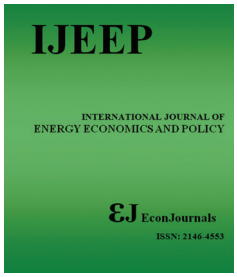

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Energy Consumption and Economic Growth in OECD Countries

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ABSTRACT

Energy consumption is analyzed economically in many ways especially in energy economics literature. The influence on the basis of this analysis shows the effects of environmental factors and energy-based economic crisis to the growth of the country. The main reason that is pushing countries to identify effective energy policies, and it is necessary to predict what will be the impact of these policies on economic growth. The aim of this study is to analyze the causal relationship between growth and energy consumption in Organization for Economic Co-operation and Development (OECD) countries during the period of 1980-2012. In this study, 4 basic hypotheses, the neutrality hypothesis, the growth hypothesis, the conservation hypothesis, the feedback hypothesis will be tested from the obtained International Energy Statistics of 23 OECD countries. The test of causality is made with Granger causality analysis. Also vector autoregressive models and Johansen co-integration analysis are used by the relevance of the data. From those analyses of 23 OECD countries, 11 neutrality, 4 conservation, and 6 growth hypothesis is found to be valid for the period of 1980-2012.

Keywords: Energy Consumption, Economic Growth, Energy Policy
JEL Classifications: Q43, O13, C32

1. INTRODUCTION

The literature on energy consumption is generally about detecting direction of the relationship between energy consumption and growth. Countries and the methods used in the literature vary highly. Thus the period range that examined in those studies also differs widely. One of the reasons of this interest is the effect of the petroleum crisis, and energy consumption to the growth of the countries. In addition another reason of the importance of this subject, as well as the energy shortages that occur during the production and consumption of energy and mainly the need of analysis of the benefits versus environmental damage caused during usage.

Four main hypotheses are tested for the examination of the relationship between energy consumption and growth.

The neutrality hypothesis; absence of a causal relationship between growth and energy consumption has been raised by the assumption of that the both cases are not interacting effectively. This hypothesis also supports the argument of restriction on energy consumption doesn't affect negatively the growth of the country.

The growth hypothesis; It reveals that the assumption of energy consumption influences the growth of countries. The hypothesis is confirmed in the case of energy consumption, causing an increase in the growth. Hence a limitation in energy consumption effects negatively the growth of the country hypothesis is also be accepted.

The conservation hypothesis; argues that the causality direction is from growth to energy consumption. So this hypothesis defends that the growth of the country is not mainly effected by the limitation of the energy consumption.

The feedback hypothesis; assumes bidirectional causality between electricity consumption and economic growth.

In the second part of the study, the literature on the subject is examined. Data and econometric methodology used is described in the third section. In fourth section the results obtained from econometric methods are given.

2. LITERATURE REVIEW

Studies examining the relationship between energy consumption and growth can be examined by subjecting multiple groupings.

Essentially, this grouping of economic theory and testes in the areas surveyed as may be desired in terms of energy economics and econometric methods can be used depending on the hypothesis in terms of the data set. When the issue is examined in terms of energy economics and economic theory shows the existence of two types of study. In the first group of study 4 hypotheses named as, "the neutrality hypothesis," "the growth hypothesis," "the conservation hypothesis," "the feedback hypothesis" is tested. The second study group is adding the energy consumption to the production function and analyzing them. A very detailed literature survey was published by Ozturk (2010).

Studies examining the relationship between energy consumption and growth can be grouped into three basic groups in terms of econometric methodology. Depending on the nature of the analyzed data, Causality analysis, vector autoregressive (VAR) models investigating the short-term dynamics, and vector error correction (VEC) models which examines the long-term equilibrium and short-term dynamics together, and the co-integration analysis has been observed. The literature shows also a wide range of differences in terms of the range of countries surveyed, country group and periods.

