Yener Altunbas[a]
Ayhan Kapusuzoglu[b]

UDK 620.9:330.35>(410)"1987/2007"

THE CAUSALITY BETWEEN ENERGY CONSUMPTION AND ECONOMIC GROWTH IN UNITED KINGDOM

ABSTRACT

This study aims to examine the relationship between the energy consumption (EC) and economic growth (GDP) in the United Kingdom during the period between 1987 and 2007. Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root tests, the Johansen Cointegration test and standard Granger causality test were applied to examine the relationship between EC and GDP. Since the analysis results indicated no cointegration relationship between the variables of EC and GDP, it was found that there is no long-term relationship between the variables; however, in the short run, there is a unidirectional causality relationship from GDP to EC.

Keywords: *Energy Consumption, Economic Growth, Causality, United Kingdom*
JEL Classification: *C32, Q43*

1.INTRODUCTION

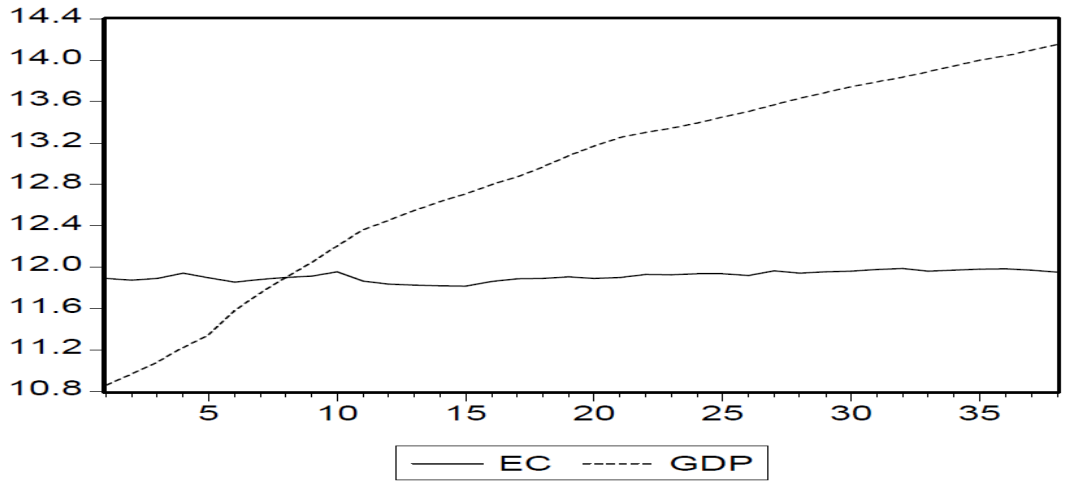
The United Kingdom is one of the countries with a highly developed economic system and thus a high income level in the world. At present, energy constitutes one of the chief factors that operate and guide economic systems. The energy factor could create a lever effect on economic growth, particularly through its contributions within the real sector. The United Kingdom is significant both for its energy use and its resources. Global energy statistics (BP, 2010) indicate that by the end of 2009, the country accounted for 0.2% of oil reserves, 1.8% of oil production, and 1.9% of oil consumption around the world; 0.2% of natural gas reserves, 2% of natural gas production, and 2.9% of natural gas consumption in the world; and 0.3% of coal production and 0.9% of coal consumption although it has no coal reserves. Figure 1 below shows the course followed by its EC and GDP between 1987 and 2007, the analysis period of the study. As an examination of Figure 1 reveals, its GDP followed an increasing trend over years, while its EC followed a stationary trend over the years, expect for some minor fluctuations.

[a]Department of Banking and Finance, Bangor University Bangor Business School, LL57 2DG, Bangor, Gwynedd, UNITED KINGDOM, Tel: +44 124 838 32 31, Fax: +44 124 838 32 28, E-mail: abs011@bangor.ac.uk

[b]Department of Business Administration, Abant Izzet Baysal University, Faculty of Economics and Administrative Sciences, 14280, Golkoy, Bolu, TURKEY, Tel: +90 374 254 10 00, Fax: +90 374 253 45 21, E-mail: ayhkap@gmail.com

Figure 1:

Changing Trends in EC and GDP Logarithmic Data (1987-2007)



The present study investigates the long and short-term relations between gross domestic product (GDP) – one of the main indicators of economic growth – and the amount of energy consumption in the United Kingdom, a country with a developed economic system. In the second part of our study, theoretical backround and findings regarding empirical studies, which can be found in the literature in relation with concerned variables, are presented. In the third part, data and methodology are presented. In the fourth part, our findings from carried out analyses are presented and there will be evaluations made in the light of obtained findings in the last part.

