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Energy Consumption and Sustainable Economic Welfare: New Evidence of Organization of Petroleum Exporting Countries#

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ABSTRACT

This paper examines the relationship between energy consumption and sustainable economic welfare in Organization of Petroleum Exporting Countries. Initially, the index of sustainable economic welfare (ISEW) is calculated followed by an investigation of the relationship between energy consumption and sustainable economic welfare in these countries. The calculation of the ISEW reveals the most important beneficial component and the most important cost component of ISEW is adjusted personal consumption and energy depletion, respectively. The estimated results based on the Westerlund (2007) test and considering cross-sectional dependence indicate that there is a long run relationship between energy consumption and sustainable economic welfare. Granger's causality test results indicated a unidirectional causality running from sustainable economic welfare to energy consumption. This result has implications for energy and environmental policy makers; energy conservation policy will be useful in improving the quality of environment and it does not have adverse impact on their sustainable economic welfare.

Keywords: Energy Consumption, Sustainable Economic Welfare, Energy Conservation Policy, Quality of Environment, Organization of Petroleum Exporting Countries

JEL Classifications: Q43, Q56, I31

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1. INTRODUCTION

The limitations of energy sources and their enduring as well as environmental pollution issues have made energy consumption even more important for energy providers. The side-effects of energy demand have penetrated so deep into the energy issues of countries around the world that almost no country can be found indifferent to it. Table 1 shows the Organization of Petroleum Exporting Countries' (OPEC) position in terms of carbon dioxide emissions and energy consumption per capita among the countries of the world.

There is concern that implementing energy saving policies will have a devastating effect on the sustainable economic welfare of these countries, as energy is a productive input and is expected to decline as well. So the key question is whether energy-saving policies will pose a threat to OPEC's sustainable economic growth. And in other words, can energy-saving policies improve the quality of the environment without damaging OPEC's sustainable economic growth? The OPEC empirical literature has not answered this question. Of course, it has done extensive research to examine the relationship between OPEC's energy consumption and economic growth, although no definitive results have been obtained. These questions and their answers are significant in issues related to sustainable development and transnational justice. Also, examining the relationship between energy consumption and sustainable economic welfare in OPEC countries and answering the question of whether energy consumption has contributed to sustainable economic growth in OPEC countries is going to be useful and remarkable for energy economics researchers because OPEC countries hold 79.4% of the world's oil reserves.

Table 1: The rank of OPEC countries among countries of the world in terms of CO_2 emissions, per capita energy consumption, and energy*

OPEC countries	Emissions CO_2	Energy use (kg of oil equivalent per capita)
Algeria	34	83
Angola	70	128
Ecuador	61	97
Gabon	126	44
Indonesia	14	98
Iran	7	33
Nigeria	39	107
Qatar	35	1
Saudi Arabia	8	9
United Arab Emirate	26	7
Venezuela	29	53
All countries included in the ranking	192	168

*The data were extracted from indexmundi website in 2014

We follow two steps in order to answer the research question. First, we calculate the sustainable economic welfare index for OPEC countries. Next, we examine the causal relationship between energy consumption and sustainable economic welfare. Given that energy is considered a productive input, one can expect that OPEC energy consumption will bring about sustainable economic welfare. However, the results of the study do not support this hypothesis. This result has an important message for energy and environmental policy makers. Energy-saving policies can increase environmental quality without detrimental effects on sustainable economic growth. The paper proceeds as follows: we proceed with the literature review on the conventional energy-growth nexus in OPEC countries. Section 3 explains the data and methodology both to construct the perused ISEW and for the energy-sustainable economic growth relationship econometric analysis. Section 4 presents experimental results and discusses the results. Section 5 concludes.

2. LITERATURE REVIEW

Next, we try to examine the impact of energy on production in a theoretical framework. Then, we focus on the empirical literature and present some hypotheses and provide some evidence to support these hypotheses in the OPEC countries. A lot of research has been done in different countries but we are focusing on research in OPEC countries. Then, we describe the sustainable economic welfare index as a proxy for sustainable economic growth.

2.1. How Energy Affects GDP?

From different economics schools' point of view, the factors affecting economic growth that are considered in the growth functions are capital and labor, both experts and non-experts. In the new growth models, the energy has also been considered, but its significance is not the same in different models. In general, there are three major views: Stern and Cleveland (2004) quoted from ecologist economists such as Ayres and Nair (1984) and argued that in biological growth models, energy is the only and most important growth factor in the production process as every production process requires energy. According to Stern, labor and capital are intermediary factors which require energy to be functional. Neoclassical economists such as Berndt (1978) and Denison (1979) are opposed to ecologist economists. Neo-classics believe that through its impact on labor and capital, energy can indirectly affect economic growth. Most neo-classical economists believe in the fact that although energy, as an intermediary factor, has had a small role in economic production, land, workforce and capital are key production factors. Berndt and Wood (1975) argued that in the total production function, energy is a production factor which has a separable and weak relationship with the labor. They discussed that after being integrated into capital and labor, energy can be used in the production process. In other words, as an intermediate input, energy can be employed to use capital. Thus, the need for energy input will be reduced by increasing capital productivity and technical progress. Accordingly, energy has a weak relationship with labor and it cannot be considered as an effective factor in the economic growth. Therefore, from neoclassical perspective, energy is not a stimulating factor in economic growth; rather, the economic growth determines energy demand and consumption. Therefore, energy-saving policies are not considered as a deterrent to economic growth. Pindyck (1979) believed that energy effect on economic growth depends on its role in the structure of production. According to him, in industries where energy is used as an input, reducing energy consumption as a result of increasing its price will affect production level and facilities and consequently reduces national production. To prove his argument, he used the total cost function and carried out analyses based on the production cost elasticity with respect to energy price.

