Govdeli, T. / Journal of Yasar University, 2019, 14/54, 96-105

# Electricity Consumption, Oil Prices, Gross Fixed Investment and Economic Growth: Evidence From G7 Countries

## Elektrik Tüketimi, Petrol Fiyatı, Sabit Sermaye Yatırımları ve Ekonomik Büyüme: G7 Ülkelerinden Kanıtlar

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*Abstract: In this study, the relationship between economic growth and electricity consumption, oil price and gross fixed investment for the period of 1980 to 2017 of G7 countries was empirically analyzed. For this purpose, firstly, the stationarities of each country series were determined. The ARDL bound test has been passed because the series are stationary in I (0) or I (1). According to the ARDL bound test results, electricity consumption and gross fixed investment have a positive impact on economic growth. In the Granger causality test, there is unidirectional Granger causality running from economic growth to electricity consumption and from economic growth to gross fixed investment in USA. In Canada, uni-directional running from economic growth to gross fixed investment, gross fixed investment to electricity consumption and oil price to gross fixed investment are found. Additionally, bi-directional causality relationship between economic growth and electricity consumption, economic growth and oil price was determined. In Japan, oil price is the cause of fixed capital investments, economic growth is the cause of oil price and electricity consumption is the cause of oil price.*

*Keywords: Electricity Consumption, Oil Price, Economic Growth, Gross Fixed İnvestment, ARDL Bound Test*

*Öz: Çalışmada G7 ülkelerinin 1980 ile 2017 dönemi boyunda ekonomik büyüme ile elektrik tüketimi, petrol fiyatı ve sabit sermaye yatırımları arasındaki ilişki ampirik olarak analiz edilmiştir. Bu amaçla öncelikle her ülke serilerinin durağanlıkları tespit edilmiştir. Seriler I(0) veya I(1)'de durağan olmaları nedeniyle ARDL sınır testine geçilmiştir. ARDL sınır testi sonuçlarına göre elektrik tüketimi ve sabit sermaye yatırımları ekonomik büyümeyi olumlu etkilemektedir. Granger nedensellik testi sonuçlarında, ABD'de ekonomik büyümeden elektrik tüketimine doğru ve ekonomik büyümeden sabit sermaye yatırımlarına doğru tek yönlü nedensellik tespit edilmiştir. Kanada'da ekonomik büyüme sabit sermaye yatırımlarının nedenseli, sabit sermaye yatırımları elektrik tüketiminin nedenseli ve petrol fiyatı sabit sermaye yatırımlarının nedenselidir. Ayrıca, ekonomik büyüme ile elektrik tüketimi arasında ve petrol fiyatı arasında çift yönlü nedensellik ilişkisi tespit edilmiştir. Japonya'da petrol fiyatı sabit sermaye yatırımlarının nedenseli, ekonomik büyüme petrol fiyatının nedenseli ve elektrik tüketimi petrol fiyatının nedenselidir.*

*Anahtar Sözcükler: Elektrik Tüketimi, Petrol Fiyatı, Ekonomik Büyüme, Sabit Sermaye Yatırımları, ARDL Sınır Testi*

## 1. Introduction

Oil is a strategic resource which is a determining factor of a country's economy. Fluctuations in oil prices directly affect any country's' targets for the future. Economic activities, domestic price movements, economic growth and labor markets are negatively affected if foreign countries depend on these fluctuations. Positive oil shocks affect oil exporting countries differently compared to importing countries. Although oil prices are seen as an advantage for oil exporting countries, it is seen negatively for oil importing countries. The decline in oil prices is just the opposite (Berument et al., 2010).

Approximately 50 years ago, the oil crisis of 1973-1974 occurred at the same time as a new crude oil regime emerged in the global market. With the oil crisis, the oil price quadrupled in that quarter. Even worse, some governments in industrialized countries have put the price of domestic crude oil and refined petroleum products, such as gasoline, topping the petrol stations and causing long queues. In addition, many governments imposed speed limits, banned automobile traffic on Sundays or made limited retail gasoline purchases (Baumeister and Kilian, 2016). This oil crisis has shown that with any country, all individuals are affected by such crises.

The fluctuations in oil prices affect the real economies of the countries on the demand and supply side. Supply-side effects are related to the fact that crude oil is the main input to production, hence the increase in oil prices leads to an increase in production costs, which leads to a reduction in firms' production. Changes in oil prices also carry demand-side effects on consumption and investment. Consumption is indirectly affected by a positive relationship with disposable income. When the oil shock is long-term, the magnitude of this effect is greater felt. Moreover, oil prices have a negative impact on investment due to increasing company costs. In addition to the previously discussed effects of oil prices on supply and demand, it should be noted that the changes in oil prices have affected the foreign exchange market and inflation, thereby causing indirect effects on real activity (Jimenez-Rodríguez and Sanchez, 2005). In addition, oil is directly linked to production processes so it can significantly impact inflation, employment and output. An oil price shock may increase production costs and lead to an increase in general prices. At the same time, inflationary pressure will lead to a decline in demand, leading to a cut in production, which may lead to unemployment by affecting employment rates (Loungani, 1986; Rafiq et al., 2009).

Previous economic theorists, such as Solow, could not explain how technological developments emerged, so this model assumes that technological change is exogenous and does not generate energy. However, some economists believe that energy plays an important role in economic growth, as well as being an important factor in explaining the industrial revolution (Allen, 2009). In addition, some economists, such as Hall et al. (2003), state that increases in energy consumption have the most significant increase in productivity, or that innovation in technological change encourages greater energy consumption and increases productivity. Energy use is therefore seen as a potential source of economic growth. Identifying the direction of causality between energy consumption and economic growth provides important implications for the establishment of significant energy policies (Omri et al., 2015).