2.THEORETICAL BACKROUND AND LITERATURE REVIEW

The economic growth is based on two major sectors. One of them is the real sector, and the other is the financial sector. As for real sector, one of the most important sources of the real sector is energy factor and it has important impacts on real sector mechanism and thus influences the economic growth process. Interest rates and stock indexes created within the financial sector have an impact on countries' economies in different ways. Although the impacts of energy prices or energy consumption and economic growth on each other are accepted by economists to a large extent, and it is caused by the direction of causality on which this relationship is based. This issue is explained by "Ecological and Neoclassical" approaches which are contrary to each other.

The main idea of Neoclassical approach is to evaluate the economic structure as a closed system. Created products are produced through capital and workforce and the products are exchanged between enterprises and clients (Ockwell, 2008). Neoclassical growth theory takes the energy factor into consideration and this kind of approach is mainly influenced by developed intrinsic growth models, public spending (Barro, 1988), human capital (Lucas, 1988) and the studies of Neoclassical economists, Hamilton (1983) and Burbridge and Harrison (1984) (Aytac, 2010). Ecologist economists criticize the ideas presented by neoclassical approach. Ecological point of view asserts that the closed system adopted by the neoclassical approach isn't realistic and that the economic system should be taken into consideration as an open global system (Ockwell, 2008).

Concerning this significant relationship between energy consumption and economic growth, the relevant literature contains numerous studies examining the relationships between energy consumption and economic growth in the field of energy economy. Yang (2000) investigated the causality relationship between energy consumption and gross domestic product in Taiwan. It is detected that GDP has a bidirectional causality relationship with total

energy consumption, coal consumption and electricity consumption, and a unidirectional causality relationship with natural gas consumption and oil consumption.

Wolde-Rufael (2004) examined in his study the relationship between energy consumption and gross domestic product in Shanghai. A unidirectional causality relationship is detected from coal, coke, electricity and total energy consumption to GDP. However no causality relationship is detected between oil consumption and GDP.

In a study, Lee (2005) investigated the causality relationship between energy consumption and gross domestic product for 18 developing countries during the period between 1975 and 2001 by using panel cointegration and panel error correction models. Research results revealed that long- and short-term energy consumption is a unidirectional causality of GDP and that a high level of energy consumption led to an increase in the GDP level.

Chontanawat, Hunt and Pierse (2006) examined the causality relationship between energy consumption and gross domestic product in 30 OECD and 70 Non-OECD countries. Covering the period between 1970 and 2000 and causality from aggregate energy consumption to GDP and GDP to energy consumption is found to be more prevalent in the developed OECD countries compared to the developing non-OECD countries.

Zou and Chau (2006) investigated the long- and short-term relations between oil consumption and economic growth (gross domestic product) in China. Covering the period between 1953-2002 and using Granger cointegration and causality tests, the study indicated the existence of a long-term relationship between the variables in question, demonstrating that oil consumption is the causality of both short-term and long-term economic growth.

In their study, Mozumder and Marathe (2007) investigated the causality relationship between electricity consumption and gross domestic product in Bangladesh. The study covered the period between 1971 and 1999, and used Johansen-Juselius cointegration test, finding that there exists a unidirectional causality relationship from GDP to electricity consumption.

Hu and Lin (2008) examined in their study the non-linear equilibrium relationship between energy consumption (electricity, gas, coal and oil) and gross domestic product in Taiwan. Applying threshold cointegration analysis to data for the period between 1982 and 2006, the study showed that there is a long-term relationship between energy consumption and GDP, in which energy consumption growth is higher than economic growth.

In a study Belloumi (2009) examined the causality relationship between energy consumption per capita and GDP per capita in Tunisia for the period between 1971 and 2004. Using the vector error correction model and Granger causality test, the study found a long-term bi-directional and a short-term unidirectional causality relationship between the variables.

Odhiambo (2009) studied the causality relationship between energy consumption and economic growth level (gross domestic product per capita) in Tanzania. Covering the period between 1971 and 2006, the study employed the ARDL test, revealing the existence of a long-term relationship between the variables, and a unidirectional causality relationship from energy consumption to economic growth level.

