the Gregory and Hansen co-integration method and the VECM, Banafea (2014) analyzed the relationship and causality between economic growth and energy consumption in Saudi Arabia for the period of 1971-2012. Along with structural breaks, the unit root test results showed that total energy and gas consumptions were stationary at levels. Therefore, these variables were excluded in the co-integration and causality analyses. Their findings indicated a causal relationship between real GDP and oil consumption in both the short and long terms.

Bayar and Özel (2014) used the Pedroni, Kao and Johansen co-integration tests and the Granger causality test to analyze the relationship between economic growth and electricity consumption for emerging economies for the period between 1970 and 2011. They determined that electricity consumption had a positive effect on economic growth and there was a bi-directional causal relationship between economic growth and electricity consumption.

Le et al. (2014) used the Johansen co-integration test and the VECM to analyze the relationship between financial development, energy consumption and economic growth as well as the direction of this relationship for the period of 1966-2011 in the US. They reached the conclusion that there was at least one co-integration relationship between the variables and a one-way causality from financial development to economic growth in the long term.

For 15 European Union member countries, Ucan et al. (2014) analyzed the relationship between renewable and non-renewable energy consumption and economic growth for the period of 1990-2011. Using the heterogeneous panel co-integration test in their study, they found a long-term relationship between real GDP and energy consumption, and with the Granger causality test results they found a one-way causal relationship between non-renewable energy consumption and economic growth.

Many researchers for Turkey, an emerging economy, have empirically analyzed the relationship between energy consumption and GDP, and these studies reached different outcomes. Among these studies, Karagöl et al. (2007) used data for the 1974-2004 period and employed the bound testing approach to analyze the relationship between economic growth and electricity consumption. While the findings showed a positive relationship between the variables in the short term, they showed the same relationship was negative in the long term.

In their study, Aktaş and Yilmaz (2008) used data for 1970-2004 and the Granger causality test and found that there was a bi-directional causality between electricity consumption and GDP in the short term. For the long term, researchers found existence of a one-way causality from GDP to electricity consumption.

Acaravci (2010) analyzed short and long term causality relationships between electricity consumption and economic growth by using the Johansen co-integration test and investigated the structural breaks using the VECM. In that study the researcher used data for 1968-2005 and showed that there was a one-way causality from electricity consumption to economic growth and a long-term relationship between the variables.

Aytaç (2010) studied the relationship between economic growth and energy for the period of 1975-2006 using the Granger causality test and the VAR model. He concluded that there was a one-way causality from energy consumption to workforce and from economic growth to capital.

Ertuğrul (2011) studied the period from 1998:Q1-2011:Q3 and analyzed the relationship between electricity consumption and economic growth by using the Johansen co-integration test, and the dynamic relationship by using the Kalman filtering model. The researcher showed that electricity consumption had an increasing effect on GDP.

For the period of 1968-2006, Acaravci and Ozturk (2012) employed the autoregressive distribution lag test and the Granger causality model to analyze the relationship and direction of the relationship between electricity consumption and economic growth. They determined that in the short and long terms there was a one-way causality relationship from per capita electricity usage to real GDP.

With data for 1970-2009, Çetin and Seker (2012) used the Johansen-Juselius and Stock-Watson co-integration and Toda-Yamamoto causality tests to analyze the relationship between energy consumption and economic growth. They found that energy consumption had a positive and strong effect on growth, and With the Toda-Yamamoto test results they showed that there was no causal relationship between energy consumption and economic growth.

Korkmaz and Develi (2012) studied the relationship between energy consumption and GDP as well as the direction of this relationship for the period 1960-2009 by using the Johansen co-integration and Granger causality tests, respectively. They reached the conclusion that there was a long term relationship between the variables and a bi-directional causal relationship between energy consumption and GDP.

Saatci and Dumrul (2013) analyzed the relationship between energy consumption and economic growth for the period 1960-2008 by using the Kejriwal co-integration test and found that there was a positive relationship between energy consumption and economic growth.

Erdoğan and Gürbüz (2014) analyzed the relationship between energy consumption and economic growth between 1970 and 2009 using Gregory-Hansen co-integration analysis, and determined an existence of co-integration between the series in the long term. As a result of Granger causality analysis, however, they did not find a causal relationship between these variables.

Topallı and Alagöz (2014) analyzed the relationship between electricity consumption and economic growth for the period 1970-2009 by using the Johansen co-integration test, the Toda Yamamoto Granger causality test, and the VECM analysis. They reached the conclusions that there was a long term co-integration between the variables and a one-way causality from real GDP to electricity consumption both in the short term and long term.

Ozturk et al. (2013) investigate the short-run and long-run relationship and causality between energy consumption and economic growth during 1960-2006 period for Turkey by using Johansen and Juselius co-integration method and vector error correction model. The results have shown that there is no short-run causality in both energy consumption and GDP models. The results also confirmed that there is unidirectional long-run causality among variables of interest and the direction of long-run causality is running from per capita GDP to per capita energy consumption. As a result, conservation hypothesis which postulates unidirectional causality from economic growth to energy consumption is confirmed for Turkey.

Shahbaz et al. (2013) investigate $CO_2$ emissions, energy intensity, economic growth and globalization using annual data over the period of 1970-2010 for Turkish economy by applying unit root test and co-integration approach in the presence of structural breaks. The direction of causality between the variables is investigated by applying the VECM Granger causality approach. The results confirmed the existence of co-integration between the series. The empirical evidence reported that energy intensity and economic growth (globalization) increase (condense) $CO_2$ emissions. The results also validated the presence of environmental Kuznets curve (EKC). The causality analysis shows bidirectional causality between economic growth and $CO_2$ emissions. This implies that economic growth can be boosted at the cost of environment.