Climate change, recent nuclear accidents and geopolitical tensions have raised concerns about energy supply security and environmental impacts related to energy production-consumption. Some countries are currently implementing strong energy substitution policies and radical energy conservation measures. It is important to assess prospects for the success of these policies, including potential impacts on economic growth (Goldemberg and Lucon, 2010).

The main purpose of this study is to investigate the relationship between oil prices, electricity consumption, gross fixed investment and economic growth. The main factor behind the development of this model is to use empirical analysis of oil prices, electricity consumption and gross fixed investments which are important macroeconomic variables that affect economic growth.

In this study, G7 economies (USA, Germany, France, UK, Italy, Japan and Canada), which are one of the most developed countries in the world, were selected and annual data obtained between 1980 from 2017. The study consists of four parts. In the first part, there is the introductory section. The second part consists of the literature review. In the third chapter, the material and method part is detailed. In order to perform the ARDL boundary test and Granger causality test analysis, stationery stability was determined. It is determined that the series, which is the prerequisite of ARDL boundary test, is zero-order I(0) or first order I(1) stationary. According to these results, ARDL boundary test and Granger causality analysis were performed. The fourth part of the study contains the conclusions and recommendations.

## 2. Literature Review

The relationship between energy and economic growth can be seen as the focus of many studies. Energy is one of the main driving forces of economic growth. In recent years, studies on the relationship between energy consumption and economic growth have been increasing. Kraft and Kraft (1978) conducted the first study to empirically examine the relationship between energy consumption and economic growth.

In the literature, studies investigating economic growth and electricity consumption can be examined via three categorizations. On the supply-side hypothesis, there is a one-way causality relationship from electricity consumption to economic growth. The studies that support this hypothesis include the study of Malaysia during the period 1971 to 2003 (Chandran et al., 2010); the study of Turkey during the period 1950 to 2000 (Altinay and Karagol, 2005); the study of Vietnam during the period 1990 to 2015 (Long et al., 2018), and; the study of Turkey during the period 1972 to 2011 (Hossen and Hasan, 2005).

The demand-side hypothesis is the one-way causal relationship from economic growth to electricity consumption. The studies that support this hypothesis include the study of Portugal during the period 1971 to 2009 (Shahbaz et al., 2011); the study of Pakistan during the period 1960 to 2008 (Jamil and Ahmad, 2010); the study of Bangladesh during the period 1971 to 1999 (Mozumder and Marathe, 2007); the study of Estonia, Lithuania and Latvia during the period 1992 to 2011 (Furuoka, 2017); the study of Algeria during the period 1980 to 2012 (Bélaïd and Youssef, 2017), and; the study of 35 OECD countries during the period 1993 to 2014 (Kirikkaleli et al., 2018).

Studies supporting the feedback hypothesis that there is a bi-directional causality between economic growth and electricity consumption include the study of Tanzania during the period 1971 to 2006 (Odhiambo, 2009); the study of Burkina Faso during the period 1968 to 2003 (Ouedraogo, 2010); the study of 157 countries during the period 1960 to 2014 (Shahbaz et al., 2017); the study of 210 countries during the period 1960 to 2014 (Sarwar et al., 2017); the study of Middle Eastern countries during the period 1990 to 2008 (Al-Mulali and Che Sab, 2018), and; the study of the Mid North African Region during the period 1971 to 2014 (Boukhelkhal and Bengana, 2018).

Lardic and Mignon (2006) examined the long-term relationship between oil prices and economic growth and used quarterly data from Q1 in 1970 to Q4 in 2003 Q4 for 12 EU countries. The findings showed that the relationship between oil price and economic growth is asymmetric, in other words, the increase in total economic activity has greater influence than decreasing oil prices. Despite the rejection of the standard cointegration between the variables, most of the participating European countries show the asymmetric cointegration between oil prices and GDP.

In the empirical literature, the causality link between oil prices and economic growth exists for three possible relationships. First; there is a one-way causality relationship from oil prices to economic growth. These include the study of the industrialized G6 countries during the period 1965 to 2008 (Lee and Chiu, 2011); the study of the USA during the period 1947 to 2007 (Benhmad, 2013); the study of Nigeria during the period 1974 to 2014 (Gummi et al., 2017), and the study of the USA during the period 1989 to 2016 (Troster et al., 2017).

Secondly, there is a one-way causality relationship from economic growth to oil prices. The study of the Japan during the period 2000 to 2008 (Hanabusa, 2009); the study of the industrialized G6 countries during the period 1971 to 2010 (Chu and Chang, 2012); the study of the industrialized China and South Korea during the period 1965 to 2010 (Naser, 2014); are listed here.

Thirdly, there is a bidirectional causality relationship between economic growth and oil prices. This includes the study of Brazil, Russia, India, China, Turkey and South Korea during the period 1980 to 2011 (Bildirici and Bakirtas, 2009); the study of 23 African countries during the period 1985 to 2011 (Behmiri and Manso, 2013); the study of the

OECD and non-OECD countries during the period 1995 to 2009 (Zhu et al., 2011); the study of four south east Asian countries (Indonesia, Malaysia, Singapore and Thailand) during the period 1971 to 2002 (Yoo, 2006); the study of the 210 countries during the period 1960 to 2014 (Sarwar, 2017); and the study of the 157 countries during the period 1960 to 2014 (Shahbaz, 2017) which are listed.

## 3. Material and Methodology

In this study, gross domestic product (GDP) data (in current US $) as a representative of economic growth; electricity consumption (EC) factor kilowatt hour (MWh) electricity consumption data; gross fixed investments (GFC) data (in US $) and crude oil price (OP) data were used. GDP and GFC data were obtained from the World Bank database, EC data from International Energy Agency, OP data from BP Statistical Review of World Energy, 2018. This study analyzes G7 countries (USA, Germany, France, UK, Italy, Japan and Canada), and covers the period between 1980 and 2017. The natural logarithm of all data is included in the analysis.

