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The Relationship between Electricity Consumption and Economic Growth in the Selected Member Countries of the International Energy Agency (IEA): An ARDL Bounds Test Approach

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Abstract

In this study, the causality links between electricity consumption and economic growth are investigated for Turkey, the United Kingdom, Spain, Belgium and United States covering the period from 1964 to 2014. The results of autoregressive distributed lag (ARDL) approach, bounds testing and error correction model show that there is a positive one-way and statistically significant causality moving from electricity consumption to economic growth in the short- and long-run. The empirical results show that electricity consumption and economic growth are not neutral with respect to each other, and therefore energy conservation policies should not be applied. The growth hypothesis is valid for five IEA countries. Electricity consumption encouraging policies support to these countries economic growth.

Keywords: Electricity Consumption, Economic Growth, ARDL, Bounds Test, Cointegration.

JEL Classification: C22, Q43, Q48.

1. Introduction

Since the last quarter of the 20th century, the relationship between energy consumption and economic growth has become one of the most important topics discussed by the policy makers and economists. Energy demand and dependency of countries increased due to the reasons such as increased oil prices caused by the oil shocks of the

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1970s, new inventions, industrialization and globalization, which resulted in an unequal distribution of energy. Countries started to look for new energy resources, which made it inevitable to develop and implement energy policies. Nowadays, energy production and consumption stands as an important factor that defines political and social power of countries. According to Stern (2011), energy plays a complementary role to capital and labor in the production process, whose role in the conventional growth theories has been neglected. With the use of energy in the production process, efficiency of labor and capital increases together with the competitiveness of the countries. It was also proven by biophysical models that capital, labor and natural resources are not sufficient alone to complete the production process without energy. Stern advocates the argument, asserted in the biophysical models of growth, that energy plays a key role in economic growth.

Energy sources are classified into two categories: primary sources and secondary sources. Coal, raw oil, natural gas, wind and uranium are among the primary sources which can be used in their natural form, while the others obtained by processing primary sources are secondary sources. Generated from various sources and used in the production process together with different technologies, electrical energy is a secondary energy source commonly used by households, the industry and service sectors. Electrical energy is the most flexible form of energy requiring to constitute the infrastructure of socio economic development (Pao, 2009: 1779). A country's total and per-capita electricity consumption is considered as a measure of welfare.

In the past, electrical energy was used in a limited number of areas. However, with the technological developments, it is now used in a wide range of areas from industrial production to lightening and meeting all energy needs of a household. The demand for electrical energy is increasing as it is clean, practical to use and easily transformable into other energy sources. Any disruption in energy consumption can cause significant economic problems for countries. The 1973 oil crisis had a negative impact on countries' economic growth, production and employment capacities. Today, efforts are exerted to reduce the effect of oil on the economies of countries by means of encouraging the use of electrical energy. The use of internal combustion engines in automobiles is being replaced by the use of electric motors which run on electric power and reduces carbon emissions.

The International Energy Agency (IEA) was established in 1974 following the 1973 oil shock as an independent international organization to safeguard energy supplies, promote economic growth, and prevent deterioration in economic growth of countries because of the energy crisis. This study aims to compare Turkey and the four developed countries; United States, United Kingdom, Spain and Belgium which are among 29 member countries of the IEA in terms of the relationship between electricity consumption and economic growth. To the best of the authors' knowledge, this is the first study to investigate the relationship between electricity consumption and economic growth in these five IEA countries with ARDL, bounds testing procedure. Following the section that includes some theoretical information about energy and electrical energy, the second section presents electricity production and consumption of the five countries. The third section the review of the national and international literature that includes some empirical studies on electricity consumption and economic growth. The fourth section presents the data set and methodology, whereas the fifth section explains the empirical findings. Finally, the conclusion section includes an interpretation of the findings as well as some suggestions made to Turkish policy makers by taking account of the relationship between electricity consumption and economic growth in the four member states of the IEA.

2. Statistics of Electricity Production and Consumption of the Five IEA Countries

The role of electrical energy in countries' economies is increasing day to day. The European Union (EU) member states of Belgium, Spain, the UK as developed countries; Turkey as a developing country, and the US as the world's superpower are all among the members of the IEA.

The total electricity generation of the US amounted to 4274.5 TWh in 2013 and the country consumed 4095 TWh electricity in 2012 (IEA, 2014: 39). In 2013, 40.2% of electricity was consumed by commercial services, agriculture and the service sector, 36.9% was by the residential sector and 22.7% was by the industrial sector. 40.2% of the country's electricity generation was obtained from coal, 26.9% natural gas and 19.2% nuclear energy. The total share of renewable energy sources in electricity generation was 12.9%, (6.3% hydroelectricity, 4% wind and 0.4% solar energy) (IEA, 2014: 41).