Ozturk and Acaravci (2013) examine the causal relationship between financial development, trade, economic growth, energy consumption and carbon emissions in Turkey for the 1960-2007 period. The bounds F-test for co-integration test yields evidence of a long-run relationship between per capita carbon emissions, per capita energy consumption, per capita real income, the square of per capita real income, openness and financial development. The results show that an increase in foreign trade to GDP ratio results an increase in per capita carbon emissions and financial development variable has no significant effect on per capita carbon emissions in the long-run. These results also support the validity of EKC hypothesis in the Turkish economy. It means that the level of $CO_2$ emissions initially increases with income, until it reaches its stabilization point, then it declines in Turkey. In addition, the paper explores causal relationship between the variables by using error-correction based Granger causality models.

## 3. ECONOMETRIC MODELS AND DATA SETS

In analyzing the relationship between energy consumption and real GDP in the Turkish economy, we used data for the period of 1960-2012. To study the relationship in question, we used energy consumption in terms of oil consumption (kt of oil equivalent) and real GDP (with 2005 prices) data. The data used in the analysis have been obtained from the World Bank Electronic Database (World Development Indicators). The natural logarithms of the series were taken and in this way the series were converted from exponential increases to arithmetic increases. The fundamental model used in the study is presented below (1):

$$\ln rgdp = \alpha + \beta_1 \ln ec + \varepsilon_t \tag{1}$$

where *lnrgdp* denotes real GDP, and *lnec* denotes energy consumption.

## 4. ECONOMETRIC METHODS AND EMPIRICAL FINDINGS

In the analysis of the long term relationship between energy consumption and GDP in Turkey, we used the traditional Johansen co-integration test and the Maki co-integration test which allows for five structural breaks. The effect of short term divergences from long term equilibrium between the series in question was analyzed using the VECM. However, investigation of the co-integration relationship between the series requires that series be stationary at the same level. Therefore, stationarity of the series has been investigated by the augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) unit root tests. However, because these unit root tests do not take into account the structural changes, stationarity of the series has been tested again by the Zivot-Andrews (1992) (ZA) unit root test, which allows for one structural break and by the Lee and Strazicich (2003) (LS) unit root test, which allows for two structural breaks. For the ADF and PP unit root tests, the Johansen co-integration test and the VECM analysis Eviews 8 have been used. For the analysis of the LS unit root test and the Maki co-integration tests, Gauss 10.0 has been used.

### 4.1. Unit Roots Tests

In order to get meaningful results from the analysis of time series, the time series should be stationary. If the average variance and common variance (at various lags) of a time series do not change over time, that time series is stationary (Gujarati, 1999:713). Granger and Newbold (1974) showed that spurious regressions would emerge in the studies conducted with non-stationary time series. Despite having high $R^2$ and significant t statistics values, parameter estimations in spurious regressions are meaningless in economic terms. Therefore, in the studies based on time series, in order to avoid spurious regressions, stationarity of the series should be tested. In the literature, the most commonly used unit root tests to test the stationarity of a time series are the ADF[1], developed by Dickey and Fuller (1979, 1981) and the PP[2], developed by Phillips-Perron (1988).

The ADF and PP unit root test results are presented in Table 1 and Table 2. The test results show that all the series in the study are stationary at the first level [I(1)] at 1% significance level.

The ADF and PP unit root tests do not take into account the structural breaks that take place in the time series in the analysis period and, therefore, in the presence of structural break in the time series, reliability of the test results decreases. This situation was first analyzed by Perron (1989). In order to test the stationarity of the time series, Perron developed the unit root test which is conducted with the assumption of a single external structural break. In the Perron unit root test, the external structural break time should be determined appropriately. Determining the timing of the external breaking point incorrectly causes a stationary time series with structural break to appear as if it is not stationary. From this viewpoint, Zivot and Andrews (1992)[3] developed a unit root test with a single structural break, where timing of the structural breaks are not known in the time series; in other words, where the structural break is determined internally.

The fact that the Turkish economy encountered negative external shocks (oil crises, the global financial crisis in 2008) and negative internal shocks (1994 crisis, 2000-2001 banking crisis) during the analysis period necessitates that stationarity of the series is tested with unit root tests involving structural changes. To this end, in the analysis period, stationarity of the series under structural breaks

1 In the ADF unit root test, three models are used: without constant and without trend, with constant and without trend, with constant and with trend. The test equation of the ADF unit root test representing the variationwith constant and with trend is presented below in the most general form:

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + e_t \quad (2)$$

where t, denotes trend variable. In the ADF test, if the absolute value of the test statistics calculated in the analyzed time series is less than absolute value of MacKinnon DF then the null hypothesis of unit root ($H_0$:δ=0) is accepted and this result shows that the analyzed series is not stationary (Dickey and Fuller, 1981, pp.1057-1072).

2 The ADF unit root test assumes that error terms are statistically independent and have constant variances. In other words, the ADF unit root test assumes that there is no autocorrelation between the error terms. With the unit root test they developed Phillips and Perron (1988) expanded the no autocorrelation assumption between the error terms. Phillips and Perron (1988) used the past values of error terms as moving average (MA-Moving Avarage). Begining to use moving average process enabled to perform trend stationarity test more powerfully (Phillips and Perron, 1988, s.345-346).