2.2. Conventional Energy–growth Nexus in OPEC Countries

Considering energy as a general unit, numerous studies have investigated the relationship between energy consumption and economic growth. Payne (2010) and Ozturk (2010) reviewed the existing literature and provided four testable hypotheses; growth hypothesis, conservation hypothesis, feedback hypothesis and neutrality hypothesis. The growth hypothesis stresses on the existence of a one-way causal relationship from energy consumption to economic growth and the vital role of energy in increasing economic growth, either directly or as a complement input for labor and capital. This hypothesis suggests the dependence of economy on energy and considers energy as a prerequisite for economic growth. In this case, lack of adequate energy supply may restrict economic growth and results in a poor economic condition (Hossein et al., 2012a; Alkhathlan and Javid, 2013; Apergis and Tang, 2013; Alshehry and Belloumi, 2015; Antonakakis et al., 2017).

The other hypothesis is the conservation hypothesis which holds that increasing economic growth will increase energy consumption. In the conservation hypothesis, it is hypothesized that there is one-way causal relationship from economic growth to energy consumption which indicates lower dependence of economy on energy. Thus, energy saving policies such as reducing and eliminating energy subsidies, reducing greenhouse gas emissions, taking measures to increase energy efficiency, along with demand management and reducing energy consumption policies, and avoiding energy wastes can be implemented without leaving adverse effects on economic growth (Al-Iriani, 2006; Mehrara, 2007; Ozturk et al., 2010; Alsahlwai, 2013; Damette and Seghir, 2013; Banafea, 2014; Salahuddin and Gow, 2014; Saidi et al., 2017; Ahmed and Azam, 2016).

The feedback hypothesis suggests that energy consumption and economic growth are interdependent and complementary. According to this hypothesis, there is a bidirectional causal relationship between energy consumption and economic growth. The internal relationship between energy and economic growth also indicates that energy saving policies may reduce economic growth. Besides, changes in economic growth can change the level of energy consumption, as well (Arouri et al., 2012; Apergis and Payne, 2012; Bélaïd and Abderrahmani, 2013; Fuinhas and Marques, 2013; Omri, 2013a; Omri and Kahouli, 2013b; Issa, 2014; Shahateet, 2014; Mohammadi and Parvaresh, 2014; Nasreen and Anwar, 2014; Sbia et al., 2014; Shahbaz et al., 2014; Charfeddine and Khediri, 2016; Jammazi and Aloui, 2015; Ozturk and Al-Mulali, 2015; Osman et al., 2016).

Neutrality hypothesis reflects the negligible and insignificant role that energy plays in the economic growth process. Based on this hypothesis, there is no causal relationship between economic growth and energy consumption. Therefore, policies to increase (decrease) energy consumption will not increase (decrease) economic growth (Hossein et al., 2012b; Ozturk and Acaravci, 2011; Narayan and Popp, 2012; Azam et al., 2015; Narayan, 2016; Pablo-Romero and De Jesús, 2016; Solarin and Ozturk, 2016).

According to the studies mentioned above, there is no uniform view on the relationship between energy consumption and economic growth in OPEC countries. Methodology, time period and variables are among the factors that influence the results of research. We have tried to use the variable of sustainable economic welfare instead of GDP to examine the relationship between energy consumption and economic growth by criticizing GDP. To this end, we will continue to explain the criticisms of GDP and the index of sustainable economic welfare (ISEW).

2.3. What is the ISEW?

Since World War II, GDP has been used as a measure of the macroeconomic performance of countries. At the 1992 Environment and Development Conference in Rio de Janeiro, it was emphasized that GDP cannot be a benchmark for sustainable development because of its limitations. Also, after the Stiglitz-Sen-Fitoussi Commission's report (2009), it was more deeply and widely recognized that GDP is not a sufficient and complete measure of social welfare and progress. The main reason for this claim was that GDP does not cover socio-economic issues such as unpaid work, quality of life, human satisfaction, environmental degradation, human capital, natural capital, income distribution and defense spending (Beça and Santos, 2014; Beça and Santos, 2010; Brennan, 2008; Brennan, 2013; Lawn, 2013; Lawn, 2003 and Neumayer, 2000 found that because of the sterile accounting it has infiltrated into GDP architecture, it cannot measure real progress and prosperity).

In the meantime, some authors have attempted to correct GDP by adding environmental, social, and political variables to it. Initially, Cobb and Daly (1989) introduced ISEW and Cobb and Cobb (1994) improved it from a methodological point of view. ISEW belongs to corrective and modifying criteria of GDP which is some form of expansion of Measurable Economic Welfare reported by Nordhaus and Tobin (1972) (Gigliarano et al., 2014).

The key role of the sustainable economic welfare index is to make some reforms to GDP to address its shortcomings and deficiencies, most of which relate to the environmental and social costs of economic growth. In other words, ISEW separates the cases which are revenue boosters but they do not increase welfare in GDP (such as pollution and depletion of natural resources). Furthermore, ISEW modulates private consumption spending in terms of income distribution inequalities. Also, ISEW only covers public spending on health and education. ISEW considers household chores such as childcare or household management as well as voluntary work because these activities, although not marketed and priced there, contribute to economic well-being. Furthermore, ISEW considers costs related to energy depletion, mineral depletion and the cost of emitting of CO_2 (climate change costs) because they reduce social welfare. And at the end ISEW takes into account the social costs of phenomena such as divorce and accidents (Gigliarano et al., 2014).

The ISEW can be formally expressed as follows (Menegaki and Tugcu, 2017):

$$ISEW = C_{ISEW} + G_{ISEW} + I_{ISEW} + W - N - C_s \quad (1)$$

C_{ISEW} refers to the weighted consumption expenditure which is calculated in the same way as in GDP but it is adjusted for income inequality. Private consumption is adjusted according to the formula: adjusted consumption = consumption× (1-Gini's index). Cobb and Daly (1989) proposed the application of the Gini's index of income distribution to adjust the level of private consumption. The value of this index may vary from 0 to 1 (where 0 means perfect income distribution and 1 means maximum inequality). G_{ISEW} is non-defensive public expenditure. I_{ISEW} is net capital growth and W is the unpaid services contributing to welfare. The first four components, namely C_{ISEW}, G_{ISEW}, I_{ISEW} and W are considered as economic variables. Other items in this equation have negative effects on *ISEW*. *N* refers to depletion of natural environment and C_s is cost from some measurable social problems.