In the UK, the total electricity generation was around 339 TWh in 2014 and 2015. In the same years, the total electricity consumption of the country amounted to 303 Twh (DUKES, 2016: 115). Coal's share in electricity generation fell from 30% to 22% in 2015 as compared to 2014, while the shares of natural gas, nuclear and renewable energy sources in generation increased by 30%, 21% and 25%, respectively. During the period of 2014-2015, low carbon emissions share in electricity's consumption increased from 39% to 46%. The UK implements environmentally friendly policies by generating electricity using renewable and clean energy sources.

Spain's total electricity generation was 274 TWh in 2014 and the total electricity consumption of the country was 237 TWh in 2013. 35.9% of electricity was consumed by the commercial services and agriculture, 30.6% was by the residential sector and 29.5% was by the industrial sector (IEA, 2015: 93). In 2014, 20.9% of electricity was generated from nuclear resources, 17.2% from natural gas, 16.3% from coal and 5.2% from oil. In 2014, 40.4% of Spain's electricity generation was from renewable energy sources including wind (19.1%), solar (5%) and hydro (14.3%) (IEA, 2015: 127).

Belgium's total electricity generation was 71.5 TWh, while the total electricity consumption of the country was 82 TWh in 2014 (IEA, 2016: 95). 46% of electricity was consumed by the industrial sector, 27.2% was by the agricultural sector and 23.1% by the residential sector. In 2014, 47.2% of Belgium's electricity generation was from nuclear sources, 27% from natural gas, 18.8% from renewable energy sources, 6.2% from coal and 0.2% from oil (IEA, 2016: 96).

Turkey's total electricity generation was 260 TWh in 2015 and the total electricity consumption was 207.4 TWh in 2014. 46.2% of electricity was consumed by the industrial sector, 30.1% was by the commercial, public services and agriculture, and 22.3% by the residential sector. In 2015, 38.6% of Turkey's energy generation was from natural gas, 28.3% from coal, 0.8% from oil and 32.3% from renewable energy sources. In the same year, the hydropower production as 66.9 TWh amounted to 25.8% of total electricity generation. This proportion corresponds to approximately 80% of electricity generation through renewable energy sources.

With the reduction of public sector's share in electrical energy and the increasing privatization, Turkey achieved compliance with the European standards. Turkey is among the IEA countries that have a high potential in terms of solar, wind and geothermal energy resources as well as having good records of using renewable energy sources in electricity generation (IEA, 2016: 165). In 2015, electricity generation from wind and solar sources amounted to 4.4% and 0.2%, respectively. Although the shares of both renewable energy sources in electricity generation were higher than those of the previous years, generation rates are still not at the desired level.

Established in 1970, the Turkish Electricity Authority (TEK) was the only institution in Turkey authorized to balance demand and supply in the electricity market until 1993. In 1993, it was restructured into the Turkish Electricity Generation and Transmission Company (TEIAŞ) and the Turkish Electricity Distribution Company (TEDAŞ) (World Bank, 2015:19). With the adoption of the Electricity Market Law No. 4628 in 2001, an important step was taken for the liberalization of the electricity market, which was followed by a series of privatizations. This law also established the Energy Market Regulatory Authority (EPDK). With the enactment of the new Electricity Market Law No. 6446 in 2013, the Energy Markets Operation Company (EPİAŞ) was founded as a joint venture with its shares owned by TEIAS (30%), Istanbul Stock Exchange (currently Borsa Istanbul) (30%) and other electricity and gas market participants (40%) (World Bank, 2015:14). The law aimed to ensure efficiency of the electricity market. Since there is no nuclear power plant in Turkey, electricity generation from nuclear sources as an alternative is out of question. On the other hand, nuclear energy is commonly used in electricity generation in the other four members of IEA. Important achievements were made in Turkey's electricity energy policies with the decisions of privatization. It is of high importance for each of the five IEA members to use environmentally friendly sources in energy generation.