The empirical analysis consists of three stages. First, the stability analysis of variables was determined with the help of ADF unit root tests. Next, the long and short term relationships between the variables were analyzed by the ARDL boundary test. Finally, with Granger causality test, causality between GDP, EC, GFC and OP were investigated.

### *3.1. Unit Root Analysis*

The preliminary and necessary step was to analyze the stationarity of the variables before performing the cointegration and causal test. The main reason for the stationarity analysis when using the ARDL model is to prevent the addition of variables from the second order difference I(2). The stationary order of variables was determined using Generalized Dickey and Fuller (ADF) test (Table 1).

Table 1. ADF Unit Root Test Results

| **Variables** | **Level** | | **1. Difference** | |
|---|---|---|---|---|
| | t-stats | p-value | t-stats | p-value |
| **USA** | | | | |
| **GDP** | -2.746 | 0.077 | -4.157* | 0.003 |
| **EC** | -2.331 | 0.169 | -6.076* | 0.000 |
| **GFC** | -1.064 | 0.718 | -3.469** | 0.015 |
| **OP** | -0.396 | 0.899 | -4.485* | 0.001 |
| **Germany** | | | | |
| **GDP** | -0.706 | 0.832 | -4.612* | 0.001 |
| **EC** | -2.103 | 0.245 | -5.398* | 0.000 |
| **GFC** | -0.707 | 0.832 | -4.628* | 0.001 |
| **OP** | -0.396 | 0.899 | -4.485* | 0.001 |
| **France** | | | | |
| **GDP** | -0.574 | 0.864 | -4.405* | 0.001 |
| **EC** | -3.967* | 0.004 | | |
| **GFC** | -0.420 | 0.895 | -4.137* | 0.003 |
| **OP** | -0.396 | 0.899 | -4.485* | 0.001 |
| **UK** | | | | |
| **GDP** | -0.635 | 0.850 | -3.641** | 0.010 |
| **EC** | -1.777 | 0.385 | -4.093* | 0.003 |
| **GFC** | -2.427 | 0.144 | -3.608** | 0.011 |
| **OP** | -0.396 | 0.899 | -4.485* | 0.001 |
| **Italy** | | | | |
| **GDP** | -1.210 | 0.659 | -4.316* | 0.002 |
| **EC** | -2.675 | 0.089 | -3.350** | 0.021 |
| **GFC** | -1.178 | 0.672 | -4.114* | 0.003 |
| **OP** | -0.396 | 0.899 | -4.485* | 0.001 |
| **Japan** | | | | |
| **GDP** | -2.616 | 0.100 | -3.731* | 0.008 |
| **EC** | -3.068** | 0.039 | | |
| **GFC** | -2.125 | 0.237 | -3.558** | 0.012 |
| **OP** | -0.396 | 0.899 | -5.984* | 0.000 |
| **Canada** | | | | |
| **GDP** | -0.624 | 0.852 | -4.242* | 0.002 |
| **EC** | -4.113* | 0.003 | | |
| **GFC** | 0.051 | 0.957 | -4.372* | 0.002 |
| **OP** | -0.396 | 0.899 | -4.485* | 0.001 |

*Not: *, ** and *** represents statistical significance at the 1%, 5% and 10% levels, respectively.*

The ADF unit root test results are given in Table 1. According to the findings, GDP, EC, GFC and OP series are unit root in level and they are stationary at 1th difference in Germany, UK and Italy. In the countries of France, Japan and Canada; GDP, GFC and OP series are unit rooted in I (0) and they are stationary in I(1), EC is stationary in I(0). EC, GFC and OP variables are stationary in I(1) in USA. According to the obtained ADF unit root results, the series, which is the prerequisite of ARDL boundary test, are provided as I(0) or I (1) are stationary.

### *3.2. Cointegration Analysis*

The main purpose of this study is to analyze the short and long term relationships between EC, OP, GFC and GDP in G-7 countries. For this, the autoregressive distributed lag (ARDL) model developed by Pesaran et al. (2001) was used. This model is widely used in empirical modeling due to its desired properties compared to the Johansen cointegration test developed by Johansen and Juselius (1990). Advantages of this model include; i) providing better results for small sample sizes (Ghatak and Siddiki, 2001). ii) The ARDL approach can be used for both I (0) and I (1) stationary series. This is not the case in the Johansen cointegration test. iii) The ARDL approach addresses the endogenous nature of some variables in the regression by providing long-term predictions with significant t-statistics (Odhiambo, 2009). iv) The ARDL approach allows the determination of a long term and short term effect of a variant at the same time (Bentzen and Engster, 2001).

After the stationary tests, long-term relationships between variables were calculated with the help of the following equation using the ARDL boundary test approach:

$$\Delta GDP = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i} \Delta GDP_{t-1} + \sum_{i=1}^{m} \alpha_{2i} \Delta EC_{t-1} + \sum_{i=1}^{m} \alpha_{3i} \Delta GFC_{t-1} + \sum_{i=1}^{m} \alpha_{4i} \Delta OP_{t-1} + \delta_1 GDP_{t-1} + \delta_2 EC_{t-1} + \delta_3 GFC_{t-1} + \delta_4 OP_{t-1} + \varepsilon_t \qquad (1)$$

In the equation (1), the delta operator, Δ; stands for the difference from first order, α; indicates parameters to be estimated, and finally $\varepsilon_t$ shows white noise error term with mean 0 and variance $\sigma^2$. The ARDL approach estimates the optimal lag length for each variable. Optimum lag length is selected according to the Akaike Information Criterion (AIC) or the Schwartz Information Criterion (SIC). The boundary test is not cointegrated and the null hypothesis is decided according to the Wald statistic or F statistic.