In respect of results obtained in previous studies, even for the same countries causality between energy consumption and growth do not indicate a common sign. Therefore, the direction of the country's energy relationship between the growths of the country varies according to the examined period.

As the literature part of this study, variables investigated the relationship between gross national product (GNP) and energy consumption and gross domestic product (GDP) and energy consumption are taking into consideration. Despite there are lots of studies on this subject, this papers literature review is limited due to the different variables in the models causality relations.

Kraft and Kraft study (1978) which is one of the first studies in this subject area, a unidirectional relation from GNP to the energy is observed after postwar between Gross Energy inputs and GNP. 1947-1974 periods was studied for USA economy. After this, Akarca and Long (1980) also examined the relationship between GNP and energy consumption for USA. The study is made for two periods, 1950-1968 and 1950-1970. It is seen that different results are gathered even in 2 years difference. Abosedra and Baghestani (1989) study showed us that the causality relation is towards to energy consumption from GDP.

As it will be understood just from this part of the literature valid results and the political suggestions are the indication of the efficiency of the selected analysis period.

Yu and Choi (1985) applied Sims and Granger causality tests for the period 1950-1976 and it is observed that the energy consumption of the countries that they examined such as USA, UK and Poland have no relationship between GNP, and the energy consumption. Philippines results showed that the causality is from energy consumption to GNP and for South Korea the causality relation is from GNP to energy consumption.

Erol and Yu (1987) study involves the analysis of causality for 6 industrialized countries. Sims and Granger causality analysis used in that study and the presence of causality from energy consumption to real income is determined for Japan and Italy. An inverse relationship was obtained for West Germany, it was concluded that there is no causal relationship between variables for Canada, France and the UK. Hwang and Gum (1991) study suggests the bi-directional causality between GNP and energy consumption for Taiwan. Similarly with using Hesiao's Granger Causality Hou (2009) observed a bi-directional causality for China's energy consumption and GNP for the period 1953-2006. Masih and Masih (1996) study examined six Asian economies with VEC models and Johansen co-integration method, co-integrating relation is found between India, Pakistan, Indonesia and no relations found for Malaysia, Singapore and Philippines.

Ebohon (1996) study is examined the relation between energy consumption and growth between Tanzania and Nigeria. However, in this study as a proxy for growth both GNP and GDP variables are used. The result obtained from causality analysis is in terms of energy utilization for growth is seen as vital to the country concerned. Lee (2006) study concerning the period of 1960-2001 has examined the causality relationship between the real GDP per capita of developed 11 countries and the energy consumption using Toda-Yamamoto causality test. Causality relation can't be found for England, Germany and Sweden and neutrality hypothesis was accepted. For Canada, Belgium, Netherlands and Switzerland GDP are found to be the cause of energy consumption and are assumed that energy conservation policies shall have a negative role on the growth. This study also was found reverse relationship for France, Italy and Japan. Lee and Chang (2007) study has examined the relationship between real GDP and energy consumption using panel-VAR analysis in 22 developed countries and 18 pre-developed countries. While getting bi-directional relationship for developed countries, a relationship from GDP towards energy consumption has been found for pre-developed countries. Chiou Wei, Chen and Zhu (2009) study has tested the causality relation between real GDP and energy consumption using linear and nonlinear Granger causality analysis in USA and eight Asian countries. Balcılar, Ozdemir and Aslanturk (2010), have made causality analysis for developed 7 countries, even though they obtained reasonable relations between samples they assumed that the results are not consistent within different period and they revealed that the analysis is not generalizable. Esso (2010) study has found bi-directional relation has been found for Cote d'Ivoire by using nonlinear co-integration and Granger causality analysis in seven African countries. For Congo and Ghana, a causality relation from GDP towards energy consumption has been found. Abbasian et al. (2010) study has examined the relation between growth and energy consumption of Iranian economy. VAR type causality Granger test and Toda-Yamamoto causality test are used for the analysis, and as a result causality relation from growth to energy

consumption has been found. Acaravcı and Ozturk (2010) study examined the long-run relation between energy consumption, CO_2 emissions and economic growth for 19 European countries and used autoregressive distributed lag method. They found long-run relationship for Denmark, Germany, Greece, Iceland, Italy, Portugal and Switzerland.