3. Literature Review

The relationship between electricity consumption and economic growth can be synthesized into four testable hypotheses. Based on these hypotheses, policies that promote energy conservation (saving) or energy consumption are implemented. 1) Neutral hypothesis: This hypothesis assumes that there is no relationship between electricity consumption and gross domestic product, thus electricity consumption has no effect on economic growth. 2) Feedback hypothesis: This hypothesis assumes that bidirectional causality exists between electricity consumption and gross domestic product, thus one of these two policies can be implemented depending on the course of the economy. Any decrease in electricity consumption may affect economic growth adversely. 3) Conservation hypothesis: It assumes that increasing gross domestic product also increases electricity consumption, thus policies promoting electricity consumption have no positive effect on economic growth. Energy conservation policies can be implemented. 4) Growth hypothesis: It assumes the existence of unidirectional causality from electricity consumption to gross domestic product, thus policies promoting electricity consumption increase economic growth, whereas energy conservation policies damage the economy. (Alshehry & Belloumi, 2015:238, Bhattacharya et al., 2016:734, Al-mulali et al., 2013:210) Since this study aims to examine the causal link between electricity consumption and economic growth, only the studies examining the relationship between economic growth and electricity consumption are included in the literature summary.

Murray and Nan (1996) used the Granger causality analysis from 1970 to 1990 for selected 23 countries and found that there is no causality between electricity consumption and economic growth for the UK and US, and there is a unidirectional causality running from electricity consumption to economic growth for Turkey. The first study examining the relationship between economic growth and electricity consumption for only Turkey was conducted by Terzi (1998), and it was found that there was a bidirectional causal link between economic growth and electricity consumption. Other studies conducted in this regard in Turkey mostly reported a unidirectional causality from electricity consumption to economic growth, despite differences in methods and periods. Terzi (1998) utilized Engle-Granger cointegration approach and error correction model covering the period of 1950-1991, and found that there was a short-run bidirectional causality between economic growth and electricity consumption by the commercial and industrial sectors. Yang (2000) employed Granger-causality test from the period 1954 to 1997 for Taiwan, and found that a short-run bidirectional causality between electricity consumption and economic growth. Aqeel & Butt (2001) used Hsiao's version of Granger causality from the period 1955 to 1996 for Pakistan and concluded the existence of a short-run unidirectional causality from electricity consumption to economic growth. Ghosh (2002) performed the Granger causality analysis covering the period from 1950 to 1997 in India and reported the existence of a short-run unidirectional causality from gross domestic product per capita to electricity consumption per capita. Shiu & Lam (2004) performed the Johansen-Juselius cointegration analysis and error correction model from the period 1971 to 2000 for China and reported the existence of a short-run unidirectional causality running from electricity consumption to economic growth. Altinay & Karagol (2005) used the Dolado-Lütkepohl causality analysis covering the period of 1950 to 2000 in Turkey and found a unidirectional causality from electricity consumption to economic growth. Yoo (2005) examined the existence of causality between electricity consumption and economic growth in South Korea over the period 1970-2002 using the Johansen-Juselius cointegration approach and error correction model, and found that a long-run unidirectional causality from economic growth to electricity consumption and a short-run unidirectional causality from electricity consumption to economic growth. Yoo (2006) also investigated the causal link between electricity consumption and economic growth for four ASEAN countries namely, Indonesia, Malaysia, Singapore, and Thailand during the period from 1971 to 2002 employing the Hsiao's version of Granger causality test. The author reported the presence of a short-run bidirectional causality between electricity consumption and economic growth in Malaysia and Singapore. For Indonesia and Thailand, the findings implied the existence of a short-run unidirectional causality from economic growth to electricity consumption. Chen, Kuo & Chen (2007) applied the Pedroni cointegration test and panel error correction model on a sample which includes 10 Asian countries over the period from 1971 to 2001, and found the evidence of long-term unidirectional causality running from economic growth to electricity consumption in the case of Hong Kong and Korea, and from electricity consumption to economic growth for Indonesia. The authors also found a short-run unidirectional causality running from electricity consumption to economic growth for Hong Kong, and from economic growth to electricity consumption for India, Malaysia, the Philippines, and Singapore. Karagol, Erbaykal & Ertugrul (2007) used the ARDL bounds testing and error correction model from 1974 to 2004 and revealed that there was both a short- and long-run causality running from electricity consumption to economic growth in Turkey. Mozumder & Marathe (2007) utilized Johansen-Juselius cointegration test and vector error correction model covering the period of 1971-1999 in Bangladesh and found evidence of a short-run unidirectional causality from real GDP per capita to electricity consumption per capita. Yuan, Zhao, Yu & Hu (2007) applied the Johansen-Juselius cointegration test and error correction model covering the period from 1978 to 2004 in China and reported the presence of a unidirectional causality from electricity consumption to economic growth both in the short- and long-run. Narayan & Prasad (2008) employed bootstrapped causality testing approach from 1970 to 2002 for US, from 1960 to 2002 for the rest of the OECD countries and reported that there is no causality between electricity consumption and economic growth for Belgium, Spain, US and Turkey, there is a unidirectional causality running from electricity consumption to economic growth for the UK. Acaravci (2009) utilized the ARDL bounds testing and error correction model covering the period from 1977 to 2006 in Turkey and reported the presence of a long-run unidirectional causality from electricity consumption to economic growth. Ghosh (2009) conducted ARDL bounds testing and error correction model from 1970 to 2006 for India, and found that there was both a short- and long-run unidirectional causality running from economic growth to electricity consumption. Odhiambo (2009) applied the Johansen-Juselius cointegration test and error correction model from 1971 to 2006 in North Africa and reported the presence of both short- and long-run bidirectional causality between electricity consumption and economic growth. Ciarreta & Zarraga (2010) used the Dolado-Lütkepohl and Toda-Yamamoto causality analysis from 1971 to 2005 for Spain and found that unidirectional linear causality running from economic growth to electricity consumption. Quedraogo (2010) utilized ARDL bounds testing and error correction model from 1968 to 2003 for Burkina Faso and found that there was both a short- and a long-run bidirectional causality between economic growth and electricity consumption. Yaprakli & Yurttancikmaz (2012) used the Johansen-Juselius cointegration test and error correction model covering the period of 1970-2010 in Turkey and found evidence of both short- and long-run bidirectional causality between economic growth and electricity consumption. Gurgul & Lach (2012) applied the Johansen-Juselius cointegration test, the Toda-Yamamoto and Dick-Panchenko nonlinear causality tests covering the period of 2000q1-2009q4 in Poland and reported the presence of a bidirectional causality between electricity consumption and economic growth. Saatci & Dumrul (2013) examined the existence of a causal relationship between electricity consumption and economic growth for the period from 1960 to 2008 using the Johansen-Juselius cointegration analysis, the dynamic ordinary least squares and fully modified ordinary least squares methods in Turkey. They revealed that 1% increase in electricity consumption increased economic growth by 0.33% to 0.37%. Nazlioglu, Kayhan & Adiguzel (2014) used ARDL bounds testing and error correction model from 1967 to 2007 for Turkey and found the presence of a bidirectional causality between electricity consumption and economic growth. They also performed the Diks-Panchenko nonlinear causality test and found that there was no causality between these two variables, suggesting that energy conservation policies would not have any adverse effect on Turkey's economic growth. Kumar, Stauvermann & Patel (2015) utilized ARDL bounds testing and the Toda-Yamamoto causality test for Gibraltar and found that electricity consumption had a positive effect in the GDP per capita both in the short- and long-run. Gokten &