Menegaki and Tugcu (2017) have calculated Sustainable Economic Welfare Index for Canada, France, Germany, Italy, Japan, UK and US, Menegaki and Tugcu (2016) calculated sustainable economic welfare index for 42 Sub-Saharan Africa. Gigliarano et al. (2014) calculated Sustainable Economic Welfare Index for all regions of Italy and Posner and Costanza (2011) calculate GPI index for Baltimore and Maryland state.

3. METHODOLOGY AND DATA

3.1. The Calculation of the ISEW Per Capita for OPEC Countries

As the cost components of social items and minimum wage payments are not accessible to OPEC countries, equation (1) can be written as equation (2):

$$ISEW = C_{ISEW} + G_{ISEW} + I_{ISEW} - N \quad (2)$$

ISEW components for OPEC countries are given with a symbol, computational method and data source in Table 2. We have defined the computational method for each item based on Menegaki and Tugcu (2017).

ISEW per capita are calculated for Iran, Saudi Arabia, Algeria, Nigeria, Angola, Gabon, Ecuador, Iraq, Qatar, Venezuela, and Indonesia (i.e. 11 member states of the OPEC), from 1995 to 2014. Kuwait, United Arab Emirates, Equatorial Guinea, and Libya were excluded from the study since their Gini coefficient data was not available. Figure 1 provides an overview of the difference between GDP per capita and ISEW per capita during the sample period (1995-2014) which is defined as $GDP_{per\ capita}–ISEW/GDP_{per\ capita}$. Figure 1 is broken to 11 sections.

It is generally assumed that when this ratio rises, economy follows a relatively unstable route. While an increasing difference between ISEW and GDP indicates an unsustainable economic trend, a decreasing difference between ISEW and GDP indicates a sustainable economic trend. According to Figure 1, this ratio is stable for most countries while Saudi Arabia shows steadily upward trend, Venezuela shows steadily downward trend. Maximum and minimum percentage differences of per capita GDP and per capita ISEW for each country are as follows: Algeria (0.53-0.83%), Angola (1.37-0.58%), Ecuador (0.56-0.77%), Gabon (0.68-1.08%), Indonesia (0.52-0.91%), Iran (0.58-0.78%), Iraq (0.44-0.75%), Nigeria (0.52-0.88%), Qatar (0.67-1.014%), Saudi Arabia (0.59-0.86%), and Venezuela (0.31-0.78%).

According to Figure 2, the most important benefit component of ISEW in all countries is adjusted personal consumption followed by health and education expenditure, and net capital growth having the greatest role in forming ISEW, respectively. Figure 2 for Angola does not show the share of net capital growth due to the negative growth of net capital.

According to Figure 3, the most important cost component of ISEW in all OPEC countries is energy depletion.

After energy depletion, environmental degradation caused by CO_2 emissions, mineral depletion, and forest depletion have the greatest role in cost components of ISEW, respectively. Due to lack of access to forest depletion data related to Iraq and mineral depletion data related to Qatar, the value 0% is shown in the figure of two countries.

3.2. Methodology

This study estimates the relationship between energy consumption and the sustainable economic prosperity (ISEW) among the OPEC countries. Long-term relationship is stated in relation (3):

$$\log ISEW_{it} = f(\log Energy_{it}) \quad (3)$$

Where $ISEW_{it}$ is the ISEW per capita and $Energy_{it}$ is energy consumption per capita. i and t refer to the cross-section and time, respectively. In this study we investigate and determine the causal relationship between energy consumption and sustainable economic prosperity (ISEW) in OPEC countries. We consider Algeria, Iran, Angola, Gabon, Saudi Arabia, Iraq, Qatar, Indonesia, Venezuela, Nigeria and Ecuador. As noted in Section 3-1, Kuwait, the United Arab Emirates, Equatorial Guinea, and Libya were excluded from our study due to their inaccessibility to Gini coefficient data. Section 3-1 discusses fully how the sustainable economic welfare index is calculated. Table 1 lists the sources of data collection used in the calculation of the sustainable economic welfare index. According to the study's methodology, we explain the variable energy consumption in this section. Energy consumption per capita data (kg of oil equivalent per capita) were obtained from the World Bank Web site for OPEC countries. Energy consumption includes coal, natural gas, crude oil and electricity.

3.2.1. Cross-sectional dependence (CD) test

The CD is an important problem for panel data econometrics. In case of panel data which is cross-sectionally dependent, the

Table 2: ISEW component, symbol, computational method, and data source for OPEC countries

+Adjusted personal consumption	We multiplied personal consumption with Gini coefficient (G) as: PC(1-G)	Gini:http://data.worldBank.org/ PC:https://www.indexmundi.com
+Education expenditure	Public expenditure on education. Assuming that half of it is defensive, we multiply this amount with 50%	http://data.worldBank.org/
+Health expenditure	Public health expenditure is also multiplied with 50% for the same reason as above	http://data.worldBank.org/
±Net capital growth	We have used data on fixed capital accumulation. We subtracted consumption of fixed capital to find the net capital and then calculated its growth rate	https://www.indexmundi.com
–Mineral depletion	It equals the stock value of mineral resources (tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite, and phosphate) to the lifetime of the rest of reserves (over 25 years limit) ratio	http://data.worldBank.org/
–Energy depletion	It is the ratio of stock value of sources of energy (natural gas, coal, and crude oil) to lifetime of rest of the reserves (over 25 years limit) capped	http://data.worldBank.org/
–Forest depletion	It is obtained based on the product of unit resource rents and surplus round wood harvest over natural growth	http://data.worldBank.org/
–Damages from CO_2 emissions	It is calculated by multiplying \$20 per ton of carbon (the unit damage in 1995 U.S. dollars) by tons of carbon emissions	http://data.worldBank.org/