Warrand and Ayres (2010) study examined causality relation from energy consumption towards growth for the US economy between the periods of 1946-2000. Ozturk et al. (2010) study also studied on energy consumption and economic growth for very wide range of countries. They studied on 51 countries data for the period of 1971-2005 and used panel cointegration and panel causality methods. They grouped those countries three income level and their results showed that energy consumption and GDP are cointegrated for all income group countries. Causality analysis showed that for low income countries the causality runs from GDP to energy consumption but for middle income counties there is a bidirectional relationship between those variables. Shahiduzzaman and Alam (2012) study has shown up causality relation from energy consumption towards GDP in Australia in period of 1961-2009. Ouedraogo (2013) study showed up an existence of equilibrium relation by the study of panel co-integration in 15 countries of Economic Community of West African States in 1980-2008 period. Baranzini et al. (2013) study for Switzerland has shown an existence of relation between heating oil and electric consumption from GDP variables. Another study which analyzed relationship between growth and energy for 26 European countries is Menegaki and Ozturk (2013) study. They found bidirectional causality between growth and energy consumption for the period of 1975 to 2009. Shahateet (2014) study has examined 1980-2011 periods for 17 Arabic countries and for 16 countries the existence of neutrality hypothesis are accepted. Shahateet et al., (2014) study showed up for Jordan that in 1970-2011 period, there has been a causality relation from growth towards energy consumption and that energy conservation policies are not significantly effecting negatively. Jebli et al. (2016) study analyzed 25 Organisation for Economic Co-operation and Development (OECD) countries for the period of 1980 to 2010 with panel data methods. They showed bidirectional causality between trade variables and energy variables and tested Kuznets curve hypothesis. One of the recent studies in this literature is Bhattacharya et al. (2016) study. They tested the relationship between energy consumption and economic growth for 38 top renewable energy consuming countries for the period of 1991-2012. Their findings put forth a policy implication that policy makers, energy planners and international agencies must act together for renewable energy investment for low carbon growth.

3. DATA AND ECONOMETRIC METHODOLOGY

3.1. Data

The data of annual growth and primary energy consumption of the counties in 1980-2012 periods are analyzed. Energy data are taken form International Energy Statistics, growth data are taken from OECD statistics. Analysis period covers the energy data obtained as possible. The growth data is based on GDP data and energy data is calculated based on the same method with annual percentage change.

3.2. Econometric Methodology

3.2.1. Granger causality analysis

Granger (1969) supposed two types of causality. The first type of test is through lagged variables (Y_{t-i}, X_{t-i}), when the coefficients of these variables are all statistically significant, and the second type can be used if the variables are cointegrated and uses an error correction-term-based causality.

The first type of Granger causality test can be expressed as follows:

$$Y_t = \alpha_1 + \sum_{i=1}^{n} \alpha_{2i} Y_{t-i} + \sum_{j=1}^{n} \alpha_{3j} X_{t-j} + u_{1t} \quad (1)$$

$$X_t = \beta_1 + \sum_{i=1}^{n} \beta_{2i} Y_{t-i} + \sum_{j=1}^{n} \beta_{3j} X_{t-j} + u_{2t} \quad (2)$$

From those equations, X_t is said to cause Y_t, provided α_{3j} is nonzero. Similarly, Y_t is causing X_t if β_{2i} is not zero in equation (2). If both of those significances occur, this shows us bidirectional causality. The significance of those parameters is tested with joint hypothesis $\alpha_{3j} = 0$ for equation (7) and $\beta_{2i} = 0$ for equation (2).