The $H_0$ hypothesis, "there is not cointegration between variables", is in the form of $H_0: \delta_1 = \delta_2 = \delta_3 = \delta_4 = 0$ and $H_1$ hypothesis $H_1: \delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq 0$ in Equation 1.

Table 2. Bound Test Results

| **Counties** | **$F_{GDP}$** | | **Critical Values** | | |
|---|---|---|---|---|---|
| | | | 1% | 5% | 10% |
| **USA** | 15.81* | I(0) | 3.65 | 2.79 | 2.37 |
| | | I(1) | 4.66 | 3.67 | 3.20 |
| **Germany** | 4.11** | I(0) | 3.65 | 2.79 | 2.37 |
| | | I(1) | 4.66 | 3.67 | 3.20 |
| **France** | 5.85* | I(0) | 3.65 | 2.79 | 2.37 |
| | | I(1) | 4.66 | 3.67 | 3.20 |
| **UK** | 4.72* | I(0) | 3.65 | 2.79 | 2.37 |
| | | I(1) | 4.66 | 3.67 | 3.20 |
| **Italy** | 12.11* | I(0) | 3.65 | 2.79 | 2.37 |
| | | I(1) | 4.66 | 3.67 | 3.20 |
| **Japan** | 6.98* | I(0) | 3.65 | 2.79 | 2.37 |
| | | I(1) | 4.66 | 3.67 | 3.20 |
| **Canada** | 4.69* | I(0) | 3.65 | 2.79 | 2.37 |
| | | I(1) | 4.66 | 3.67 | 3.20 |

*Not: *, ** and *** represents 1%, 5% and 10% respectively.*

Boundary test results are given in Table 2. In comparison to the critical values of Peseran, F statistics were found to be statistically significant at 1% in the USA, France, Italy, Japan and Canada, and in 5% in the UK and 10% in Germany. Accordingly, the cointegration relationship between the series was determined in all countries. Because of the cointegration between the series, the short and long term coefficients of the parameters can be estimated.

Table 3. Diagnostic Tests

| **Countries** | **LM test** (p-values) | **ARCH test** (p- values) | **RESET test** (p- values) | **Normality test** (p- values) |
|---|---|---|---|---|
| **USA** | 0.329 | 0.073 | 0.031 | 0.686 |
| **Germany** | 0.255 | 0.411 | 0.643 | 0.491 |
| **France** | 0.880 | 0.159 | 0.291 | 0.512 |
| **UK** | 0.588 | 0.815 | 0.557 | 0.904 |
| **Italy** | 0.493 | 0.401 | 0.042 | 0.070 |
| **Japan** | 0.345 | 0.595 | 0.573 | 0.489 |
| **Canada** | 0.160 | 0.994 | 0.595 | 0.264 |

Diagnostic tests for the ARDL model are presented in Table 3. When the results of the diagnostic tests were evaluated at the level of 1%, the LM test (Breusch-Godfrey Lagrange Multiplier) tests the autocorrelation problem. The findings show that there is no autocorrelation for any evaluated country. The ARCH test reveals the problem of heteroscedasticity, according to which there are no heteroscedasticity problems in the time series for G7 countries. The Ramsey RESET test is tested according to correct model specifications. According to the results of the reset test, the model is properly constructed and that the estimates obtained are reliable. Jarque-Bera Normality test shows that whether the error term is normally distributed. The error term for this model appears to be normally distributed for G7 countries according to the test results.

Table 4. Long Term Coefficient Results

| | **ARDL Estimates** | | **FMOLS Estimates** | | **DOLS Estimates** | |
|---|---|---|---|---|---|---|
| | **Coefficient** | **p-values** | **Coefficient** | **p-values** | **Coefficient** | **p-values** |
| **USA** | | | | | | |
| **EC** | -2.995 | 0.429 | 0.968* | 0.002 | 1.497* | 0.000 |
| **GFC** | 1.896 | 0.157 | 0.634* | 0.000 | 0.372** | 0.010 |
| **OP** | -0.089 | 0.640 | 0.077* | 0.004 | 0.126* | 0.000 |
| **Constant** | 43.246 | 0.364 | -9.616* | 0.002 | -14.008* | 0.000 |
| **Germany** | | | | | | |
| **EC** | 1.222 | 0.000 | 1.107* | 0.000 | 1.007* | 0.002 |
| **GFC** | 0.926 | 0.000 | 0.934* | 0.000 | 0.969* | 0.000 |
| **OP** | 0.032 | 0.117 | 0.052* | 0.000 | 0.062* | 0.002 |
| **Constant** | -21.168 | 0.000 | -19.136* | 0.000 | -18.134* | 0.001 |
| **France** | | | | | | |
| **EC** | 0.260** | 0.031 | 0.431* | 0.001 | 0.488** | 0.013 |
| **GFC** | 0.912* | 0.000 | 0.868* | 0.000 | 0.843* | 0.000 |
| **OP** | -0.062* | 0.001 | -0.035*** | 0.066 | -0.032 | 0.208 |
| **Constant** | -1.042 | 0.387 | -3.393* | 0.009 | -3.840*** | 0.053 |
| **UK** | | | | | | |
| **EC** | 0.104 | 0.877 | 1.343* | 0.003 | 1.518** | 0.014 |
| **GFC** | 1.321* | 0.000 | 0.821* | 0.000 | 0.824* | 0.000 |
| **OP** | -0.086 | 0.379 | 0.115* | 0.002 | 0.094*** | 0.074 |
| **Constant** | -9.120 | 0.476 | -29.604* | 0.001 | -34.226* | 0.006 |
| **Italy** | | | | | | |
| **EC** | 0.361 | 0.475 | 1.085* | 0.004 | 1.462* | 0.010 |
| **GFC** | 1.216* | 0.000 | 0.911* | 0.000 | 0.851* | 0.000 |
| **OP** | -0.054 | 0.455 | 0.100* | 0.005 | 0.093*** | 0.062 |
| **Constant** | -10.790 | 0.111 | -17.582* | 0.001 | -23.348* | 0.002 |
| **Japan** | | | | | | |
| **EC** | 0.759* | 0.000 | 0.723* | 0.000 | 0.733* | 0.003 |
| **GFC** | 0.755* | 0.000 | 0.780* | 0.000 | 0.754* | 0.000 |
| **OP** | 0.053* | 0.001 | 0.094* | 0.000 | 0.090* | 0.000 |
| **Constant** | -7.710* | 0.000 | -7.848* | 0.000 | -7.312* | 0.010 |
| **Canada** | | | | | | |
| **EC** | 0.731* | 0.000 | 0.848* | 0.000 | 0.682* | 0.001 |
| **GFC** | 0.691* | 0.000 | 0.710* | 0.000 | 0.708* | 0.000 |
| **OP** | 0.061*** | 0.063 | 0.048 | 0.106 | 0.057 | 0.178 |
| **Constant** | -5.256** | 0.021 | -8.086*** | 0.000 | -4.713** | 0.046 |