Figure 1: Difference between GDP per capita and ISEW per capita $((GDP_{per\ capita}–ISEW)/GDP_{per\ capita})$ for 11 OPEC countries from 1995 to 2014

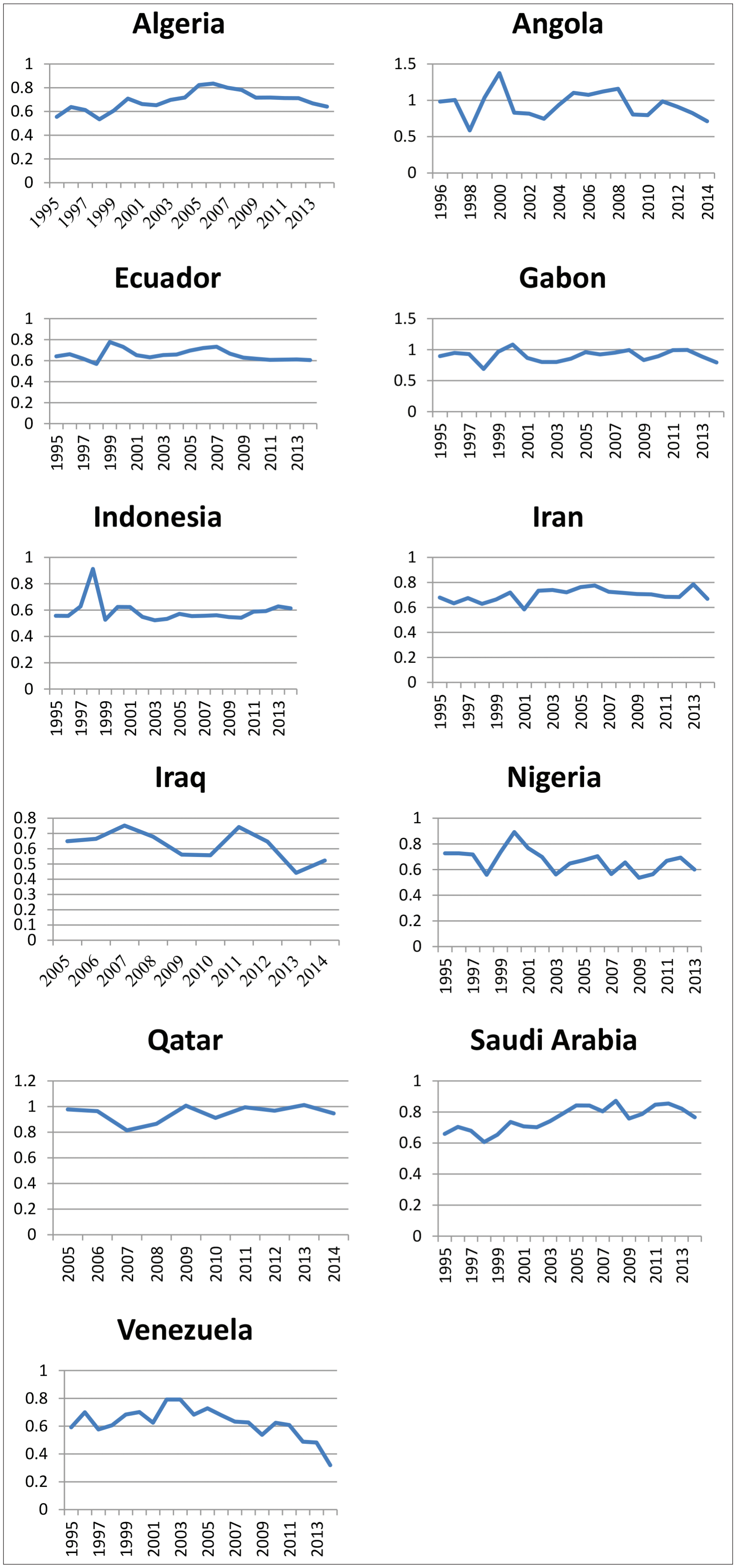


Figure 2: Benefit components of ISEW for 11 OPEC countries from 1995 to 2014

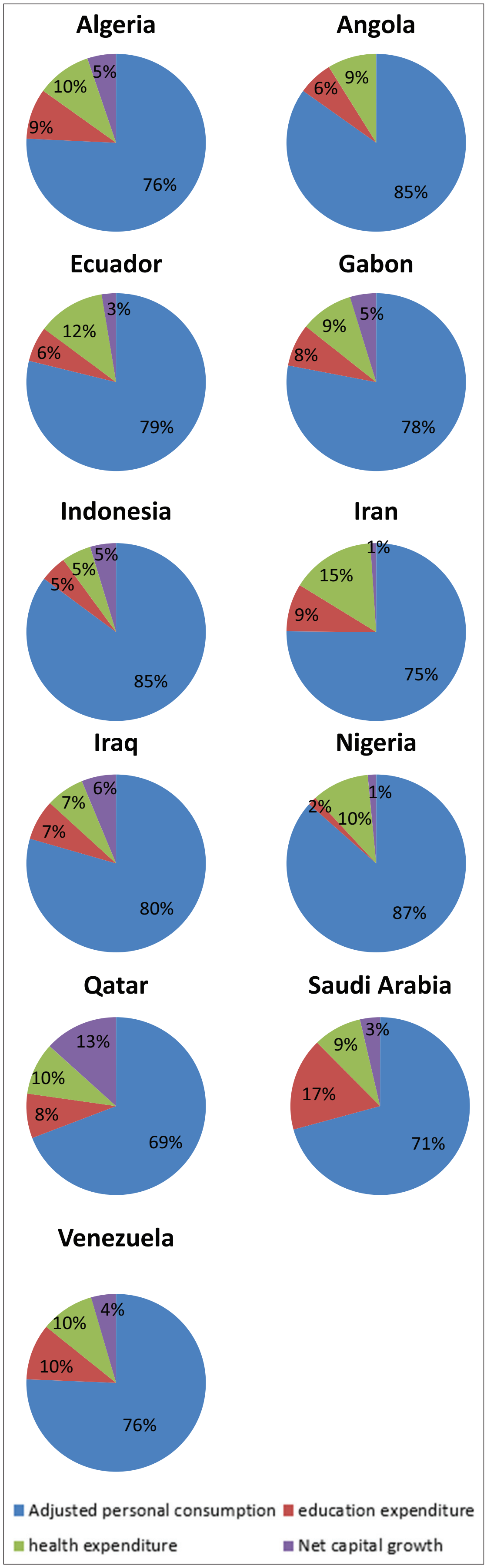
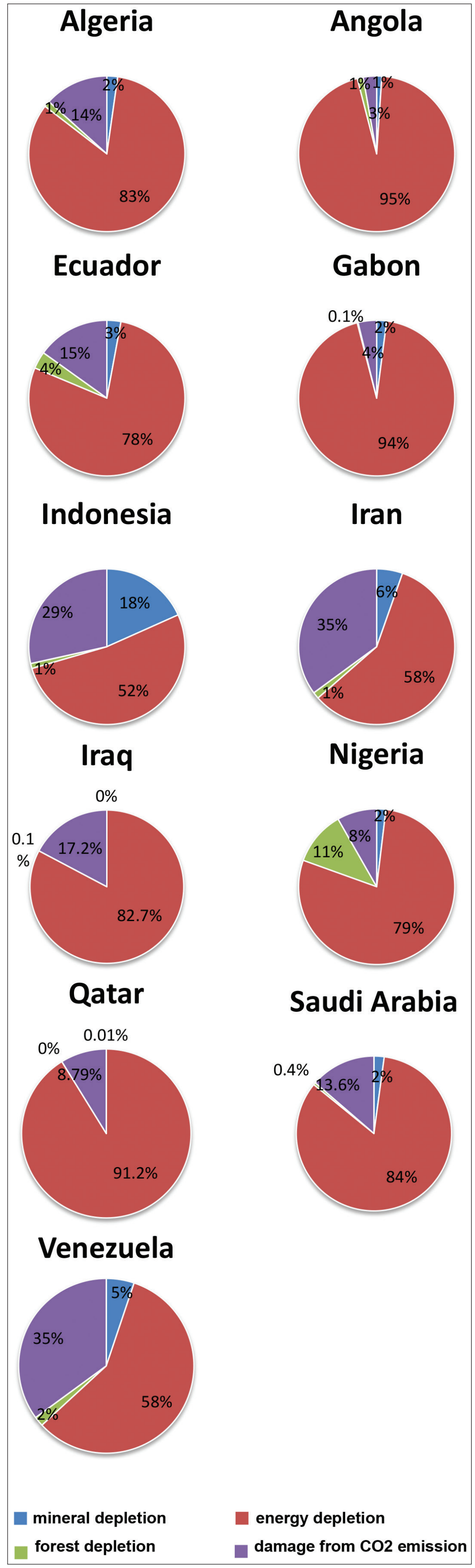


Figure 3: Cost components of ISEW for 11 OPEC countries from 1995 to 2014



estimation results generally become inconsistent and upward-biased. Therefore, it is important to test the existence of CD, before the analysis takes place.

For testing the CD, we used the CD test which was developed by Pesaran (2004) for investigating the existence of CD. Under the null hypothesis of no CD, CD test is asymptotically distributed as normal and efficient even in panels with small sample sizes. The CD test statistic proposed by Pesaran (2004) is as shown in Eq. (4):

$$CD = \sqrt{\frac{2T}{N(N-1)}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{p}_{ij}\right)} \quad (4)$$

T is time interval, N is the number of sections, and $\hat{p}_{ij}$ is pair-wise correlation between cross-sections.

3.2.2. Panel unit root test

Given the existence of CD in the series, a conventional unit root test becomes inappropriate and there is a need to utilise a unit root test, which provide for CD such as the Pesaran (2007) test. Pesaran (2007) proposed a unit root test defined as cross-sectionally augmented IPS test (hereafter, CIPS) for the given purpose.