4. ECONOMETRIC RESULTS

To decide the method to be applied to examine the relationship between variables a stationarity analysis of the data was performed. After the data's order of integration is determined from the unit root analysis countries with the same degree of stationarity, method of analysis is selected. Countries subjected to unit root analysis of data are as follows; Australia, Austria, Belgium, Canada, Denmark, Finland, France, Greece, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States.

Unit root analysis results determined that there are three groups of countries. Firstly, countries with level stationary data I(0) (Austria, Belgium, Canada, Denmark, France, Italy, Luxembourg, Switzerland, United States). Secondly, Countries that are first difference stationary I(1) (Australia, Ireland, Mexico, Netherlands, New Zealand, Portugal, Spain, United Kingdom, Korea, Japan, Greece, Finland). The third group is the countries which have different ranges of stability data and these countries are excluded from analysis (Norway, Sweden). VAR analysis is done for the first two group and results impulse-response and variance de composition analysis results are obtained. Granger causality analysis is used with the same lag length with VAR model lag length which is chosen by LR and AIC lag length information criteria. As the main object is to obtain the causality relation, VAR models are not reported. However variance decomposition results obtained from VAR model are added to the annexes. Johansen co-integration model is applied for the countries which are stationary of order one and considered to be in conservation and growth hypothesis as the result of causality analysis and co-integrating equation information are also given in Table 1.

Table 1: Granger causality and co-integration results

Neutrality country	GDP<≠>TPEC		Co-integrating equation
	F-stat		
	GDP-TPEC	TPEC-GDP	
Austria (1)	0.20529	0.83585	
Canada (1)	1.62318	1.16498	
Denmark (1)	0.06397	0.34748	
Italy (2)	0.66924	0.17175	
Luxembourg (1)	0.97355	0.91566	
Δ Australia (2)	1.19895	0.27993	
Δ Ireland (1)	1.20207	0.20335	
Δ Netherlands (2)	0.70904	2.01294	
Δ New Zealand (2)	2.20919	0.53143	
Δ United Kingdom (1)	0.23831	0.74700	
Δ Korea (2)	0.50793	1.60689	
Conservation	**GDP→TPEC**		
Switzerland (2)	3.20078	0.01153	
Portugal (3)	2.77803	0.09024	$Eneray_t$=−0.94+0.39 GDP_t+u_t (5.14)
Finland (1)	5.23677	1.31655	$Eneray_t$=1.002+0.31 GDP_t+u_t (2.87)
Japan (2)	4.10913	1.51261	$Eneray_t$=0.07+0.65 GDP_t+u_t (6.89)
Growth	**GDP←TPEC**		
Belgium (1)	0.08588	3.44861	
France (1)	0.30933	3.21296	
United States (2)	0.54789	3.23480	
Mexico (4)	1.25464	2.81639	GDP_t=377.17+147.43 $Eneray_t$+u_t (3.62)
Spain (1)	2.48520	6.15042	GDP_t=−5.197+147.43 Enerayt+u_t (3.63)
Greece (1)	1.35091	6.88998	GDP_t=4.90+3.43 Enerayt+u_t (4.08)

*Numbers in (·) in 1st column are Lag lengths, **Numbers in (·) in 4th column are t-values. GDP: Gross domestic product, TPEC: Total primary energy consumption

Unit root test is applied to the variables and reported in Annex Table A1. The augmented Dickey-Fuller unit root test applied to all variables and it has been decided to be based on 5% margin of error. Lag length is selected using the AIC information criterion. In cases where we accept stationarity or unit root between 5% and 10% ERS-DF-GLS test is applied to the variable under consideration. Variables which are non-stationary are re-subjected to unit root analysis for to test if the variables are stationary in first difference. VAR model and Granger causality test was applied to stationary variables. Linear trend observed in the data of GDP for Italy and Denmark. De-trending has been applied for those two variables.

Variable names are also reported in Annex Table A1 to ease following variance decomposition Annex Graphs 1 and 2.