Karatepe (2016) employed Dolado-Lütkepohl causality analysis covering the period of 1950-2010 in Turkey and found the existence of a unidirectional causality from electricity consumption to economic growth. Hwang & Yoo (2016) used the Engle-Granger cointegration test and Hsiao's version of Granger causality analysis from 1971 to 2010 for Nicaragua and reported that electricity consumption affected economic growth in the short-run. Pata & Terzi (2016) used the Johansen-Juselius cointegration test and the Dolado-Lütkepohl VAR Granger causality analysis built into a seemingly unrelated regression (SUR) form covering the period 1972-2011 for Turkey and found that electricity consumption increased economic growth in the short-run. Pata & Terzi (2017) also examined the relationship between electricity consumption and economic growth for the period of 1960-2014 in Turkey by employing ARDL, bounds testing approach, and they found that electricity consumption positively affect economic growth both short- and long-run.

4. Data and Methodology

4.1. Data source and Descriptive Statistics

This study was conducted using annual data covering the period from 1964 to 2014. Y represents the gross domestic product and EC represents the total electricity consumption. Among the variables incorporated into the analysis, EC in kilowatt-hour (KWh) was calculated by multiplying electricity consumption per capita by population sizes of the countries. Y was converted into real GDP in dollars based on the 2010 prices. Both variables were obtained from the World Bank's World Developments Indicators (WDI) database. Table 1 shows a strong positive relationship among the series with Pearson coefficient values close to 1 and statistically significant.

Table 1: Descriptive Statistics and Pearson Correlation Coefficients

Country	Statistics	Y	EC	ΔY	ΔEC
Turkey	Mean	11.50	10.60	0.02	0.03
	Median	11.51	10.67	0.02	0.03
	Std. Dev.	0.27	0.52	0.02	0.02
	Correlation	0.99***			
US	Mean	12.93	12.41	0.01	0.01
	Median	12.95	12.45	0.01	0.01
	Std. Dev.	0.19	0.18	0.01	0.01
	Correlation	0.98***			
UK	Mean	12.19	11.46	0.01	0.01
	Median	12.21	11.48	0.01	0.01
	Std. Dev.	0.15	0.09	0.01	0.01
	Correlation	0.96***			
Belgium	Mean	11.49	10.75	0.01	0.01
	Median	11.51	10.79	0.01	0.01
	Std. Dev.	0.15	0.20	0.01	0.02
	Correlation	0.99***			
Spain	Mean	11.91	11.08	0.01	0.02
	Median	11.92	11.13	0.01	0.02
	Std. Dev.	0.19	0.30	0.01	0.02
	Correlation	0.99***			

Note: *** significant at %1 level.