$$CIPS = N^{-1}\sum_{i=1}^{N} t_i(N,T) \quad (5)$$

Where $t_i(N,T)$ is the cross-sectionally augmented Dickey-Fuller statistic for the i^{th} cross-section unit.

3.2.3. Panel cointegration test

Given the CD, it is also necessary to perform the co-integration test to take CD into account by examining the co-integration relationship simultaneously. Accordingly, a novel panel cointegration method introduced by Westerlund (2007) was used to find out whether there is a cointegration relationship between the research variables, or not. Westerlund (2007) introduced four novel panel tests enabled with boot-strapping alternative to examine relationships of integrated variables over a long term using data with CD. The goal was to examine existence/absence of the long-run relationships which were determined through learning about error-correcting characteristic of each members. The proposed error-correction model is explained in Equation (6):

$$\begin{aligned}\Delta y_{i,t} &= C_i + \alpha_{i,1}\Delta y_{i,t\text{-}1} + \alpha_{i,2}\Delta y_{i,t\text{-}2} + \ldots \\ &+\alpha_{i,p}\Delta y_{i,t\text{-}p} + \beta_{i,0}\Delta x_{i,t} + \beta_{i,1}\Delta x_{i,t\text{-}1} + \ldots + \\ &\beta_{i,p}\Delta x_{i,t-p} + \alpha_i(y_{i,t-1} - \beta_i x_{o,t-1}) + \mu_{i,t}\end{aligned} \quad (6)$$