In their study, Yuan, Liu, Fang and Xie (2010) investigated the relationship between economic growth (gross domestic product and added value of primary-secondary-tertiary industries) and energy consumption in China. The study examined four different period (1980-1992, 1993-1996, 1997-2000 and 2001-present day), and employed Grey analysis and Granger causality test, obtaining different results between the variables for different periods.

Arbex and Perobelli (2010) investigated the effects of economic growth (gross domestic product) upon energy consumption in Brazil. Covering the period between 1960

and 2003, the study examined 11 economic sectors in Brazil by using the economic growth model, and found that energy consumption level in each sector was closely correlated with the output growth level in corresponding sectors.

Kapusuzoglu and Karan (2010) studied the causality relationship between electricity consumption and gross domestic product in Turkey. The study covered the period between 1975 and 2006, and used Johansen-Juselius cointegration and Granger causality tests, finding that there exists a unidirectional causality relationship from GDP to electricity consumption.

In a study Quedraogo (2010) investigated the causality relationship between electricity consumption and economic growth (gross domestic product and gross capital formation) in Burkina Faso. Using the ARDL model for the period between 1968 and 2003, the study failed to find any causality relationship between electricity consumption and investments, but detected a long-term bi-directional causality relationship between electricity consumption and GDP.

3.DATA AND METHODOLOGY

The time series data employed for the empirical analysis in the study consist of the data on real gross domestic product (GDP) and aggregate energy consumption (EC) data in the United Kingdom on an annual basis for the period between 1987 and 2007. The EC (thousand tonnes of oil equivalent) data (all final users) were obtained from the Department of Energy and Climate Exchange of the United Kingdom. The GDP (in millions / U.S. Dollars) data were obtained from OECD Stat Extracts. Before starting analysis process, natural logarithm is applied on data. Table 1 presents descriptive statistics for EC and GDP series.

Table 1:

Descriptive Statistics of EC and GDP

Variables	Definition	Usable observations (1987-2007)	Mean	St. Dev.	Min.	Max.
EC[a]	Total Energy Consumption	21	11.945	0.030	11.892	11.988
GDP[b]	Total Gross Domestic Product	21	13.611	0.348	12.968	14.151

[a] thousand tonnes of oil equivalent.
[b] millions, U.S. Dollars.

The study used Granger (1969) causality test to examine the causality relationship between economic growth and energy consumption in the United Kingdom. Causality tests require variables to have the same order of stationarity. Augmented Dickey-Fuller (1979-ADF) and Philips-Perron (1988-PP) unit root tests were performed to examine the stationarity of the EC and GDP series. If these tests do not yield the same order of stationarity for the variables, they need to repeated by using the first differences. The series should have the same order of stationarity so that the cointegration relationship can be investigated between EC and GDP series.

The study investigated the presence of a long-term linear relationship (cointegration) between the series by using the test introduced by Johansen (1988) and Johansen and Juselius (1990) frequently used in investigating cointegration relations. Investigation of the cointegration relationship was based on the results of the trace and maximum eigenvalue likelihood ratio obtained from the test. In the presence of a cointegration relationship, the causality relationship is determined by Granger causality test performed in line with the

VECM model, while the absence of a cointegration relationship requires that causality relationship should be determined by the standard Granger causality test.

4.EMPIRICAL RESULTS

The results in Table 2 concern the findings about the ADF and PP test results for the EC and GDP variables in the United Kingdom. As an examination of Table 2 will clearly show, the EC and GDP variables do not have the same order of stationarity, but only become stationary when their first differences are taken to put it differently, H_0 hypothesis was rejected at the significance level of 1% after taking the first differences for both variables.

Table 2:

Results of ADF and PP Unit Root Tests

	ADF statistics		PP statistics	
	Levels	First differences	Levels	First differences
Variables				
EC	**-1.988**	**-6.112[a] (0.0001)**	**-1.967**	**-6.655[a] (0.000)**
GDP	**-2.420**	**-3.972[a] (0.0075)**	**-2.509**	**-7.319[a] (0.000)**
Critical Values				
1%	**-3.808**	**-3.831**	**-3.808**	**-3.831**
5%	**-3.020**	**-3.029**	**-3.020**	**-3.029**
10%	**-2.650**	**-2.655**	**-2.650**	**-2.655**

Each ADF and PP tests uses an intercept and no trend and lag length has been chosen basen on minimum Schwarz Info Criterion (SIC), p-values are one-sided (MacKinnon 1996).