4.2. ADF and PP Unit Root Tests

In the Augmented Dickey Fuller (ADF) unit root test which was developed by Dickey & Fuller (1981) is commonly used to test the stationarity of time series, the null hypothesis H_0 means the series contain a unit root (they are not stationary), whereas the alternative hypothesis means series do not contain a unit root (they are stationary). The PP Unit Root Test developed by Phillips & Perron (1988) is different from the ADF test in that error terms are statistically weakly dependent and heterogeneously distributed. While calculating the t-statistics with this test, the Newey-West estimator (1986) is used to solve the problem of autocorrelation by making nonparametric corrections using moving averages. If the test statistics are found to be larger than the critical values at the MacKinnon table in both unit root tests, the null hypothesis is rejected and the series are confirmed to be stationary.

4.3. ARDL, Bounds Test

The ARDL approach to cointegration introduced by Pesaran & Shin

(1999) and then developed into its current form by Pesaran, Shin & Smith (2001) is advantageous over other similar cointegration tests in many aspects. Contrary to other techniques, the ARDL does not require stationarity at the same level. Thus, one of the series can be stationary at level I(0), while the other can be stationary at first difference I(1). Since there is no table of critical values to test the presence of cointegration between the series when they are stationary at the second difference I(2), unit root tests are used to prove that the variables are not stationary at the second difference I(2). Another advantage of the ARDL approach is that it can give more reliable results even when the sample size is small.

In the bounds testing, long-run coefficients are not restricted and included in the model, which provides an advantage in the estimation compared to the other cointegration methods. The unrestricted error correction model (UECM) is used to estimate a long-run cointegration from which the F-statistic is obtained.

$$\Delta Y_t=\alpha_0+\alpha_1 Trend+\sum_{i=1}^{k}\alpha_i\,\Delta Y_{t-i}+\sum_{i=0}^{l}\lambda_i\,\Delta EC_{t-i}+\beta_1 Y_{t-1}+\beta_2 EC_{1t-1}+\ldots+\beta_k EC_{kt-1}+u_t \qquad (1)$$

In Equation 1, ΔY_t is the first difference of the dependent variable; α_0 is the constant; α_1 is the coefficient of the trend; α_i, λ_i, β_1, β_2 and β_k are the coefficients and u_t is the error term. In Equation, dependent and independent variables are differenced in the explanatory variable section. However, the lag of the dependent variable starts at 1, while that of the independent variable starts at 0. The optimal lag length is determined based on the information criteria such as Akaike, Schwarz and Hannan-Quinn. After the optimal lag length has been determined, the coefficients β_1, β_2 … β_k are tested to confirm whether they are equal to 0. Finally, it is determined whether there is a cointegration relationship between the variables. If any of these coefficients are different from 0, the null hypothesis $H_0 : \beta_1= \beta_2=\ldots= \beta_k= 0$ is rejected, or vice versa.

The bounds test is performed using statistically appropriate models. In this study, using Equation 1, we tested whether the coefficients β_1, β_2 and β_k for Model I (no trend and no intercept), the coefficients α_1, β_1, β_2 and β_k for Model IV (unrestricted intercept and restricted trend) and the coefficients β_1, β_2 and β_k for Model V (unrestricted intercept and unrestricted trend) were equal to 0 (Pesaran, Shin & Smith, 2001: 298-299). The F-statistic was compared with the critical values set out by Pesaran, Shin & Smith (2001). When the value was lower than the critical value of lower bound I(0), H_0 was accepted, meaning that there was no cointegration. When the F-statistic was higher the critical value of upper bound I(1), H_0 was rejected, pointing out the presence of cointegration between the series. In this case, an error correction model was used to estimate long- and short-run coefficients. When the computed F-statistic fell between I(0) and I(1), it was inconclusive whether cointegration existed, or not. Thus, the use of other cointegration tests is recommended.

$$Y_t = \alpha_0 + \alpha_1 Trend + \sum_{i=1}^{j} \alpha_1 Y_{t-i} + \sum_{i=0}^{f} \alpha_2 EC_{t-i} + \varepsilon_t \qquad (2)$$

Equation 2 estimates the long-term coefficients of two cointegrated variables. To estimate short-run coefficients, an error correction model is established by taking one lag of the error correction term (ECT) obtained from Equation 2. This term is the lagged residuals of the model obtained in the long-run.

$$\Delta Y_t = \alpha_0 + \alpha_1 Trend + \sum_{i=1}^{k} \alpha_i \Delta Y_{t-i} + \sum_{i=0}^{l} \lambda_i \Delta EC_{t-i} + \delta ECM_{t-1} + u_t \qquad (3)$$

ECT is used to estimate to what extent the imbalance that occurred in the short-run can be eliminated in the long-run. The coefficient (δ) of the error correction term must be between 0 and -1 and statistically significant in Equation 3.