Causality relation between growth and energy consumption cannot be found for 11 countries.

Causality relation towards energy consumption from growth is found in 6 countries and causality relation towards growth from energy consumption are found in 4 countries.

In the case where the existence of causality relation occurs for I(1) variables, co-integrating equation obtained by Johansen co-integration method are given in Table 1 at third column.

5. CONCLUSION

Causality relation between energy consumption and growth in 1980-2012 in OECD countries is analyzed by Granger causality analysis. Firstly, the degree of stationarity for growth and energy consumption variable for each country are identified. VAR model also estimated for each country. Granger causality analysis is based on VAR model with the same lag length according to the AIC and LR information criteria.

From Granger causality analysis 3 group of energy hypothesis are observed for 23 OECD countries in 1980-2012 period and countries are grouped by those hypothesis.

Neutrality hypothesis is valid and accepted in; Austria, Canada, Denmark, Italy, Luxembourg, Australia, Ireland, Netherlands, New Zealand, United Kingdom, and Korea. Conservation hypothesis is valid and accepted in; Switzerland, Portugal, Finland and Japan. Growth hypothesis is valid and accepted in; Belgium, France, United States, Mexico, Spain and Greece.

In addition if the case of causality occurs, for countries which we grouped in conservation and growth hypothesis with the variables of I(1), co-integrating equations are reported which are obtained by applying Johansen co-integration.

Also, in addition, variance decomposition applied for the causality relations for those two hypothesis group are added to the results.

Another result obtained is that the co-integrating relations for the countries in which the conservation and growth hypothesis is valid, shows a positive relation between growth and energy consumption.

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ANNEX IMAGES AND TABLES

Annex Table

Table A1: Unit root test results

Country	Variable name	ADF/ERS-DF-GLS		ADF (first difference)	Integration order
Australia	australgdp	−1.971466		−7.420439	I(1)
Australia	australtpec	−2.121721		−7.562653	I(1)
Austria	austgdp	ADF: −3.361311*	ERS-DF-GLS: −2.856696		I(0)
Austria	austtpec	−6.488566			I(0)
Belgium	belggdp	ADF: −3.618276*	ERS-DF-GLS: −3.687791		I(0)
Belgium	belgtpec	−5.772383			I(0)
Canada	Cangdp	−5.169542			I(0)
Canada	cantpec	−4.265614			I(0)
Denmark	dengdp (tr)	−4.475543			I(0)
Denmark	dentpec	−6.110631			I(0)
Finland	Fingdp	−2.912343		−5.672327	I(1)
Finland	Fintpec	−1.734532		−7.052386	I(1)
France	Frgdp	−3.467840			I(0)
France	Frtpec	−4.883151			I(0)

(Contd...)