[a] Implies significance at 1% levels, numbers in paratheses are the corresponding p-values.

Table 3 shows the results of Johansen Cointegration test performed to examine the presence of a cointegration relationship between EC and GDP. The cointegration test uses no intercept and no trend. The optimum lag length for the Johansen cointegration test was determined on the basis of the minimum AIC value obtained as a result of unconstrained VAR analysis. As demonstrated by the results of Johansen cointegration test given in Table 3, it was found that the EC and GDP variables do not have a cointegration relationship both according to the trace and maximum eigen value statistical results (H_0: r=0 not rejected at 10%, 5% and 1% levels).

Table 3:

Johansen Test for the Number of Cointegrating Relationships (EC-GDP)

H_0:H_1	Eigenvalue	Trace statistic	10% critical value	5% critical value	1% critical value
None	**0.373**	**10.905**	**13.428**	**15.494**	**19.937**
At most 1	**0.100**	**2.014**	**2.705**	**3.841**	**6.634**
H_0:H_1	Eigenvalue	Max-Eigen statistic	10% critical value	5% critical value	1% critical value
None	**0.373**	**8.891**	**12.296**	**14.264**	**18.520**
At most 1	**0.100**	**2.014**	**2.705**	**3.841**	**6.634**

r indicates the number of cointegrating relationships. The critical values for trace and max-eigen test satistics are given by Johansen and Juselius (1990). The specification for EC-GDP model includes an intercept and no trend in the cointegrating equations.

Table 4 presents the results of the Pairwise Granger causality test between the EC and GDP variables. The results indicate that there is a unidirectional causality relationship from GDP to EC at 5% significance level, while no causality relationship exists from EC to GDP. This result suggests that energy consumption is affected by economic activities and an increase in the economic growth level results in an increase in energy consumption level.

Table 4:

Pairwise Granger Causality Test

Null hypothesis	F-statistics	Implication
GDP does not Granger cause EC	**5.202 (0.035)[a]**	**GDP causing EC (significant 5%)**
EC does not Granger cause GDP	**0.522 (0.479)**	**EC not causing GDP**

[a] **Implies significance at 0.05 level, numbers in parantheses are the corresponding p-values.**

5.CONCLUSION

The present study investigated the causality relationship between energy consumption (EC) and economic growth (GDP) in the United Kingdom during the period between 1987 and 2007. Granger causality test was used to examine the causality relationship between energy consumption and economic growth, while Johansen cointegration test was performed to examine long-term cointegration relationship. As a result of these analyses, we could not reject the hypothesis that there is no long-term relationship between energy consumption and economic growth, and it was found that there is not long-term relationship between the variables. Nevertheless, we rejected the hypothesis that there is no short-term causality relationship between energy consumption and economic growth. In other words, the study found a unidirectional causality relationship between energy consumption and economic growth from GDP to EC (Mozumder and Marathe, 2007; Belloumi, 2009; Kapusuzoglu and Karan, 2010; Quedraogo, 2010). The results obtained suggest that the economic growth process in the United Kingdom will increase energy consumption in the short run and GDP falls as a result of the unfavorable trends in economic growth process will adversely affect energy consumption; however, in the long run, the changes in economic growth and energy consumption will not have significant influences upon each other. All these results indicate that the economic growth policies implemented in the United Kingdom exert their influence as one of the main factors that affect energy consumption in the short run.

According to the findings, it can be said that in the process of economic growth in United Kingdom, gross domestic product amount was an important variable which affected the energy consumption and therefore it can be said that it is important to provide the primary energy sources used in energy production and in time without any interaction for preventing the failures which may arise during the process of economic growth and for the stability of the economic production and consumption process.

REFERENCES

Arbex, M. and Perobelli, F. S., (2010), "Solow meets Leontief: Economic growth and energy consumption", *Energy Economics*, 32:43-53.

Aytac, D., (2010), "Enerji ve ekonomik büyüme ilişkisinin çok değişkenli VAR yaklaşımı ile tahmini", *Maliye Dergisi*, 158, 482-495.

Barro, R. J., (1988), "Government spending in a simple model of endogenous growth", *NBER Working Paper*, No:2588.

Belloumi, M., (2009), "Energy consumption and GDP in Tunisia: Cointegration and causality analysis", *Energy Policy*, 37:2745-2753.