*Not: *, ** and *** represents 1%, 5% and 10% respectively.*

Table 4 presents the long-term coefficient estimates. The results of the ARDL test, the modified least squares (FMOLS) method and the dynamic least squares (DOLS) method were given in the estimation of long-term coefficients. The reason for the use of FMOLS and DOLS long-term coefficient estimators is that long-term coefficients can be interpreted more robustly.

The long-term coefficients obtained for the USA show a significant and positive relationship between EC and GDP. Two of the three coefficient estimators (FMOLS and DOLS) were statistically significant. Thus, the energy-driven growth hypothesis is confirmed for this country. The relationship between GFC and GDP is significant and positive compared to FMOLS and DOLS estimators. FMOLS and DOLS results are statistically significant in relation to OP and GDP. When the results of three estimators were examined in Japan, they were found that all three variables were statistically significant and positive. In the findings obtained for Canada, EC and GFC variables are statistically significant and positive compared to the three estimators. The OP variable was only significant at the level of 10% in the ARDL test.

When the long-term coefficients of four European countries (Germany, France, England and Italy) in the G7 are analyzed, the elasticity coefficient of EC in Germany and France is positive and statistically significant. The fact that all three estimations give similar results reinforces the accuracy of the findings. According to the results of FMOLS and DOLS for England and Italy, EC positively affects GDP and is statistically significant. In Germany, France, England and

Italy, the energy-driven growth hypothesis can be mentioned. For Germany, France, England and Italy, the results are significant and the flexibility coefficients are positive in all three estimators in relation to GFC and GDP. When the relationship between OP and GDP is examined it is seen that in Germany and UK, two estimators are statistically significant and positive, while in France, OP are negatively related to GDP.

When the GDP of G7 countries and the results of EC, GFC and OP are examined, the coefficients are generally consistent in all three estimators. The findings are consistent with Sarwar and Waheed (2017).

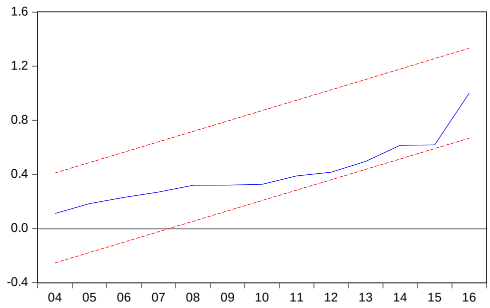
Table 5. Short Term Coefficient Results

| | **Coefficient** | **p-values** | **Coefficient** | **p-values** | **Coefficient** | **p-values** |
|---|---|---|---|---|---|---|
| | **USA** | | **Germany** | | **France** | |
| **Δ(EC)** | 0.053 | 0.360 | 0.214 | 0.217 | -0.287* | 0.009 |
| **ΔGFC)** | 0.346* | 0.000 | 0.872* | 0.000 | 0.895* | 0.000 |
| **Δ(OP)** | 0.006 | 0.117 | -0.030** | 0.021 | -0.046* | 0.000 |
| **CointEq(-1)** | -0.052* | 0.000 | -0.475* | 0.000 | -0.590* | 0.000 |
| | **UK** | | **Italy** | | **Japan** | |
| **Δ(EC)** | 0.049 | 0.833 | -1.028* | 0.000 | 0.134 | 0.134 |
| **Δ(GFC)** | 0.859* | 0.000 | 0.943* | 0.000 | 0.987* | 0.000 |
| **Δ(OP)** | -0.026 | 0.162 | -0.007 | 0.591 | -0.025* | 0.008 |
| **CointEq(-1)** | -0.369* | 0.000 | -0.068* | 0.000 | -0.503* | 0.000 |
| | **Canada** | | | | | |
| **Δ(EC)** | 0.655* | 0.001 | | | | |
| **Δ(GFC)** | 0.528* | 0.000 | | | | |
| **Δ(OP)** | 0.062* | 0.000 | | | | |
| **CointEq(-1)** | -0.677* | 0.000 | | | | |

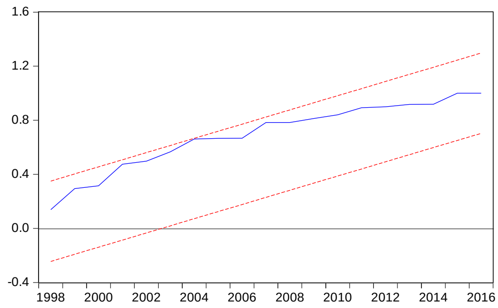
*Not: *, ** and *** represents 1%, 5% and 10% respectively.*

Table 5 presents the short-term forecast results. The majority of the estimated coefficients are statistically significant. When the short term coefficients of the countries are examined, the elasticity coefficients of EC of Japan and Canada are positive and statistically significant. GFC has a positive impact on GDP in the US, Japan and Canada. While the elasticity coefficient of OP is negative in Japan, it is positive and significant in Canada. The reason for the negative elasticity factor in Canada is that Canada is one of the oil producing countries and has approximately 11% of total world reserves.