5. Empirical Results

We performed the ADF and PP unit root tests to analyze whether the series are I(2). Table 2 shows the results of the ADF and PP unit root tests. According to the results, the gross domestic product series is stationary for the Belgium and Spain at the level values I(0), and stationary for the UK, US, and Turkey at the first-difference level I(1). The electricity consumption series is stationary at the level values I(0) for all of the five countries.

Table 2: ADF and PP Unit Root Test Results

	Test		Turkey	US	UK	Belgium	Spain
Y	ADF	C	-1.00	-1.68	-1.24	-3.82***	-2.07
		C+t	-3.31	-1.64	-2.90	-1.97	-2.33
	PP	C	-1.13	-2.75	-1.22	-3.79***	-3.05**
		C+t	-3.37	-1.59	-1.67	-1.97	-1.78
EC	ADF	C	-4.70***	-6.31***	-4.35***	-5.32***	-2.34
		C+t	-1.40	-2.22	-1.51	-1.12	-2.48
	PP	C	-4.78***	-6.31***	-3.79***	-5.91***	-5.23***
		C+t	-1.14	-2.22	-1.70	-0.89	-2.11
ΔY	ADF	C	-7.13***	-5.15***	-4.83***	-5.47***	-2.92
		C+t	-7.17***	-5.43***	-4.87***	-6.58***	-3.39
	PP	C	-7.14***	-4.99***	-4.77***	-5.57***	-2.91
		C+t	-7.26***	-5.30***	-4.67***	-6.59***	-3.42
ΔEC	ADF	C	-4.26***	-4.70***	-4.82***	-1.35	-1.68
		C+t	-5.48***	-6.98***	-5.80***	-7.70***	-2.51
	PP	C	-4.26***	-4.81***	-4.88***	-5.24***	-2.44
		C+t	-5.30***	-6.98***	-5.83***	-7.70***	-4.57***

Notes: *** and ** denotes statistical significance at 1%, 5% level respectively.

The optimal lag lengths are determined by the Schwarz information criterion (SIC) in ADF.

Table 3: Bounds Test Results

k=1	Turkey	US	UK	Belgium	Spain
Model I				7.42***	
Model IV	11.99***	5.39**	7.12***		7.45***
Model V	16.26***		9.17**		9.87***

Notes: The critical values were obtained from the study by Pesaran et al. (2001). The lower and upper bound critical values were as follows: 4.81 and 6.82 at the significance level of 1%, 3.15 and 4.11 at the significance level of 5% for Model I; 6.10 and 6.73 at the significance level of 1%, 4.68 and 5.15 at the significance level of 5% for Model IV; 8.74 and 9.63 at the significance level of 1%, 6.56 and 7.30 at the significance level of 5% for Model V. *** and ** denotes statistical significance at 1% and 5% level respectively.

Table 4 shows the coefficients of the ARDL models whose optimal lag lengths were found based on the AIC following the determination of long-run cointegration. The JB tests confirm the normality of the estimated residuals. The RESET test support that there is no specification error. The White, BGP and ARCH tests confirm that the residuals are homoscedastic. The LM test does not reject the null hypothesis of no autocorrelation.