3 In ZA unit root test, three models are used: Model A allows for a single structural break in constant, Model B allows for in the trend and Model C allows for in the constant and trend. The periods when the t statistics values calculated for these models are minimum show the years of structural break. Accordingly, if the absolute value of the calculated t stastiscs values are greater than the ZA critical values, the null hypothesis (H0) is rejected, and in other words the alternative hypothesis stating that the time series has a structural break and is trend stationary is accepted. When the absolute value of t statistics calculated for breaking years is less than the ZA critical values, the null hypothesis (H0) is accepted, and in other words it is concluded that there is no structural break in the time series and there exists unit root (Zivot and Andrews, 1992: 251-270).

**Table 1: ADF unit root test results**

| Variables | Constant | | | Constant and trend | | |
|---|---|---|---|---|---|---|
| | ADF test statistic | MacKinnon critical values (%) | | ADF test statistics | MacKinnon critical values (%) | |
| | | 1 | 5 | | 1 | 5 |
| lngdp | –1.028 (0) | –3.562 | –2.918 | –2.733 (0) | –4.144 | –3.498 |
| lnec | –1.617 (0) | –3.562 | –2.918 | –1.871 (0) | –4.144 | –3.498 |
| Δlngdp | –7.269* (0) | –3.565 | –2.919 | –7.341* (0) | –4.148 | –3.500 |
| Δlnec | –6.843* (0) | –3.565 | –2.919 | –7.126* (0) | –4.148 | –3.500 |

The values in the parentheses indicate the lag numbers selected by AIC, (Δ) denotes the first difference operator, (*) denotes 1% significance level, AIC: Akaike information criterion

**Table 2: PP unit root test results**

| Variables | Constant | | | Constant and trend | | |
|---|---|---|---|---|---|---|
| | PP test statistic | PP critical values (%) | | PP test statistic | PP critical values (%) | |
| | | 1 | 5 | | 1 | 5 |
| lngdp | –1.161 (4) | –3.562 | –2.918 | –2.756 (1) | –4.144 | –3.498 |
| lnec | –1.726 (3) | –3.562 | –2.918 | –1.882 (1) | –4.144 | –3.498 |
| Δlngdp | –7.271* (2) | –3.565 | –2.919 | –7.365* (3) | –4.148 | –3.500 |
| Δlnec | –6.843* (0) | –3.565 | –2.919 | –7.146* (3) | –4.148 | –3.500 |

The values in the parentheses indicate the harmonised lag numbers. Harmonised lag numbers are determined according to Newey-West and by applying the Barlett-Kernel, (Δ) denotes the first difference operator, (*) denotes 1% significance level was analyzed first with the ZA unit root test, which allows for a single structural break. When we examined the stationarity of the series by the ZA unit root test, we took into account the Model A that allows for breaking in the constant and Model C that allows for breaking in the constant and trend. Because, according to ZA unit root test results, the test statistics of all series are less than critical value at 1% significance level in the analysis period, the hypothesis that series are stationary in the respective breaking periods has been rejected. The fundamental hypothesis showing the existence of unit root without the existence of structural break has been accepted (Table 3).

On the other hand, testing stationarity of macro-economic data by unit root tests with a single break leads to incorrect results, and in cases where there are two breaks in the series, the power of the ZA unit root test diminishes. With this in mind, Lumsdaine and Papell (1997) (LP) expanded the ZA unit root test and developed a unit root test which allows for two breaks in the series. However, the null hypothesis of the ZA and LP unit root tests assumes that there is no unit root under structural break and the critical values are obtained based on this assumption. However, Lee and Strazicich (2003, 2004) (LS) claimed that in the alternative hypothesis to the null hypothesis used in the ZA and LP unit root tests, the series should not be stationary with structural break. The reason for this is that the alternative hypothesis might be in the form of existence of structural breaks and this can show existence of a unit root with structural break in the analyzed series. In answer to this problem, Lee and Strazicich developed a unit root test with a single break as an alternative to the ZA unit root test that was based on Lagrange multipliers (LM) and developed by Schmidt and Phillips (1992). Likewise, as an alternative to the LP unit root test, they developed a two-break unit root test. The two-break LM[4] unit root test is based on two models with respect to breaks taking place in the constant (Model AA) and in the trend (Model CC) (Lee and Strazicich, 2003, pp.2-3). Therefore, because the two-break LM unit root test is superior to the ZA unit root test, stationarity of the series have been analyzed again by the two-break LM unit root test. Test results are presented in Table 4.

4 The statistics that tests the null hypothesis of LM unit root test below is obtained by. In order to determine the breaking times, the points where test statistics is minimum are selected.

$$LM_{\tau} = \inf_{\lambda} \tilde{\tau}(\lambda)$$

where, $\lambda = T_B/T{:}T_B$. denotes the breaking time, $T$ denotes number of observations.
The two-break LS unit root test statistics are obtained from Lee and Strazicich (2003). If the calculated test statistics is less than the critical value then the null hypothesis ($H_0$) that there exists unit root under structural breaks cannot be rejected. If the calculated test statistics is greater than the critical value then the null hypothesis ($H_0$) that there exists a unit root under structural break is rejected (Lee and Strazicich, 2003: 1082-1089).