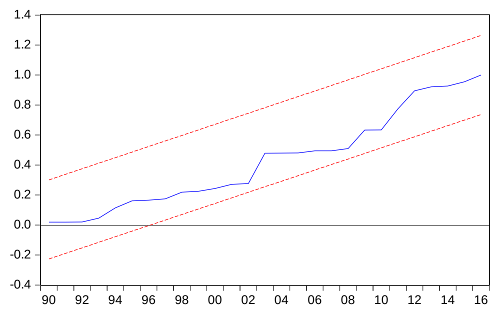
EC has a positive impact on GDP in the short term in France and Italy. In Germany, France, England and Italy, which are European countries and among the G7 countries, the coefficient of flexibility of gross fixed investments is positive and significant. The short-term elasticity coefficients of these countries which import crude oil are estimated negatively.



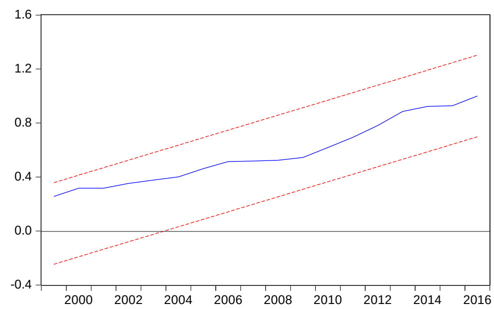

**FRANCE**



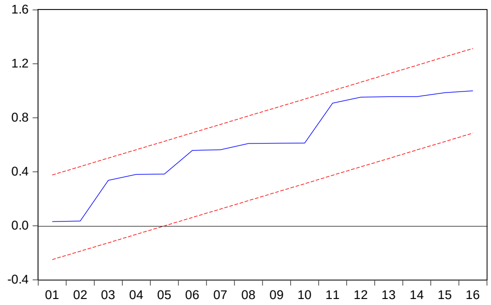

**UK**




**ITALY**




**JAPAN**




**CANADA**

Figure 1. Plot of CUSUMQ Tests

The stability of the parameters should be determined in the ARDL boundary test. For this purpose, the CUSUMQ test was used in this model. The CUSUMQ shows the sudden departure from constant regression coefficients. The CUSUMQ test results are presented in Figure 1. According to the CUSUMQ results, it is seen that the sum of residual squares in every G7 country is stationary at 5%. This means that the predicted variables for long-term equilibrium model are stationary and there is not any structural breakage.

### *3.3. Causality Analysis*

In this part of the study, the causality relationship between OP, GDP, GFC and EC was analyzed with Granger Causality test.

Tablo 6. Granger Causality Analysis

| Dependent Variable | GDP | EC | GFC | OP | Direction of Causality |
|---|---|---|---|---|---|
| **USA** | | | | | |
| **GDP** | - | 2.878(0.237) | 2.387(0.303) | 0.274(0.871) | |
| **EC** | 13.921(0.000) | - | 0.885(0.642) | 3.718(0.155) | GDP-EC |
| **GFC** | 7.372(0.025) | 2.451(0.293) | - | 0.494(0.780) | GDP-GFC |
| **OP** | 0.461(0.797) | 0.094(0.953) | 1.684(0.430) | - | |
| **Germany** | | | | | |
| **GDP** | - | 4.398(0.036) | 0.177(0.673) | 1.463(0.226) | EC-GDP |
| **EC** | 2.856(0.091) | - | 3.437 (0.063) | 1.541(0.214) | GDP-EC; GFC-EC |
| **GFC** | 0.059(0.807) | 3.741(0.053) | - | 1.929(0.164) | EC-GFC |
| **OP** | 0.269(0.603) | 0.686(0.407) | 0.084(0.771) | - | |
| **France** | | | | | |
| **GDP** | - | 12.028(0.034) | 2.764(0.736) | 9.721(0.083) | EC-GDP; OP-GDP |
| **EC** | 4.1076(0.534) | - | 4.459(0.485) | 0.239(0.998) | |
| **GFC** | 2.227(0.816) | 7.157(0.209) | - | 5.046(0.410) | |
| **OP** | 3.212(0.667) | 15.547 (0.008) | 2.875(0.719) | - | EC-OP |
| **UK** | | | | | |
| **GDP** | - | 8.831(0.012) | 0.559(0.755) | 0.896(0.639) | EC-GDP |
| **EC** | 0.529(0.767) | - | 0.072( 0.964) | 2.436(0.295) | |
| **GFC** | 1.318(0.517) | 5.075(0.079) | - | 2.062(0.356) | EC-GFC |
| **OP** | 1.650(0.438) | 0.163(0.921) | 1.820(0.402) | - | |
| **Italy** | | | | | |
| **GDP** | - | 3.132(0.076) | 0.098(0.753) | 0.915(0.338) | EC-GDP |
| **EC** | 0.377(0.539) | - | 0.308(0.578) | 3.008(0.083) | OP-EC |
| **GFC** | 0.006(0.933) | 2.981(0.084) | - | 1.415(0.234) | EC-GFC |
| **OP** | 0.872( 0.350) | 0.274( 0.600) | 1.355( 0.244) | - | |
| **Japan** | | | | | |
| **GDP** | - | 2.423(0.297) | 1.007(0.604) | 3.498(0.174) | |
| **EC** | 0.166(0.920) | - | 0.539(0.763) | 1.036(0.595) | |
| **GFC** | 0.347(0.840) | 1.992(0.369) | - | 6.164(0.045) | OP-GFC |
| **OP** | 5.698(0.057) | 7.338(0.025) | 4.195(0.122) | - | GDP-OP; EC-OP |
| **Canada** | | | | | |
| **GDP** | - | 6.079(0.047) | 0.652(0.721) | 5.673(0.059) | EC-GDP; OP-GDP |
| **EC** | 5.571(0.061) | - | 5.447(0.065) | 3.034(0.219) | GDP-EC; GFC-EC |
| **GFC** | 4.898(0.086) | 2.609(0.271) | - | 6.650(0.036) | GDP-GFC; OP-GFC |
| **OP** | 10.537(0.005) | 2.276(0.320) | 3.153(0.206) | - | GDP-OP |

