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AN INVESTIGATION OF THE CONTRIBUTION OF RENEWABLE AND NON-RENEWABLE ENERGY CONSUMPTION TO ECONOMIC GROWTH IN OIC COUNTRIES

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ABSTRACT

Modeling the relationship between energy consumption and economic growth in developing economies has been a very active area of research. In recent years, renewable energy resources have increased their shares in electricity generation in the majority of countries due to environmental and security of supply concerns. This study considers the simultaneous use of renewable and non-renewable energy consumption to investigate the long-run relationship between two types of energy consumption and economic growth. It makes a comparison between renewable and non-renewable energy sources in order to determine which type of energy consumption is more important for economic growth processes in OIC countries within a multivariate panel data framework over the period 1990-2010. In addition to renewable and non-renewable energy consumption measures, the model includes the measures of the real gross capital formation and the labor force. The results of the unit root test indicate that all series are non-stationary in level and integrated of order one. Afterwards, the panel co-integration test results indicate that there are the co-integrating relationships between real GDP, renewable energy consumption, non-renewable energy consumption, real gross fixed capital formation, and the labor force. The results of the Dynamic OLS (DOLS) estimator indicate that renewable and non-renewable energy consumption have a positive and significant effect on GDP but the impact of non-renewable energy is more than renewable energy. Also, the impact of real gross fixed capital and the labor force on economic growth is positive and statistically significant.

JEL classification: O13, O57, O40, C23

Keywords: Renewable energy consumption, Non-renewable energy consumption, Economic growth, Panel data, OIC countries.

1. INTRODUCTION

The Organization of Islamic Cooperation (OIC) is a mostly Muslim bloc of nations which has a membership of 57 countries spread over four continents. The organization attempts to act as the collective voice of the Muslim world and endeavors to safeguard the interests and ensure the progress and well-being of Muslims. At present, these interests include the issue of the sustainable or renewable energy in economic growth.

Renewable energy resources, such as sunlight, wind, rain, tides, and geothermal heat, and significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy, energy efficiency, and technological diversification of energy sources, would result in significant energy security and economic benefits. Fast depleting energy resources, energy scarcity, increasing cost of energy and environmental pollution are reasons that increase the importance of using renewable energy resources to protect societies from the greenhouse effect, destruction of ozone layer and air pollution which cause acid rain and smog.

Collectively labeling renewable energy resources as nonpolluting would be inaccurate. Renewable resources though, present fewer environmental problems than fossil fuels. Perhaps most significant is the elimination of carbon dioxide, sulfur dioxide and nitrous emissions in using wind, solar and hydro power. Also, the non-depletable nature of renewable energy resources and the capacity for domestic production provide a more stable supply system. Therefore, renewable resources can bridge the chasm between environmental protection and economic growth. This energy could be employed in a number of ways including the generation of electricity and providing irrigation.

According to the International Energy Outlook (2010), renewable energy is projected to be the fastest growing global energy source. Specifically, world renewable energy use for electricity generation will grow by an average of 3% per year and renewable energy consumption is increasing by 2.6% per year over the period 2007 to 2035. As a result, the renewable share of world electricity generation will increase from 18% in 2007 to 23% in 2035. Hydro-electricity and wind energy are projected as the largest shares in total renewable electricity generation at 54% and 26%, respectively.

The market for renewable energy technologies has continued to grow. Climate change concerns coupled with high oil prices, peak oil, and increasing government support, are driving increasing renewable energy legislations, incentives and commercialization.

In recent years renewable resources has been used as alternatives for non-renewable energy sources. Therefore the numbers of energy economic literatures have focused on the relationship between renewable energy and economic growth. The rapid increase in price of other energy sources and concerns about the environmental consequences of carbon emissions are factors to the consumption of renewable energy.

According to Togcu et al. (2012), one of the reasons behind focusing on this topic is that energy consumption shows considerable promise understanding the role of energy in economic growth. Another reason which conducts researchers to focus on the link between energy consumption and economic growth is the vision of sustainable development. Today, a large number of countries have agreed on conserving energy and reducing CO2 emissions. This has increased the attractiveness of energy consumption related studies. However, the key dynamic in those studies is the consumption of renewable energy sources. With the growing importance of sustainable development, researchers are interested more in the effects of renewable energy consumption on economic growth. Renewable energy sources have begun to be seen as one of the most important components in the total energy consumption of the world.

Energy is a key factor in economic growth, but even though the OIC countries have access to a wide range of energy resources, they are lacking the necessary technologies and R&D investments to process these resources. With regards to renewable energy sources, the performance of the OIC countries during the last decade is impressing. However, it is still far below the performance of developed countries.

In this regard, the objectives of this study are:

- to investigate the long-run relationship between renewable and non-renewable energy consumption and economic growth.

- to make a comparison between renewable and non-renewable energy sources in order to determine which type of energy consumption is more important for economic growth processes in OIC countries.

Apart from the introduction, the remainder of the paper is organized as follows. Section 2 is the review of the renewable energy consumption and economic growth literature. Section 3 is about data source, methodology and empirical results. Section 4 presents concluding remarks.