**Table 3: ZA unit root test results**

| Variables | Model | Break period | The minimum t statistics |
|---|---|---|---|
| lngdp | Model A | 1996 | –4.1883 (3) |
| | Model C | 1977 | –4.7840 (3) |
| lnec | Model A | 1970 | –3.6651 (0) |
| | Model C | 1970 | –4.1548 (0) |
| Δlngdp | Model A | 1974 | –5.3017** (3) |
| | Model C | 1974 | –5.2399** (3) |
| Δlnec | Model A | 1985 | –7.2476* (0) |
| | Model C | 1985 | –7.3061* (0) |

The values in the parentheses indicate the number of lags chosen by AIC, Critical values are excerpted from Zivot and Andrews (1992, p. 30). For Model A, 1% significance level refers to –5.34 and 5% significance level denotes –4.80. For Model C, 1% significance level refers to –5.57 and 5% significance level denotes –5.08, (*) denotes 1% significance level, (**) denotes 5% significance level, AIC: Akaike information criterion

The two-break LM unit root test results show that, in the analysis period, the t statistics calculated in both models are less than the critical value at 1% significance level for all the variables in the study. Therefore, the null hypothesis stating that there exists a unit root at the breaking periods given in Table 4 is accepted. When we take the first difference of the series, however, the t statistics calculated for all series are greater than the critical value at 1% significance level. Therefore, the null hypothesis showing that there exists a two-break unit root is rejected and we reach the conclusion that the series are stationary at the first difference.

### 4.2. Johansen Co-integration Test

The ADF, PP, ZA and two-break LM unit root test results show that variables are stationary at the same level during the analysis period, and this fulfills the first requisite for the co-integration test. The co-integration relationship between the series has been analyzed by the Johansen co-integration test, which was first introduced by Engle and Granger (1987) and later developed by Johansen (1988), and Johansen and Juselius (1990). The Johansen co-integration test is based on VAR analysis, developed by Sims (1980) (Sims, 1980; Enders, 2004) in which each variable involved in the system and its lagged values takes a part. The Johansen co-integration test method is explained by the below equation:

$$\Delta Z_t = \mu + \prod Z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \varepsilon_t \tag{3}$$

$$\Gamma_i = -I + \Pi_1 + ... + \Pi_i \qquad (i = 1, ..., k)$$

where, π denotes the coefficient matrix and rank of coefficient matrix gives the existing co-integration number. Rank of π matrix being equal to zero shows there is no co-integration relationship between the variables. It's being equal to 1 shows there is one co-integration relationship between the variables, and its being >1 shows there are more than one co-integration relationship between the variables. In the Johansen co-integration test, the co-integration relationship between the series is analyzed by the help of trace and maximum eigenvalue statistics. If the test statistics are greater than trace and maximum eigenvalue statistics, the null hypothesis ($H_0$) is rejected and the alternative hypothesis ($H_1$) is accepted.

Before the co-integration relationship between the variables of the study is analyzed by the Johansen co-integration test, appropriate lag should be determined. To this end, the appropriate lag has been determined by the VAR model with no constraint and results are presented in Table 5.

Table 5 shows that for one lag FPE, AIC, SC and HQ criteria give the minimum value, and LR criterion gives the maximum value. According to these results, the lag length for the Johansen co-integration test has been determined as 1. The results of the

**Table 4: Two-break LM unit roots test results**

| Variables | λ values | Model | Break period | The minimum t statistic | Critical values for model CC (%) | |
|---|---|---|---|---|---|---|
| | | | | | 1 | 5 |
| lngdp | | Model AA | 1993 and 2000 | −3.31 (1) | | |
| | $\lambda_1$: 0.4 | Model CC | 1978 and 1993 | −5.66 (3) | −6.45 | −5.67 |
| | $\lambda_2$: 0.6 | | | | | |
| lnec | | Model AA | 1993 and 2000 | −2.93 (1) | | |
| | $\lambda_1$: 0.2 | Model CC | 1971 and 1999 | −5.59 (7) | −6.33 | −5.71 |
| | $\lambda_2$: 0.8 | | | | | |
| Δlngdp | | Model AA | 1978 and 1987 | −7.59 (0) | | |
| | $\lambda_1$: 0.4 | Model CC | 1978 and 2000 | −7.71 (0) | −6.42 | −5.65 |
| | $\lambda_2$: 0.8 | | | | | |
| Δlnec | | Model AA | 1977 and 1997 | −8.08 (0) | | |
| | $\lambda_1$: 0.4 | Model CC | 1975 and 1999 | −8.19 (7) | −6.42 | −5.65 |
| | $\lambda_2$: 0.8 | | | | | |

The values in the parentheses indicate the number of lags chosen by AIC. Critical values are excerpted from Lee and Strazicich (2003): For Model AA, 1% significance level refers to –4.54 and 5% significance level denotes −3.84, AIC: Akaike information criterion

**Table 5: Determining the optimal lag**

| Lag | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|
| 0 | - | 2.82e-05 | −4.801158 | −4.723941 | −4.771862 |
| 1 | 309.1586* | 4.00e-08* | −11.35873* | −11.12708* | −11.27084* |
| 2 | 1.261440 | 4.58e-08 | −11.22414 | −10.83805 | −11.07766 |
| 3 | −11.07766 | 5.21e-08 | −11.09753 | −10.55701 | −10.89245 |
| 4 | 1.198408 | 5.98e-08 | −10.96422 | −10.26927 | −10.70056 |

(*) denotes the optimal lag values, LR, sequential modified LR test statistic, FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quin information criterion

Johansen co-integration test, in which lag length was taken as 1, are presented in Table 6.

Because in the Johansen co-integration test results, the trace and maximum eigenvalue statistics values are greater than 5% critical value, the null hypothesis of "no co-integration relationship between the series (r=0)" is rejected against the alternative hypothesis of "at least one co-integration relationship (r≥1)." On the other hand, because the trace and maximum eigenvalue statistics values are <5% critical values, the null hypothesis of "maximum of one co-integration relationship between the variables (r≤1)" is accepted against the alternative hypothesis of "at least two co-integration relationship between the variables (r≥2)." This result shows that in the analysis period there is one co-integration relationship between the real GDP and the energy consumption series (Table 6).