Table 4: Estimated ARDL Equations

Countries	Turkey	US	UK	Belgium	Spain
Constant	7.06*** [5.67]	1.77** [2.43]	2.97*** [3.98]		2.12*** [4.27]
Trend	0.01*** [5.50]	0.002*** [2.71]	0.003*** [4.39]		0.002*** [3.96]
Y(-1)	0.26 [2.00]**	1.09*** [10.36]	0.96*** [8.40]	0.99*** [63.11]	1.21*** [10.58]
Y(-2)		-0.32*** [-2.98]	-0.35*** [-3.31]		-0.60*** [-3.26]
Y(-3)					0.44** [2.38]
Y(-4)					-0.33*** [-3.03]
EC	0.74*** [7.40]	0.56*** [6.46]	0.50*** [6.12]	0.39*** [6.58]	0.41*** [5.96]
EC(-1)	-0.25 [-1.28]	-0.47*** [-5.56]	-0.36 [-4.00]***	-0.25*** [-2.98]	-0.30*** [-4.18]
EC(-2)	-0.20 [-1.20]			-0.12** [-2.22]	
EC(-3)	-0.06 [-0.41]				
EC(-4)	-0.24** [-2.27]				
TB2001	-0.02** [-2.50]				
ARDL	(1,4)	(2,1)	(2,1)	(1,2)	(4,1)
Diagnostics Tests					
LM	0.31(0.87)	1.44(0.25)	2.22(0.12)	0.89(0.42)	1.10(0.37)
JB	2.33(0.31)	2.98(0.23)	1.41(0.49)	0.49(0.78)	1.42(0.49)
BPG	0.68(0.70)	0.37(0.87)	0.33(0.89)	0.74(0.57)	1.03(0.43)
White	0.76(0.64)	0.60(0.70)	0.30(0.91)	0.73(0.57)	0.68(0.69)
ARCH	1.87(0.14)	0.04(0.96)	0.83(0.44)	0.43(0.65)	0.13(0.97)
RESET	2.34(0.13)	0.60(0.55)	1.68(0.10)	0.44(0.51)	0.33(0.57)

Note: [ ]: t-statistics value, ( ): probability value. ** and *** denotes statistical significance at 1%, 5% level respectively.

Table 5 demonstrates the long-run coefficients obtained from Equation 2 and the results of the error correction model obtained using Equation 3. The coefficient of the error correction model is statistically significant and has a minus (-) sign for all countries. The effects of any shock will be balanced in the following period at the rates of 77% in Turkey, 38% in the UK, 23% in the US, 1% in the Belgium and 28% in Spain. The statistical significance of the estimated coefficient of the first difference and level of EC shows that there is a positive and statistically significant unidirectional causality from electricity consumption to Y both in the long- and short-run in five member countries of IEA.

Table 5: Short and Long Run Coefficients

Countries	Turkey	US	UK	Belgium	Spain
ΔY(-1)		0.33*** [3.15]	0.35*** [3.45]		0.49*** [5.13]
ΔY(-2)					-0.11 [-0.94]
ΔY(-3)					0.33*** [3.11]
ΔEC	0.75*** [8.96]	0.56*** [7.56]	0.50*** [7.01]	0.39*** [7.89]	0.41*** [7.56]
ΔEC(-1)	0.37*** [2.97]			0.12** [2.47]	
ΔEC(-2)	0.21* [1.89]				
ΔEC(-3)	0.25** [2.41]				
C	7.32*** [6.21]		2.98*** [4.74]		2.12*** [4.85]
ECT(-1)	-0.77*** [-6.21]	-0.23*** [-4.12]	-0.38*** [-4.73]	-0.01*** [3.90]	-0.28*** [-4.85]
EC	0.15*** [4.51]	0.41*** [4.24]	0.37*** [4.59]	1.10*** [21.92]	0.38*** [7.42]
TB2001	-0.03** [-2.37]				
TREND	0.01*** [12.78]	0.01*** [8.52]	0.01*** [17.18]		0.006*** [6.65]

Notes: [ ]: t-statistics value, ( ): probability value. ** and *** denotes statistical significance at 1% and 5% level respectively.

In addition to the diagnostic tests, we also performed the Cusum and Cusum-sq tests developed by Brown et al. (1975). Figure 1 and Table 6 show the results of the tests confirming that the estimators are stable for all of the five countries.