BP, (2010), *BP Statistical Review of World Energy*, http://www.bp.com/statisticalreview, July 17, 2010.
Burbridge, J. and Harrison, A., (1984), "Testing for the effects of oil prices rises using vector autoregressions", *International Economic Review*, 25:459-484.
Chontanawat, J., Hunt, L. C. and Pierse, R., (2008), "Does energy consumption cause economic growth?:Evidence from a systematic study of over 100 countries", *Journal of Policy Modelling*, 30:209-220.
Dickey, D. and Fuller, W., (1979), "Distribution of the estimators for autoregressive time series with a unit root", *Journal of the American Statistical Association*, 74(366):427–431.
Granger, C. W. J., (1969), "Investigating causal relations by econometric models and cross-spectral methods", *Econometrica*, 37(3), 424–438.
Hamilton, J. D., (1983), "Oil and the macroeconomy since World War II", *Journal of Political Economy*, 91:228-248.
Hu, J. L. and Lin, C. H., (2008), "Disaggreated energy consumption and GDP in Taiwan: A threshold co-integration analysis", *Energy Economics*, 30:2342-2358.
Johansen, S., (1988), "Statistical analysis of cointegration vectors", *Journal of Economic Dynamics and Control*, 12:231–254.
Johansen, S. and Juselius, K., (1990), "Maximum likelihood estimation and inferences on cointegration with applications to the demand for money", *Oxford Bulletin of Economics and Statistics*, 52(2):169–210.
Kapusuzoglu, A. and Karan, M. B., (2010). "An analysis of the co-integration and causality relationship between electricity consumption and gross domestic product (GDP) in the developing countries: An empirical study of Turkey", *Business and Economics Research Journal*, 1(3):57-68.
Lee, C. C., (2005), "Energy consumption and GDP in developing countries: A cointegrated panel analysis", *Energy Economics*, 27:415-427.
Lucas, R. E., (1988), "On the mechanics of economic development", *Journal of Monetary Economics*, 22:3-42.
MacKinnon, J. G., (1996), "Numerical distribution functions for unit root and cointegration tests", *Journal of Applied Economics*, 11(6):601–618.
Mozumder, P. and Marathe, A., (2007), "Causality relationship between electricity consumption and GDP in Bangladesh", *Energy Policy*, 35:395-402.
Ockwell, D. G., (2008), "Energy and economic growth: Grounding our understanding in physical reality", *Energy Policy*, 36:4600-4604.
Odhiambo, N. M., (2009), "Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach", *Energy Policy*, 37:617-622.
Phillips, P. C .B. and Perron, P., (1988), "Testing for unit root in the time series regression", *Biometrika*, 75(2):335–340.
Quedrago, I. M., (2010), "Electricity consumption and economic growth in Burkina Faso: A cointegration analysis", *Energy Economics*, 32:524-531.
Wolde-Rufael, Y., (2004), "Disaggreated industrial energy consumption and GDP: The case of Shanghai, 1952-1999", *Energy Economics*, 26:69-75.
Yang, H. Y., (2000), "A note on the causal relationship between energy and GDP in Taiwan", *Energy Economics*, 22:309-317.
Yuan, C., Liu, S., Fang, Z. and Xie, N., (2010), "The relation between Chinese economic development and energy consumption in the different periods", *Energy Policy*, 38:5189-5198.
Zou, G. and Chau, K. W., (2006), "Short and long run effects between oil consumption and economic growth in China", *Energy Policy*, 34:3644-3655.

KAUZALNOST IZMEĐU POTROŠNJE ENERGIJE I GOSPODARSKOG RASTA U UJEDINJENOM KRALJEVSTVU

SAŽETAK

Rad istražuje odnos između potrošnje energije (EC) i gospodarskog rasta (GDP) u Ujedinjenom Kraljevstvu tijekom perioda od 1987. i 2007. Prošireni Dickey-Fuller (ADF) i Philips-Peron (PP) testovi jediničnog korijena, Johansenov kointegracijski test i standardni Grangerov test kauzalnosti primijenjeni su kako bi se ispitao odnos između EC i GDP. Zaključeno je da ne postoji dugoročan odnos između varijabli; ipak, kratkoročno postoji jednosmjerna kauzalna veza od GDP-a prema EC.

***Ključne riječi**: Potrošnja energije, Gospodarski rast, Kauzalnost, Ujedinjeno Kraljevstvo*

***JEL klasifikacija:** C32, Q43*