## 4.3. Maki Co-integration Test

Gregory and Hansen (1996) mentioned that in case there are structural breaks in the time series, the traditional co-integration tests could give misleading results. Therefore, they developed a co-integration test that allows for one structural break where timing of the structural breaking is determined internally. The Gregory-Hansen co-integration test has been expanded around Hatemi (2008)'s model, where structural break timings are determined internally and the existence of two structural breaks are allowed.

Maki (2012) developed a co-integration test where structural breaking times are determined internally when there are more than two structural breaks in the series, and five structural breaks are allowed. In this situation, existence of more than two structural breaks in the series shows that the Maki co-integration test is superior to the Gregory-Hansen and the Hatemi co-integration tests (Maki, 2012, p.2011). The Maki co-integration test is based on the four different models below:

Model 0: $$y_t = \alpha + \sum_{i=1}^{k} \alpha_i D_{i,t} + \beta x_t + e_t \quad (4)$$

Model 1: $$y_t = \alpha + \sum_{i=1}^{k} \alpha_i D_{i,t} + \beta x_t + \sum_{i=1}^{k} \beta_i x_t D_{i,t} + e_t \quad (5)$$

Model 2: $$y_t = \alpha + \sum_{i=1}^{k} \alpha_i D_{i,t} + \gamma t + \beta x_t + \sum_{i=1}^{k} \beta_i x_t D_{i,t} + e_t \quad (6)$$

Model 3: $$y_t = \alpha + \sum_{i=1}^{k} \alpha_i D_{i,t} + \gamma t + \sum_{i=1}^{k} \gamma_i t D_{i,t} + \beta x_t + \sum_{i=1}^{k} \beta_i x_t \quad (7)$$

Model 0 represents the model in which there is a break in the constant term. Model 1 represents the model with no trend, where there is a break in the constant term and trend. Model 2 represents the model with trend, where there is a break in the constant term. Model 3 represents the model with trend, where there is a break in the constant term and trend. Here, $D_{i,t}(i = 1,....,k)$ denotes dummy variables and it takes the value of 1 when $t \succ T_{Bi}$ and takes the value of 0 otherwise. $T_{Bi}$ represents the structural break period.

The critical values required for testing of the co-integration relationship between the series under structural breaks have been generated by Monte Carlo simulation (Maki, 2012) Accordingly, when the absolute value of the Maki co-integration test statistics is greater than the critical values in absolute value terms, the null hypothesis of "there is no co-integration relationship between the series under structural breaks" is rejected against the alternative hypothesis of "there is a co-integration relationship between the series under structural breaks." When the absolute value of the test statistics is less than the critical values in absolute value terms, the null hypothesis of "there is no co-integration relationship between the series under structural breaks" is accepted.

In the presence of structural breaks the traditional Johansen co-integration test can give erroneous results; therefore, the co-integration relationship between the series used in the study has been examined again by the Maki co-integration test with multiple structural breaks. The results are presented in Table 7.

When we analyze the results of the co-integration test with multiple structural breaks in Table 7 we see that, (excepting model 2), in models 0 and, 1 the test statistics value is greater than the critical value in terms of absolute value at 1% significance level, whereas it is greater than the critical value in terms of absolute value at 5% significance level. The obtained test results show that the null hypothesis stating that there is no co-integration relationship between real GDP and energy consumption in the breaking times of the analysis period given in Table 7 is rejected. In other words, we reach the conclusion that in the presence of multiple structural breaks there is a long-term relationship between real GDP and energy consumption variables.

### 4.4. Vector Error Correction Model

The Johansen and Maki co-integration tests with multiple structural breaks do not determine the direction of the causality between the variables. In their study, Engle and Granger (1987) showed that in the presence of co-integration relationship between the variables, the causality relationship could be determined by VECM.

In addition, the model in question does not allow for spurious relationships between the variables and, by using short-term and long-term information from the data, it distinguishes the long-term and short-term dynamics between the variables. The vector error correction model constructed for the variables of the study is presented in the equations below: (Equations 8-9).

$$\Delta \ln gdp_t = \alpha_1 + \sum_{i=1}^{m} \beta_{1i} \Delta \ln gdp_{t-i} + \sum_{i=1}^{n} \delta_{1i} \Delta \ln ec_{t-i} + \phi_1 ECT_{t-1} + \varepsilon_{1t} \quad (8)$$

$$\Delta \ln ec_t = \alpha_2 + \sum_{i=1}^{m} \beta_{2i} \Delta \ln ec_{t-i} + \sum_{i=1}^{n} \delta_{2i} \Delta \ln gdp_{t-i} + \phi_2 ECT_{t-1} + \varepsilon_{2t} \quad (9)$$

In the Equations 8 and 9, $ECT_{t-1}$ denotes the error correction term. The coefficients of error correction terms ($Ø_1$, $Ø_2$), however, represent the speed of reaching long-term equilibrium from the short-term equilibrium between the series. At least one of the error correction coefficients should be negative and statistically significant. The t statistics values for these variables being significant shows that there is a long-term causality between the variables. In order to determine the short-term causality between the variables, coefficients of independent variables should be applied by the Wald test as a whole. As a result of the applied Wald test, the value F statistics that analyze the coefficients of independent variables as a whole being significant shows the short-term causality between the variables. The Granger causality test results based on the VECM are presented in Tables 8 and 9.