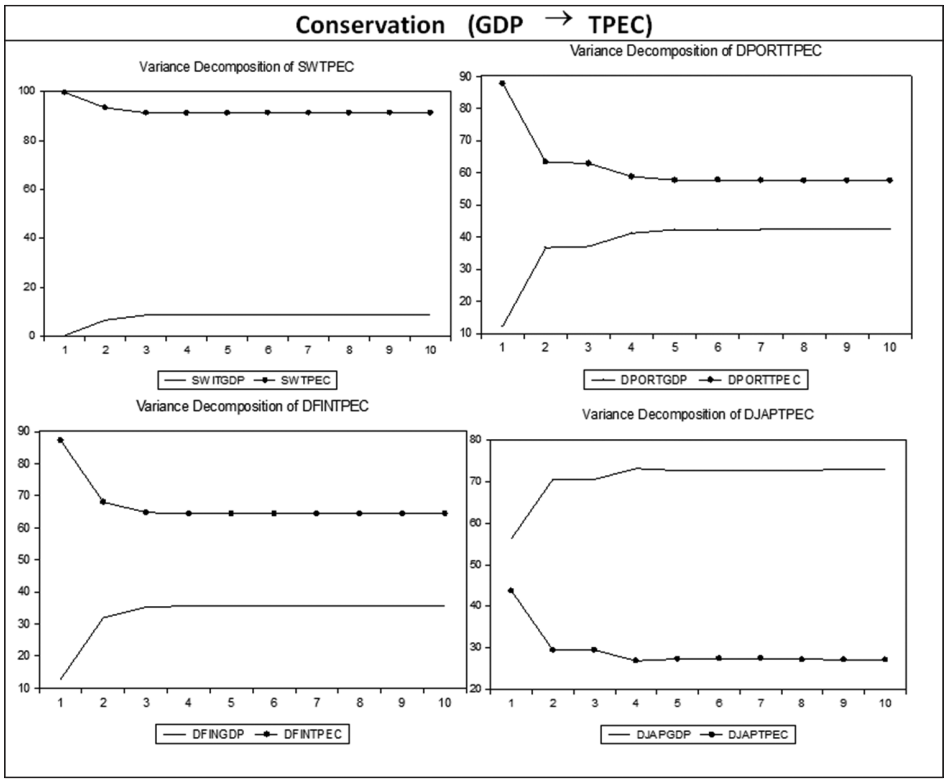
Table A1: *(Continued)*

Country	Variable name	ADF/ERS-DF-GLS		ADF (first difference)	Integration order
Greece	Gregdp	−0.690822		−8.216080	I(1)
Greece	gretpec	−0.603101		−8.549985	I(1)
Ireland	iregdp	−2.327576		−4.869150	I(1)
Ireland	iretpec	−1.889590		−4.532880	I(1)
Italy	italgdp (tr)	−3.770046			I(0)
Italy	italtpec	−4.877063			I(0)
Japan	japgdp	−2.570826		−7.409347	I(1)
Japan	japtpec	−0.129706		−7.075641	I(1)
Korea	korgdp	−1.149140			I(1)
Korea	kortpec	−1.174926			I(1)
Luxembourg	luxgdp	−4.141364			I(0)
Luxembourg	luxtpec	−4.535628			I(0)
Mexico	mexgdp	−2.844710		−5.890728	I(1)
Mexico	mextpec	ADF: −3.224538*	ERS-DF-GLS: −0.296278	−4.634977	I(1)
Netherlands	nethgdp	−2.925331		−6.610041	I(1)
Netherlands	nettpec	−0.598423		−5.195603	I(1)
New Zealand	nzgdp	−1.782661		−5.690275	I(1)
New Zealand	nztpec	−2.699433		−5.727368	I(1)
Norway	norgdp	−5.075474			I(0)
Norway	nortpec	−8.001235			I(1)
Portugal	portgdp	−1.026345		−7.292932	I(1)
Portugal	porttpec	−1.659722		−4.679516	I(1)
Spain	spgdp	−0.930944		−6.018488	I(1)
Spain	sptpec	−2.476270		−8.091326	I(1)
Sweden	swegdp	−2.737269			I(1)
Sweden	swetpec	−5.716982			I(0)
Switzerland	switgdp	ADF: −3.121125*	ERS-DF-GLS: −2.678673		I(0)
Switzerland	swtpec	−8.215560			I(0)
United Kingdom	ukgdp	−2.537817		−7.126078	I(1)
United Kingdom	uktpec	−1.782265		−7.404979	I(1)
United States	usgdp	−4.114212			I(0)
United States	ustpec	−4.623109			I(0)

*Shows the significance level of nonstationarity for 1%. ADF critical values: 1%: −3.653730, 5%: −2.957110, 10%: −2.617434. ERS-DF-GLS critical values: 1%: −2.641672, 5%: −1.952066, 10%: −1.610400. ADF: Augmented Dickey-Fuller

Annex Images

Graph 1: Variance decomposition graphs for countries indicates conservation hypothesis



Graph 2: Variance decomposition graphs for countries indicates growth hypothesis