*Note: Probability values are shown in brackets.*

Table 6 presents the Granger causality test results. Economic growth in the US is the cause of both EC and GFC. According to the results of Germany's Granger causality analysis, there is bi-directional causality between GDP and EC, GFC and EC. According to the Granger causality analysis for France, there is one-way causality from EC to GDP, from OP to GDP and from EC to oil price. EC in the UK is the cause of both GDP and GFC.

EC is the cause of GDP and GFC in Italy. In addition, OP is the cause of EC. According to the Granger causality analysis for Japan, the OP is the cause of GFC, the reason of the GDP, OP and the EC are the cause of the OP. In Canada, GDP is the cause of GFC, GFC is the cause of EC and OP is the cause of GFC. A bi-directional causality relation between GDP and EC and between GDP and OP has been determined.

## 4. Conclusion

In this study, the relationship between electricity consumption, gross fixed investments, crude oil price and economic growth prices of G7 countries (USA, Germany, France, England, Italy, Japan and Canada) was analyzed. This study covered the period between 1980 and 2017. Firstly, a unit root test was applied to the variables of each country. With the results obtained, it was determined that all series were stationary I(0) or I(1). Thus, the ARDL boundary test has to be stationary in series I(0) or I(1).

The ARDL test began by providing the precondition of ARDL bound test. First of all, the bound test results were examined. The F statistics for all countries are significant in the findings. In other words, the cointegration relationship has been determined for all countries covered in this study. After cointegration was determined, diagnostic tests of the model were investigated. The results obtained with the help of diagnostic tests were found to be appropriate and accurate. The long-run coefficients of the variables were estimated with the help of the ARDL boundary test. Electricity consumption positively affects economic growth. This effect is more pronounced in Germany than in any other country. Gross fixed investments also positively affects economic growth. In England, this impact is greater than in other countries.

According to the results of Granger causality analysis, a one-way causality from economic growth to electricity consumption and from economic growth to gross fixed investments has been determined in USA. According to the Granger causality analysis for Japan, oil price is the cause of gross fixed investments, economic growth is the cause of oil price and electricity consumption is the cause of oil price. Economic growth is the cause of gross fixed investments, gross fixed investments is the cause of electricity consumption and oil price is the cause of gross fixed investments in Canada. A bi-directional causality relation between economic growth and electricity consumption and between economic growth and oil price has been determined.

There is a one-way causality relationship from electricity consumption to oil price and from economic growth to electricity consumption in Germany. In addition, there is bi-directional causality between gross fixed investments and electricity consumption. In France, there is one-way causality from electricity consumption to economic growth, from oil price to economic growth and from electricity consumption to oil price. Electricity consumption is the cause of economic growth and gross fixed investments in Italy. In addition, the oil price is the cause of electricity consumption. Electricity consumption is the cause of economic growth and gross fixed investments in Italy.

Oil prices can be used as a tool to predict the rate of economic growth. The change in oil prices can provide information regarding a country's economy. Proper fiscal and monetary policy is required to ensure that an oil price shock to the government or central bank does not cause stagnation in the economy. In addition, policy makers need to limit greenhouse gas emissions by taking economic actions into consideration.

In every G7 country, which make up a large part of the world's economy, electricity consumption positively affects economic growth. It is important that the energy sources to meet electricity consumption are produced from renewable energy sources. These countries need to use clean energy sources such as solar energy, and wind energy for electrical energy. The fact that policymakers will make decisions that will increase the prosperity of their country in the long term and will serve as a model for other developed and developing countries.

## REFERENCES


Allen, R. C. 2009. *The British industrial revolution in global perspective*. Cambridge: Cambridge University Press.

Baumeister, C., & Kilian, L. 2016. "Forty years of oil price fluctuations: Why the price of oil may still surprise us." *Journal of Economic Perspectives*, 30(1), 139-60.

Behmiri, N. B., & Manso, J. R. P. 2013. "How crude oil consumption impacts on economic growth of Sub-Saharan Africa?." *Energy*, 54, 74-83.

Bélaïd, F., & Youssef, M. 2017. "Environmental degradation, renewable and non-renewable electricity consumption, and economic growth: Assessing the evidence from Algeria." *Energy Policy*, 102, 277-287.

Benhmad, F. 2013. "Dynamic cyclical comovements between oil prices and US GDP: A wavelet perspective." E*nergy Policy*, 57, 141-151.

Bentzen, J., & Engsted, T. 2001. "A revival of the autoregressive distributed lag model in estimating energy demand relationships." *Energy*, 26(1), 45-55.

Berument, M. H., Ceylan, N. B., & Dogan, N. 2010. "The impact of oil price shocks on the economic growth of selected MENA countries." *The Energy Journal*, 149-176.