When we analyze the VECM results we see that the coefficient of error correction term for Equation 8 is significant at 1% significance level and its coefficient sign is negative (Table 8). This result shows that there exists long-term Granger causality from real GDP to electricity consumption. The divergences that emerge between the variables moving together in the long-term disappear and, in the long-term, variables approach their equilibrium values again. When we analyze the error correction term for Equation 9, we see that the coefficient is not significant and its sign is positive.

**Table 6: Johansen co-integration test results**

| Trace test | | | | | |
|---|---|---|---|---|---|
| $H_0$ | $H_1$ | Eigenvalue | Trace statistic | Critical value 5% | Probability |
| r=0 | r≥1 | 0.312 | 21.494 | 18.397 | 0.017 |
| r≤1 | r≥2 | 0.053 | 2.733 | 3.841 | 0.098 |
| **Maximum eigenvalue test** | | | | | |
| $H_0$ | $H_1$ | Eigenvalue | Maxmum eigenvalue statistic | Critical value 5% | Probability |
| r=0 | r≥1 | 0.312 | 18.760 | 17.147 | 0.028 |
| r≤1 | r≥2 | 0.053 | 2.733 | 3.841 | 0.098 |

AIC is used for model selection before Johansen co-integration test is applied. In model 5 which includes a quadratic deterministic trend, represents a model with a trend and constant, model 5 is applied in co-integration test since AIC refers to the minimum value, AIC: Akaike information criterion

**Table 7: Maki co-integration test result**

| Model | Test statistics | 1% critical value | 5% critical value | 10% critical value | Break periods |
|---|---|---|---|---|---|
| Model 0 | −7.533* | −5.563 | −5.083 | −4.784 | 1966, 1971 and 2001 |
| Model 1 | −6.668* | −5.708 | −5.196 | −4.938 | 1972 and 2003 |
| Model 2 | −5.124 | −6.915 | −6.357 | −6.057 | 1965, 1971, 1983,1991 and 2003 |
| Model 3 | −6.998** | −7.082 | −6.524 | −6.267 | 1970,1979 and 2003 |

Instruction: While the number of dependent variables is 1 - (RV=1) - and the number of maximum break is five - (m=5) - the critical values of 1%, 5% and 10% at a significance level is excerpted from Maki (2012, p. 2013). (*) denotes 1% significance level, (**) denotes 5% significance level

**Table 8: VECM results**

| Equation | Dependent variable | Independent variable | Coefficients | t statistic value (*P* value) | F statistic value (*P* value) |
|---|---|---|---|---|---|
| 8 | Δlngdp | Δlngdp (-1) | 0.0227 | 0.106 (0.916) | 3.254 (0.019) |
| | | Δlnec (-1) | 0.169 | 0.866 (0.39) | |
| | | ECT (-1)* | −0.571 | −3.186 (0.0026) | |
| 9 | Δlnec | Δlnec (-1) | 0.020 | 0.094 (0.924) | 0.872 (0.487) |
| | | Δlngdp (-1) | 0.003 | 0.014 (0.988) | |
| | | ECT (-1) | 0.081 | 0.911 (0.366) | |

(*) Denotes 1% significance level. In equation 8, the probability values (p) of Breush-Godfrey (BG) autocorrelation test and Breush-Godfrey conditional variant test are 0.7008 and 0.4706, respectively. According to BG and Breush-Pagan Godfrey test results, H0 hypotheses are accepted and it is concluded that there exists no autocorrelation and conditional variant in the model. Durbin Watson and $R^2$ values are 2.05 and 0.2205, respectively. In equation 9, the probability values (p) of Breush-Godfrey (BG) autocorrelation test and Breush-Godfrey conditional variant test are 0.5860 and 0.4714, respectively. According to BG and Breush-Pagan Godfrey test results, H0 hypotheses are accepted and it is concluded that there exists no autocorrelation and conditional variant in the model, Durbin Watson and $R^2$ values are 1.96 and 0.07, respectively

Therefore, this result shows that there is no Granger causality from electricity consumption to real GDP in the long term (Table 8).

As a result of the Wald test[5], which is applied to the coefficient of independent variables in Equations 8 and 9 to determine short-term causality between the variables, the F statistics values have been found to be less than F table values. This result shows that there is no short term causality between the variables (Table 9).

## 5. CONCLUSION

In this study the long-term relationship between energy consumption and real GDP in the period of 1960-2012 for the Turkish economy was first analyzed by the Johansen co-integration method. Our study takes into account the structural changes caused by internal and external shocks taking place during the analysis period in Turkey, and makes a contribution to existing economy literature by studying again the co-integration relationship between the series using the "Maki co-integration with multiple structural breaks" method. Within this context, stationarity of the series was analyzed with ADF/PP unit root tests that do not take structural breaks into account, as well as with ZA/LS unit root tests that allow for one/two internal structural breaks and we have reached the conclusion that series are stationary in the first difference.

As a result of unit root tests, by fulfilling the required prerequisite for co-integration tests, the long-term relationship between the variables has been analyzed with the help of the Johansen co-integration test, and one co-integration relationship has been found between the variables. On the other hand, in the presence of structural breaks, the long-term relationship between the variables has been analyzed with the Maki co-integration test that allows for five internal structural breaks. We find that there is a long-term relationship between the variables. In order to eliminate the effect of short-term divergences between the variables and analyze the direction of causality in the short and long terms, the VECM method was used. According to the VECM results, no causality was found between the variables in the short term. In the long term, however, existence of causality from real GDP to energy consumption was determined.