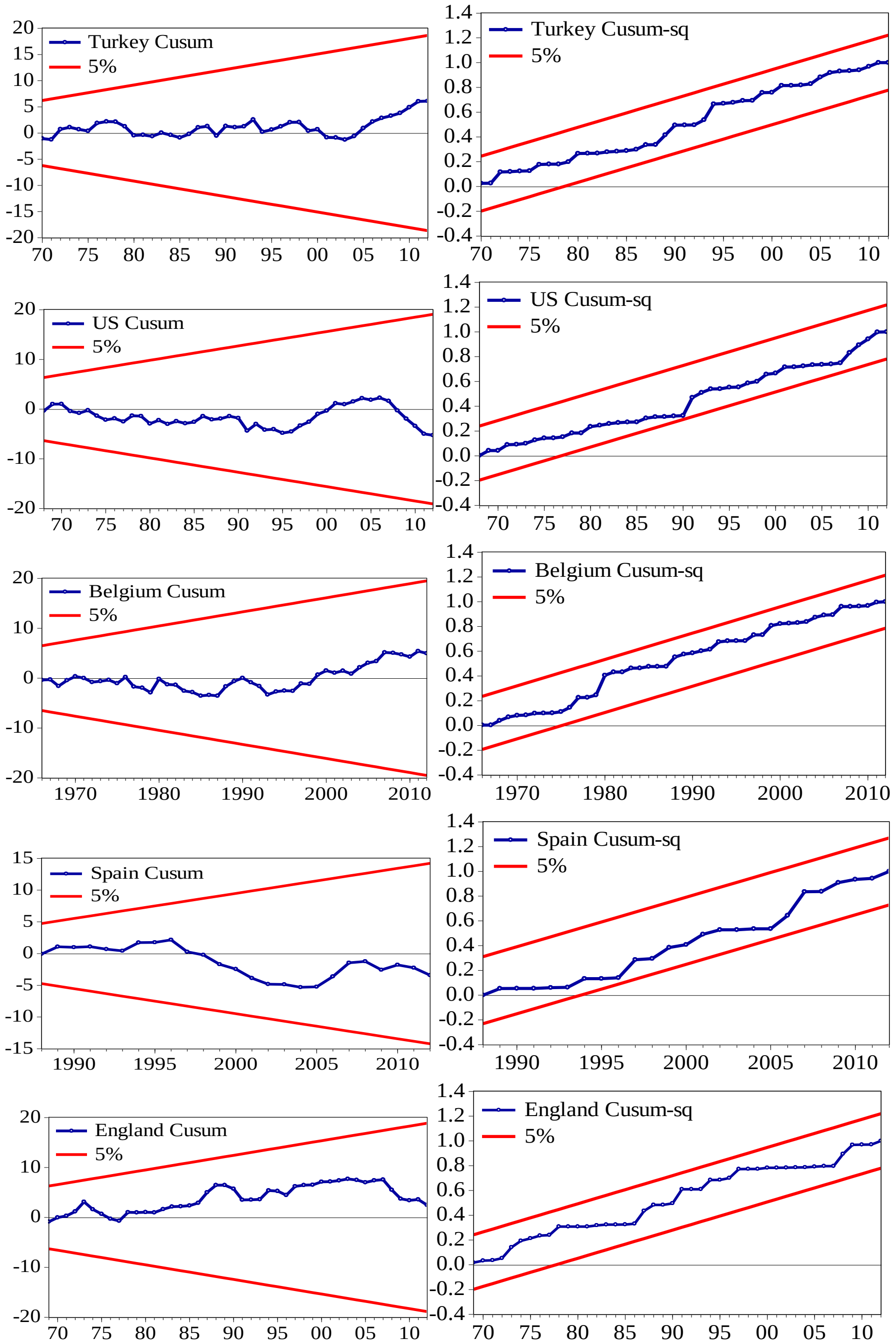

Figure 1: Cusum and Cusum-sq Tests

Table 6: Cusum and Cusum Square Tests Results

Countries	Cusum Test		Cusum-sq Test	
	Test statistic	p-value	Test statistic	p-value
Turkey	0.32	1.00	0.16	0.48
US	0.32	1.00	0.17	0.33
UK	0.43	0.83	0.11	0.90
Belgium	0.34	1.00	0.13	0.64
Spain	0.29	0.96	0.35	0.93

6. Conclusions

In today's societies where the process of globalization is experienced intensely, electricity is becoming more and more important as one of the key indicators of economic prosperity. Thus, electrical energy constitutes an important part of the energy products. With the industrialization and increasing population, the world economy not only aim to increase their production capacities, but also achieve growth together with sustainable environmental quality. Therefore, the use of environmentally friendly energy sources is encouraged. Since electricity is an environmentally friendly source of energy, it plays an important role in the economic growth and development policies of the countries.

This study analyzed the causality between electricity consumption (EC) and economic growth (Y) in Turkey, the UK, Belgium, US and Spain. As a result of the unit root tests, integration degrees of the series were found to be different. Therefore, the ARDL bounds testing approach was used. According to the results of the test, there is a positive and statistically significant unidirectional causality from electricity consumption to economic growth both in the long- and short-run for all of the five member states of the IEA.

Stern's (2011) argument about the important role of energy in economic growth is suitable for these five countries, whereas the assumptions of the neo-classical growth model are not valid. Our findings show that the growth hypothesis is valid in all of the five economies. Energy conservation policies were found to have a negative effect on the economic growth of these IEA member states. Electrical energy is of high importance for the economies of these developed countries, i.e. Spain, Belgium, the UK and the US. As a country aiming to break into the world's top 10 leading economies, Turkey must give due importance to electrical energy. To sustain their economic growth, countries should encourage electricity consumption and diversify their sources of supply to generate electrical energy.

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