Bildirici, M. E., & Bakirtas, T. 2014. "The relationship among oil, natural gas and coal consumption and economic growth in BRICTS (Brazil, Russian, India, China, Turkey and South Africa) countries." *Energy*, 65, 134-144.

Boukhelkhal, A., & Bengana, I. 2018. "Cointegration and causality among electricity consumption, economic, climatic and environmental factors: Evidence from North-Africa region." *Energy*, 163, 1193-1206.

Chandran, V. G. R., Sharma, S., & Madhavan, K. 2010. "Electricity consumption–growth nexus: the case of Malaysia." *Energy Policy*, 38(1), 606-612.

Chu, H. P., & Chang, T. 2012. "Nuclear energy consumption, oil consumption and economic growth in G-6 countries: Bootstrap panel causality test." *Energy Policy*, 48, 762-769.

Furuoka, F. 2017. "Renewable electricity consumption and economic development: New findings from the Baltic countries." *Renewable and Sustainable Energy Reviews*, 71, 450-463.

Ghatak, S., & Siddiki, J. U. 2001. "The use of the ARDL approach in estimating virtual exchange rates in India." *Journal of Applied statistics*, 28(5), 573-583.

Goldemberg, J., Lucon, O. 2010. "Energy, Environment and Development, 2nd edition." *Earthscan*, London.

Gummi, U. M., Buhari, A. I., & Muhammad, A. 2017. "Oil Price Fluctuations and Economic Growth in Nigeria (Evidence From Granger Causality Test)." *Science*, 3(1), 1-16.

Hall, C., Tharakan, P., Hallock, J., Cleveland, C., & Jefferson, M. 2003. "Hydrocarbons and the evolution of human culture." *Nature*, 426(6964), 318.

Hanabusa, K. 2009. "Causality relationship between the price of oil and economic growth in Japan." *Energy Policy*, 37(5), 1953-1957.

Hossen, S. S., & Hasan, M. 2018. "Does electricity consumption affect economic growth in Bangladesh?." *Economic Affairs*, 63(2), 449-458.

Jamil, F., & Ahmad, E. 2010. "The relationship between electricity consumption, electricity prices and GDP in Pakistan." *Energy policy*, 38(10), 6016-6025.

Jiménez-Rodríguez, R., & Sánchez, M. 2005. "Oil price shocks and real GDP growth: empirical evidence for some OECD countries." *Applied Economics*, 37(2), 201-228.

Johansen, S., & Juselius, K. 1990. "Maximum likelihood estimation and inference on cointegration—with applications to the demand for money." *Oxford Bulletin of Economics and statistics*, 52(2), 169-210.

Kirikkaleli, D., Sokri, A., Candemir, M., & Ertugrul, H. M. 2018. "Panel cointegration: Long-run relationship between internet, electricity consumption and economic growth. Evidence from OECD countries." *Investigación económica,* 77(303), 161-176.

Kraft, J., & Kraft, A. 1978. "On the relationship between energy and GNP." *The Journal of Energy and Development*, 401-403.

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

Long, P. D., Ngoc, B. H., & My, D. T. H. 2018. "The Relationship between Foreign Direct Investment, Electricity Consumption and Economic Growth in Vietnam." *International Journal of Energy Economics and Policy*, 8(3), 267-274.

Loungani, P. 1986. "On price shocks and the dispersion hypothesis." *Review of Economics and Statistics*, 68 (3), 536–539.

Naser, H. 2014. "Oil market, nuclear energy consumption and economic growth: evidence from emerging economies." *International Journal of Energy Economics and Policy*, 4(2), 288.

Odhiambo, N. M. 2009. "Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach." *Energy Policy*, 37(2), 617-622.

Omri, A., Mabrouk, N. B., & Sassi-Tmar, A. 2015. "Modeling the causal linkages between nuclear energy, renewable energy and economic growth in developed and developing countries." *Renewable and Sustainable Energy Reviews*, 42, 1012-1022.

Ouédraogo, I. M. 2010. "Electricity consumption and economic growth in Burkina Faso: A cointegration analysis." *Energy Economics*, 32(3), 524-531.

Pesaran, M. H., Shin, Y., & Smith, R. J. 2001. "Bounds testing approaches to the analysis of level relationships." *Journal of applied econometrics*, 16(3), 289-326.

Rafiq, S., Salim, R., & Bloch, H. 2009. "Impact of crude oil price volatility on economic activities: An empirical investigation in the Thai economy." *Resources Policy*, 34(3), 121-132.

Sarwar, S., Chen, W., & Waheed, R. 2017. "Electricity consumption, oil price and economic growth: Global perspective." *Renewable and Sustainable Energy Reviews*, 76, 9-18.

Shahbaz, M., Sarwar, S., Chen, W., & Malik, M. N. 2017. "Dynamics of electricity consumption, oil price and economic growth: Global perspective." *Energy Policy*, 108, 256-270.

Shahbaz, M., Tang, C. F., & Shabbir, M. S. 2011. "Electricity consumption and economic growth nexus in Portugal using cointegration and causality approaches." *Energy policy*, 39(6), 3529-3536.

Solow, R. M. 1956. "A contribution to the theory of economic growth." *The Quarterly Journal of Economics*, 70(1), 65-94.

Troster, V., Shahbaz, M., & Uddin, G. S. 2018. "Renewable energy, oil prices, and economic activity: A Granger-causality in quantiles analysis." *Energy Economics*, 70, 440-452.

Yoo, S. H. 2006. "The causal relationship between electricity consumption and economic growth in the ASEAN countries." *Energy policy*, 34(18), 3573-3582.

Zhu, H. M., Li, S. F., & Yu, K. 2011. "Crude oil shocks and stock markets: A panel threshold cointegration approach." *Energy Economics*, 33(5), 987-994.