**Table 9: Wald test results**

| $H_0$ | F statistic value (*p* value) | Decision |
|---|---|---|
| Δlngdp is not the short-term causal of Δlnec. (Equation 8) | 0.011 (0.916) | Acceptance |
| Δlnec is not the short-term causal of Δlngdp. (Equation 9) | 0.0002 (0.988) | Acceptance |

According to the obtained empirical results from the analysis period in Turkey, existence of a long-term relationship between energy consumption and real GDP and direction of causality being from real GDP to energy consumption show that the production of goods and services is dependent on energy consumption. Within this context, adverse shocks that might be experienced in the energy sector would decrease real GDP and therefore economic growth. In order to maintain a sustainable economic growth, Turkey should develop energy policies to meet its increasing energy consumption. Foreign source dependency in energy should be decreased and use of renewable energy sources should be increased.

5 In Equation (8) for $\Delta \ln gdp \rightarrow \Delta \ln ec$ $\quad H_0: \delta_{1i} = 0$, $H_1: \delta_{1i} \neq 0$

In Equation (9) for $\Delta \ln ec \rightarrow \Delta \ln gdp$ $\quad H_0: \delta_{2i} = 0$, $H_1: \delta_{2i} \neq 0$

## REFERENCES


Abaidoo, R. (2011), Economic growth and energy consumption in an emerging economy: Augmented granger causality approach. Research in Business and Economic Journal, 4, 1-15.

Abid, M., Sebri, M. (2012), Energy consumption-economic growth nexus: Does the level of aggregation matter? International Journal of Energy Economics and Policy, 2(2), 55-62.

Acaravci, A. (2010), Structural breaks, electricity consumptıon and economıc growth: Evidence from Turkey. Romanian Journal of Economic Forecasting, 140-154. Available from: http://www.ipe.ro/rjef/rjef2_10/rjef2_10_8.pdf. [Last accessed on 2015 May 15].

Acaravci, A., Ozturk, I. (2012), Electricity consumption and economic growth nexus: A multivariate analysis for Turkey. The Amfiteatru Economic Journal, 14(31), 246-257.

Adhikari, D., Chen, Y. (2013), Energy consumption and economic growth: A panel cointegration analysis for developing countries. Review of Economics and Finance, 3, 68-80.

Aktaş, C., Yılmaz, V. (2008), Causal relationship between electricity consumption and economıc growth in Turkey. Zonguldak Karaelmas Üniversitesi, Sosyal Bilimler Dergisi (Social Sciences Journal), 4(8), 45-54.

Aqeel, A., Butt, M.S. (2001), The relatıonship between energy consumption and economic growth in Pakistan. Asia-Pacific Development Journal, 8(2), 101-110.

Asafu-Adjaye, J. (2000), The relationship between energy consumption, energy prices and economic growth: Time series evidence from Asian developing countries. Energy Economics, 22(6), 615-625.

Aytaç, D. (2010), Enerji ve Ekonomik Büyüme İlişkisinin Çok Değişkenli VAR Yaklaşımı ile Tahmini. p483-495. Available from: http://www.dergiler.sgb.gov.tr/calismalar/maliye_dergisi/yayinlar/md/158/25.Deniz.AYTAC.pdf. [Last accessed on 2015 May 15].

Banafea, W.A. (2014), Structural Breaks and causality relationship between economic growth and energy consumption in Saudi Arabia. International Journal of Energy Economics and Policy, 4(4), 726-734.

Bayar, Y., Özel, H.A. (2014), Electricity consumption and economic growth in emerging economies. Journal of Knowledge Management, Economics and Information Technology, 4(2), 411-419.

Binh, P.T. (2011), Energy consumption and economic growth in vietnam: Threshold cointegration and causality analysis. International Journal of Energy Economics and Policy, 1(1), 1-17.

Çetin, M., Seker, F. (2012), Enerji Tüketiminin Ekonomik Büyüme Üzerindeki Etkisi: Türkiye Örneği. Uludağ Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 31(1), 85-106.

Chontanawat, J., Hunt, L.C., Pierse, R. (2006), Causality Between Energy Consumption and GDP: Evidence from 30 OECD and 78 Non-OECD Countries. Surrey Energy Economics Discussion Papers, SEEDS No. 113. Surrey EnergyEconomics Centre (SEEC), University of Surrey. p1-58.

Dickey, D.A., Fuller, W.A. (1979), Distribution of the estimators for autoregressive time series with a unit root. Journal of the American Statistical Association, 74(366), 427-431.

Dickey, D.A., Fuller, W.A. (1981), Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica, 49(1), 1057-1072.

Dünya Enerji Konseyi, Türkiye Enerji Verileri. (2012), Available from: http://www.dektmk.org.tr/upresimler/TURKIYEENERJIVERILERI2012.pdf. [Last accessed on 2015 13 Mar].

Enders, W. (2004), Applied Econometric Time Series. 2nd ed. Hoobeken, N.J: John Wiley.

Engle, R., Granger, C. (1987), Cointegration and error-correction: Represention, estimation and testing. Econometrica, 55(2), 251-276.

Erdoğan, S., Gürbüz, S. (2014), Türkiye'de enerji tüketimi ve ekonomik büyüme ilişkisi: yapısal kırılmalı zaman serisi analizi. Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 32, 79-87.

Erol, U., Yu, E.S.H. (1987), On the Relationship between energy and ıncome for ındustrialized countries. Journal of Energy and Employment, 13,113-122.

Ertuğrul, H.M. (2011), Türkiye'de Elektrik Tüketimi Büyüme İlişkisi: Dinamik Analiz. Enerji, Piyasa ve Düzenleme. Cilt. 2, p49-73. Available http://www.epddergi.org/articles/2011/Ertugrul.pdf. [Last accessed on 2015 May 15].