Where α_i is an approximate error-correction speed for i series in long-run equilibrium; $y_{i,t} = -(\beta_i/\alpha_i) \times x_{i,t}$. The following four test statistics are reported (equations 7-10). The first two are panel statistics (7 and 8) and the next two (9 and 10) are group statistics. Equations (7) and (8) test the hypothesis H_0: α_i=0 against H_A: α_i<0 for all i. Rejecting the null hypothesis means that there is long-run relationship in the panel. Equations (9) and (10) test the hypothesis H_0: α_i=0 for all i against H_A: α_i<0 for at least one i. Rejecting the null hypothesis means that there is long-run relationship in at least one of the cross-sectional units.

$$P_r = \frac{\hat{\alpha}}{SE(\hat{\alpha})} \quad (7)$$

$$P_\alpha = T\hat{\alpha} \quad (8)$$

Where $\hat{\alpha}_i$ is the estimated value of error correction parameter and $SE(\hat{\alpha}_i)$ is the conventional standard error of $\hat{\alpha}_i$. The two group mean statistics are as follows:

$$G_r = \frac{1}{N}\sum_{i=1}^{N}\frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)} \quad (9)$$

$$G_{á} = \frac{1}{N}\sum_{i=1}^{N}\frac{T\hat{\alpha}_i}{\hat{\alpha}_i(1)} \quad (10)$$

Where $\hat{\alpha}_i(1)$=1-$\sum_{j=1}^{p_i}\hat{\alpha}_{ij}$ and $SE(\hat{\alpha}_i)$ is the conventional standard error of $\hat{\alpha}_i$.

3.2.4. Pairwise panel causality test

Long-run relationship between variables indicates that there is at least one causal relationship between variables. Granger causality test is used to find the causal relationship between the variables. We test the Granger causality panel with VAR model estimates in the following:

$$\begin{aligned}y_{it} &= a_0 + a_1 y_{it-1} + \cdots + a_p y_{it-p} + b_1 x_{it-1} + \cdots + b_p x_{it-p} + u_{it} \\ x_{it} &= c_0 + c_1 x_{it-1} + \cdots + c_p x_{it-p} + d_1 y_{it-1} + \cdots + d_p y_{it-p} + v_{it}\end{aligned} \quad (11)$$

Testing H_0: $b_1 = b_2 = \ldots b_p = 0$ against H_A: *otherwise* is a test that x_{it} does not Granger cause y_{it}. Also, testing H_0: $d_1 = d_2 = \ldots d_p = 0$ against H_A: *otherwise* is a test that y_{it} does not Granger cause x_{it}. In both tests, rejecting the null hypothesis and accepting the alternative hypothesis means that there is Granger causality among the variables. In total, four outcomes may occur: one-way Granger causality from x_{it} to y_{it}, one-way Granger causality from y_{it} to x_{it}, bi-directional causality and the absence of causality.

4. RESULTS AND DISCUSSION

In order to analyze the causality between the ISEW per capita and energy consumption per capita, experimental analysis of this study was carried out using the following steps: The first step was to examine the dependency between cross sections (countries) and whether the dependency between the panel cross sections affects the estimation results to a great extent (Pesaran, 2004). The results of this test are reported in the Table 3.

According to the test results presented in Table 4, the null hypothesis is rejected at %1 level of significance. This means that there exists strong CD in the series. From this result, a shock affecting one country does affect other countries too. We conducted

Table 3: Cross-sectional dependence test

Test	Statistics	P-value
CD	3.708	0.0002

Table 4: Panel unit root test with cross-sectional dependence

Variable	CIPS	Critical value at		
		10%	5%	1%
Log energy	–1.005	–1.52	–1.67	–1.93
Log ISEW	–2.743	–1.52	–1.67	–1.93

Table 5: Westerland's (2007) co-integration test with regard to cross-sectional dependency

Tests	Value	P-value
P_r	–5.347	0.612
P_α	–12.974	0.037
G_r	–2.898	0.037
G_α	–17.003	0.021

Table 6: Pairwise granger causality test

The null hypothesis	F-stat	Prob
Energy consumption does not cause sustainable economic welfare	1.34	0.26
Sustainable economic welfare does not cause Energy consumption	7.07	0.0002

panel unit root test and panel co-integration test with regard to CD in the next steps.

The second step of the analysis examines whether the panel data remained stationary over time. The test results are reported in Table 4.

Panel unit root test with CD shows that ISEW is stationary in level and has no unit root, but energy consumption is non-stationary in level. Therefore, co-integration among variables of the model should be investigated. The third step of the analysis examines whether there is long-term relationship between the ISEW per capita and energy consumption per capita. The test results are reported in Table 5.

According to panel co-integration test, there is a long-run relationship between the ISEW per capita and energy consumption per capita. Long-term relationship among variables suggests that causality must exist at least in one direction. In the next stage, we analyze the causality between the GDP per capita and energy consumption per capita.

Pairwise Granger causality test was carried out in this research and the results are reported in Table 6. With respect to criteria for selecting the optimal lag, three lags are used.

Thus, it is acceptable to say that sustainable economic welfare is the cause of energy consumption, and energy consumption does not lead to sustainable economic welfare in OPEC countries. The results of this study are comparable to those of Mehrara (2007) and Al Iranian (2006). Mehrara (2007) showed that energy consumption is not the cause of economic growth in oil-exporting countries.

5. CONCLUSION AND POLICY RECOMMENDATIONS

Despite the limitations of end-energy resources and the environmental problems caused by fossil fuel consumption, the question can be raised whether reducing energy consumption is jeopardizing the sustainable economic growth of OPEC countries. To answer these questions, this research examines the relationship between energy consumption and sustainable economic welfare (growth) in OPEC countries, namely Algeria, Angola, Ecuador, Gabon, Indonesia, Iran, Iraq, Nigeria Qatar, Saudi Arabia and Venezuela during the sample period of (1995-2014). The ISEW is calculated followed by an investigation of the relationship between energy consumption and sustainable economic welfare for these countries. The most important benefit component of ISEW in all countries is adjusted personal consumption followed by health and education expenditure, and net capital growth having the greatest role in forming ISEW, respectively. The most important cost component of ISEW in all OPEC countries is energy depletion. After energy depletion, environmental degradation caused by CO_2 emission, mineral depletion, and forest depletion have the greatest role in cost components of ISEW, respectively. According to panel co-integration test, there is a long-run relationship between sustainable economic welfare and energy consumption. Long-term relationship among variables suggests that causality must exist at least in one direction. It is acceptable to say that sustainable economic welfare is the cause of energy consumption, and energy consumption does not lead to sustainable economic welfare in OPEC countries.

Our results in this study have important implications for energy policy makers in OPEC countries; energy conservation policy does not have adverse impact on their sustainable economic welfare. In other words, energy conservation can lead to a better quality of the environment without leaving adverse effects on sustainable economic growth. Improving energy prices (and eliminating energy subsidies) is one way to reduce energy consumption in these countries. Because policies to raise energy prices and eliminate energy subsidies lead to increased households' living costs, these policies must be accompanied by the implementation of income distribution policies. Another way to reduce energy consumption is to increase energy efficiency in these countries.

REFERENCES

Ahmed, M., Azam, M. (2016), Causal nexus between energy consumption and economic growth for high, middle and low income countries using frequency domain analysis. Renewable and Sustainable Energy Reviews, 60, 653-678.

Al-Iriani, M.A. (2006), Energy-GDP relationship revisited: An example from GCC countries using panel causality. Energy Policy, 34(17), 3342-3350.

Alkhathlan, K., Javid, M. (2013), Energy consumption, carbon emissions and economic growth in Saudi Arabia: An aggregate and disaggregate analysis. Energy Policy, 62, 1525-1532.

Alsahlwai, M.A. (2013), Measuring energy efficiency in GCC countries using data envelopment analysis. The Journal of Business Inquiry, 12(1), 15-30.

Alshehry, A.S., Belloumi, M. (2015), Energy consumption, carbon dioxide emissions and economic growth: The case of Saudi Arabia. Renewable and Sustainable Energy Reviews, 41, 237-247.

Antonakakis, N., Chatziantoniou, I., Filis, G. (2017), Energy consumption, CO_2 emissions, and economic growth: An ethical dilemma. Renewable and Sustainable Energy Reviews, 68, 808-824.

Apergis, N., Payne, J.E. (2012), Renewable and non-renewable energy consumption-growth nexus: Evidence from a panel error correction model. Energy Economics, 34(3), 733-738.

Apergis, N., Tang, C.F. (2013), Is the energy-led growth hypothesis valid? New evidence from a sample of 85 countries. Energy Economics, 38, 24-31.

Arouri, M.E.H., Youssef, A.B., M'henni, H., Rault, C. (2012), Energy consumption, economic growth and CO_2 emissions in middle East and North African countries. Energy Policy, 45, 342-349.

Ayres, R.U., Nair, I. (1984), Thermodynamics and economics. Physics Today, 37(11), 62-71.

Azam, M., Khan, A.Q., Bakhtyar, B., Emirullah, C. (2015), The causal relationship between energy consumption and economic growth in the ASEAN-5 countries. Renewable and Sustainable Energy Reviews, 47, 732-745.

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

Beça, P., Santos, R. (2010), Measuring sustainable welfare: A new approach to the ISEW. Ecological Economics, 69(4), 810-819.

Beça, P., Santos, R. (2014), A comparison between GDP and ISEW in decoupling analysis. Ecological Indicators, 46, 167-176.

Bélaïd, F., Abderrahmani, F. (2013), Electricity consumption and economic growth in Algeria: A multivariate causality analysis in the presence of structural change. Energy Policy, 55, 286-295.

Berndt, E.R. (1978), Aggregate energy, efficiency, and productivity measurement. Annual Review of Energy, 3(1), 225-273.

Berndt, E.R., Wood, D.O. (1975), Technology, prices, and the derived demand for energy. The Review of Economics and Statistics, 57, 259-268.

Brennan, A.J. (2008), Theoretical foundations of sustainable economic welfare indicators-ISEW and political economy of the disembedded system. Ecological Economics, 67(1), 1-19.

Brennan, A.J. (2013), A critique of the perceived solid conceptual foundations of ISEW and GPI-Irving Fisher's cognisance of human-health capital in 'net psychic income'. Ecological Economics, 88, 159-166.

Charfeddine, L., Khediri, K.B. (2016), Financial development and environmental quality in UAE: Cointegration with structural breaks. Renewable and Sustainable Energy Reviews, 55, 1322-1335.

Cobb, C.W., Cobb, J.B. (1994), The Green National Product: A Proposed Index of Sustainable Economic Welfare. Lanham, MD: University Press of America.

Cobb, J., Daly, H. (1989), For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future. Boston: Beacon Press.

Damette, O., Seghir, M. (2013), Energy as a driver of growth in oil exporting countries? Energy Economics, 37, 193-199.

Denison, W.C. (1979), *Lobaria oregana*, a nitrogen-fixing lichen in old-growth Douglas fir forests. In: Symbiotic Nitrogen Fixation in the Management of Temperate Forests. Corvallis, Oregon: Oregon State University School of Forestry. p266-275.

Fuinhas, J.A., Marques, A.C. (2013), Rentierism, energy and economic growth: The case of Algeria and Egypt (1965-2010). Energy Policy, 62, 1165-1171.

Gigliarano, C., Balducci, F., Ciommi, M., Chelli, F. (2014), Going regional: An index of sustainable economic welfare for Italy. Computers, Environment and Urban Systems, 45, 63-77.

Hossein, A., Yazdan, G.F., Ehsan, A.G. (2012b), The relationship between energy consumption, energy prices and economic growth: Case study (OPEC countries). OPEC Energy Review, 36(3), 272-286.

Hossein, S.S.M., Yazdan, G.F., Hasan, S. (2012a), Consideration the relationship between energy consumption and economic growth in oil exporting country. Procedia-Social and Behavioral Sciences, 62, 52-58.