Granger, C.W.J., Newbold, P. (1974), Spurious regressions in econometrics. Journal of Econometrics, 2(2), 111-120.

Gregory, A.W., Hansen, B.E. (1996), Residual-based tests for cointegration in models with regime shifts. Journal of Econometrics, 70(1), 99-126.

Gujarati, N.D. (1999), Temel Ekonometri. (1. Basım), (Çevirenler: Şenesen, Ü., Şenesen, G.G.). İstanbul: Literatür Yayıncılık.

Hatemi, J.A. (2008), Tests for cointegration with two unknown regime shifts with an application to financial market ıntegration. Empirical Economics, 35(3), 497-505.

Hou, Q. (2009), The relationship between energy consumption growths and economic growth in China. International Journal of Economics and Finance, 1(2), 232-237.

Hye, Q.M.A., Riaz, S. (2008), Causality between energy consumption and economic growth: The case of Pakistan. The Lahore Journal of Economics, 13(2), 45-58.

Johansen, S. (1988), Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 122(2-3), 231-254.

Johansen, S., Juselius, K. (1990), Maxsimum likelihood estimation ınference on cointegration with applications to the demand for money. Oxford Bulletin of Economics and Statistics, 52(2), 169-210.

Karagöl, E., Erbaykal, E., Ertuğrul, H.M. (2007), Türkiye'de Ekonomik Büyüme ile Elektrik Tüketimi İlişkisi: Sınır TestiYyaklaşımı. Doğuş Üniversitesi Dergisi, 8(1), 72-80.

Kraft, J., Kraft, A. (1978), On the relationship between energy and GDP. Journal of Energy and Development, 3(2), 401-403.

Korkmaz, Ö., Develi, A. (2012), Türkiye'de birincil enerji kullanımı, üretimi ve gayri safi yurt içi hasıla (GSYİH) arasındaki ilişki. Dokuz Eylül Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 27(2), 1-25.

Lee, J., Strazicich, M.C. (2003), Minimum lagrange multiplier unit root test with two structural breaks. The Review of Economics and Statistics, 85(4), 1082-1089.

Lee, J., Strazicich, M.C. (2004), Minimum LM Unit Root Test with One Structural Break. Appalachian State University Working Papers, (04-17), 1-15.

Lumsdaine, R.L., Papell, D.H. (1997), Multiple trend breaks and the unit root hypothesis. Review of Economics and Statistics, 79(2), 212-218.

Le, K., Hassan, K., Gasbarro, D., Cullen, G. (2014), The relation between financial development, energy consumption and economic growth: Empirical evidence for the United States. 27th Australasian Finance and Banking Conference 2014, (August 20). Paper, Available from: http://www.ssrn.com/abstract=2484279 or http://www.dx.doi.org/10.2139/ssrn.2484279. [Last accessed on 2015 May 16].

Maki, D. (2012), Tests for cointegration allowing for an unknown number of breaks. Economic Modelling, 29(5), 2011-2015.

Ozturk, I., Acaravci, A. (2013), The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Economics, 36, 262-267.

Ozturk, I., Kaplan, M., Kalyoncu, H. (2013), The causal relationship between energy consumption and GDP in Turkey. Energy and Environment, 24(5), 727-734.

Perron, P. (1989), The great crash, the oil price shock, and the unit root hypothesis. Econometrica, 57(2), 1361-1401.

Philips, P., Perron, P. (1988), Testing for a unit root in time series regressions. Biometrica, 75(2), 345-346.

Saatci, M., Dumrul, Y. (2013), The relationship between energy consumption and economic growth: Evidence from a structural break analysis for Turkey. International Journal of Energy Economics and Policy, 3(1), 20-29.

Schmidt, P., Phillips, P.C.B. (1992), LM tests for a unit root in the presence of deterministic trends. Oxford Bulletin of Economics and Statistics, 54(3), 257-287.

Shahbaz, M., Ozturk, I., Afza, T., Ali, A. (2013), Revisiting the environmental kuznets curve in a global economy. Renewable and Sustainable Energy Reviews, 25, 494-502.

Sims, C. (1980), Macroeconomics and reality. Econometrica, 48(1), 1-48.

T.C. Enerji ve Tabii Kaynaklar Bakanlığı, Enerji ve Tabii Kaynaklar Görünümü, Sayı 6. Available from: http://www.enerji.gov.tr/Resources/Sites/1/Pages/Sayi_06/Sayi_06.html#p=21. [Last accessed on 2015 Mar 13].

Stern, D.I. (2000), Multivariate cointegration analysis of the role of energy in the US macroeconomy. Energy Economics, 22(2), 267-283.

Ucan, O., Aricioglu, E., Yucel, F. (2014), Energy consumption and economic growth nexus: evidence from developed countries in Europe. International Journal of Energy Economics and Policy, 4(3), 411-419.

Topallı, N., Alagöz, M. (2014), Energy consumption and economic growth ın Turkey: An empirical analysis. Selcuk University Journal of Institute of Social Sciences, 32, 151-159.

Yong-xiu, H., De-zhi, L., Yan, L. (2007), Research on the cointegration relationship of energy consumption and economy growth in beijing. WSEAS Transactıons on Environment and Development, 3(9), 165-170.

Yu, E.S., Hwang, B. (1984), The relationship between energy and GNP: Further results. Energy Economics, 6, 186-190.

Zivot, E., Andrews, D. (1992), Further evidence on the great crash, the oil-price shock and the unit-root hypothesis. Journal of Business Economic Statistics, 10(3), 251-270.