Jammazi, R., Aloui, C. (2015), RETRACTED: On the interplay between energy consumption, economic growth and CO_2 emission nexus in the GCC countries: A comparative analysis through wavelet approaches. Renewable and Sustainable Energy Reviews, 51, 1737-1751.

Lawn, P. (2013), The failure of the ISEW and GPI to fully account for changes in human-health capital-a methodological shortcoming not a theoretical weakness. Ecological Economics, 88, 167-177.

Lawn, P.A. (2003), A theoretical foundation to support the index of sustainable economic welfare (ISEW), genuine progress indicator (GPI), and other related indexes. Ecological Economics, 44(1), 105-118.

Mehrara, M. (2007), Energy consumption and economic growth: The case of oil exporting countries. Energy Policy, 35(5), 2939-2945.

Menegaki, A.N., Tugcu, C.T. (2016), Rethinking the energy-growth nexus: Proposing an index of sustainable economic welfare for Sub-Saharan Africa. Energy Research and Social Science, 17, 147-159.

Menegaki, A.N., Tugcu, C.T. (2017), Energy consumption and sustainable economic welfare in G7 countries; a comparison with the conventional nexus. Renewable and Sustainable Energy Reviews, 69, 892-901.

Mohammadi, H., Parvaresh, S. (2014), Energy consumption and output: Evidence from a panel of 14 oil-exporting countries. Energy Economics, 41, 41-46.

Narayan, P.K., Popp, S. (2012), The energy consumption-real GDP nexus revisited: Empirical evidence from 93 countries. Economic Modelling, 29(2), 303-308.

Narayan, S. (2016), Predictability within the energy consumption-economic growth nexus: Some evidence from income and regional groups. Economic Modelling, 54, 515-521.

Nasreen, S., Anwar, S. (2014), Causal relationship between trade openness, economic growth and energy consumption: A panel data analysis of Asian countries. Energy Policy, 69, 82-91.

Neumayer, E. (2000), On the methodology of ISEW, GPI and related measures: Some constructive suggestions and some doubt on the 'threshold' hypothesis. Ecological Economics, 34(3), 347-361.

Nordhaus, WD., Tobin J. (1972), Is Growth obsolete? In economic research: (NBER chapters) retrospect and prospect: Economic growth, General series, 96, 1-80.

Omri, A. (2013a), CO_2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. Energy Economics, 40, 657-664.

Omri, A., Kahouli, B. (2013b), Causal relationships between energy consumption, foreign direct investment and economic growth: Fresh evidence from dynamic simultaneous-equations models. Energy Policy, 67, 913-922.

Osman, M., Gachino, G., Hoque, A. (2016), Electricity consumption and economic growth in the GCC countries: Panel data analysis. Energy Policy, 98, 318-327.

Ozturk, I. (2010), A literature survey on energy-growth nexus. Energy Policy, 38, 340-349.

Ozturk, I., Acaravci, A. (2011), Electricity consumption and real GDP causality nexus: Evidence from ARDL bounds testing approach for 11 MENA countries. Applied Energy, 88(8), 2885-2892.

Ozturk, I., Al-Mulali, U. (2015), Natural gas consumption and economic growth nexus: Panel data analysis for GCC countries. Renewable and Sustainable Energy Reviews, 51, 998-1003.

Ozturk, I., Aslan, A., Kalyoncu, H. (2010), Energy consumption and economic growth relationship: Evidence from panel data for low and middle income countries. Energy Policy, 38(8), 4422-4428.

Pablo-Romero, M.D.P., De Jesús, J. (2016), Economic growth and energy consumption: The energy-environmental Kuznets curve for Latin America and the Caribbean. Renewable and Sustainable Energy Reviews, 60, 1343-1350.

Payne, J. (2010), A Survey of the electricity consumption-growth literature. Applied Energy, 87, 721-732.

Pesaran, M.H. (2004), General Diagnostic Tests for Cross Section Dependence in Panels. Cambridge Working Papers in Economics. No: 0435, Faculty of Economics. United Kingdom: University of Cambridge.

Pesaran, M.H. (2007), A simple panel unit root test in the presence of cross-section dependence. Journal of Applied Econometrics, 22(2), 265-312.

Pindyck, R.S. (1979), The Structure of World Energy Demand. Cambridge, MA: MIT Press. p309-317.

Posner, S.M., Costanza, R. (2011), A summary of ISEW and GPI studies at multiple scales and new estimates for Baltimore City, Baltimore Country, and the State of Maryland. Ecological Economics, 70(11), 1972-1980.

Saidi, K., Toumi, H., Zaidi, S. (2017), Impact of information communication technology and economic growth on the electricity consumption: Empirical evidence from 67 countries. Journal of the Knowledge Economy, 8(3), 789-803.

Salahuddin, M., Gow, J. (2014), Economic growth, energy consumption and CO_2 emissions in gulf cooperation council countries. Energy, 73, 44-58.

Sbia, R., Shahbaz, M., Hamdi, H. (2014), A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. Economic Modelling, 36, 191-197.

Shahateet, M.I. (2014), Modeling economic growth and energy consumption in Arab countries: Cointegration and causality analysis. International Journal of Energy Economics and Policy, 4(3), 349-359.

Shahbaz, M., Sbia, R., Hamdi, H., Ozturk, I. (2014), Economic growth, electricity consumption, urbanization and environmental degradation relationship in United Arab Emirates. Ecological Indicators, 45, 622-631.

Solarin, S.A., Ozturk, I. (2016), The relationship between natural gas consumption and economic growth in OPEC members. Renewable and Sustainable Energy Reviews, 58, 1348-1356.

Stern, D.I., Cleveland, C.J. (2004), Energy and Economic Growth. Rensselaer Working Paper in Economics No.0410. Troy, NY: Rensselaer Polytechnic Institute.

Westerlund, J. (2007), Testing for error correction in panel data. Oxford Bulletin of Economics and Statistics, 69(6), 709-748.