2. LITERATURE REVIEW

Renewable energy is a means to mitigate the environmental impact of carbon emissions whilst satisfying the energy needs for economic growth, thus, in recent years, increasing attention is being paid to renewable energy and as a result, research on the relationship between renewable energy consumption and economic growth has emerged in literature. According to Apergis and Payne (2011) and Togcu et al. (2012), the relationship between energy consumption and economic growth is set around four different hypotheses: growth, conservation, feedback and neutrality. The growth hypothesis refers to a situation in which energy consumption plays a vital role in the economic growth process directly and/or as a complement to capital and labor. The growth hypothesis is supported, if uni-directional causality is found from energy consumption to economic growth. In this case, energy conservation policies aimed at reducing energy consumption will have negative impacts on economic growth. The conservation hypothesis means that economic growth is a dynamic process which causes the consumption of energy sources. The validity of the conservation hypothesis is proved if there is uni-directional causality from economic growth to energy consumption. In this situation, energy conservation policies which may prevent energy consumption will not have a negative impact on economic growth. The feedback hypothesis states a mutual relationship between energy consumption and economic growth. The feedback hypothesis is supported if there is bi-directional causality between energy consumption and economic growth. In the case of the validity of this hypothesis, energy conservation policies designed to reduce energy consumption, may decrease economic growth performance, and likewise, changes in economic growth are reflected back to energy consumption. The neutrality hypothesis indicates that energy

consumption does not affect economic growth. The absence of causality between energy consumption and economic growth provides evidence for the presence of the neutrality hypothesis. In this case, energy conservation policies devoted to reducing energy consumption will not have any impact on economic growth.
Table 1 shows some of these recent studies.

TABLE 1
Some literature reviews for renewable energy consumption and economic growth

Study	Methodology	Country	Result	Confirmed hypothesis
Sadorsky (2009)	18 emerging countries	FMOLS, DOLS	Unidirectional causality from GDP to energy consumption	Conservation
Apergis and Payne (2010)	OECD countries	VECM causality test	Bidirectional causality in short and long run	Feedback
Apergis and Payne (2011-a)	6 Central American countries	Panel causality test	Bidirectional causality between renewable energy consumption and economic growth	Feedback
Apergis and Payne (2011-b)	16 emerging market economies	Panel cointegration and causality test	Unidirectional causality from economic growth to renewable electricity consumption	Conservation
Fang (2011)	China	SVAR	Unidirectional causality from energy consumption to economic growth	Growth
Menegaki (2011)	27 European countries	Panel cointegration and causality test	No relationship between renewable energy and economic growth	Neutrality
Tugcu, Ozturk and Aslan (2012)	G7 countries	Causality test	Bidirectional causality for all countries	Feedback

Kum, Ocal and Aslan (2012)	G-7 countries	Bootstrap-corrected causality test	Different causality relation in these countries	Growth, Conservation and Feedback

3. DATA, METHODOLOGY AND RESULTS

3.1. DATA

Annual data from 1990 to 2010 were obtained from the World Development Indicators (World Bank, 2011) for the investigated countries in this research. These are including Azerbaijan, Bangladesh, Algeria, Egypt, Gabon, Indonesia, Iran, Jordan, Kazakhstan, Kyrgyzstan, Mozambique, Malaysia, Nigeria, Pakistan, Senegal, Syrian Arab Republic, Tajikistan, Tunisia, Turkey and Uzbekistan. The selected number of OIC countries has been decreased to 20 countries due to the lack of data for renewable and non-renewable energy consumption for other countries. The production modeling framework is given as follows in general notation:

(1) $Y_{it} = f(RE_{it}, NRE_{it}, K_{it}, L_{it})$

where Y_{it} denotes real GDP in billions of constant 2000 U.S. dollars; RE_{it} is total renewable electricity consumption defined in millions of kilowatt hours; NRE_{it} is total non-renewable electricity consumption defined in millions of kilowatt hours; K_{it} represents real gross fixed capital formation in billions of constant 2000 U.S. dollars; and L_{it} is total labor force in millions.

3.2. METHODOLOGY AND RESULTS

Since the appearance of the papers by Levin and Lin (1992, 1993) and Im, Pesaran, and Shin, 1997, the use of panel data unit root tests has become very popular among empirical researchers with access to a panel data set. In the first step we use these two tests to examine the existence of unit roots in panel data sets. In the second step, the Johansen Fisher panel cointegration test is used to examine the cointegrating relationship. Afterward, we proceed to estimate the model with the DOLS (dynamic OLS) estimator. In what follows, the econometric procedures and the resulting findings are to be described in the steps of the present exercise.

3.2.1. PANEL UNIT ROOT TESTS

One familiar panel unit root test is the Levin and Lin's test (2002). The LL test is an extension of the standard Dickey–Fuller test to the panel framework. The null of a unit root is investigated against the alternative of a stationary process for all cross-sectional regions. That is, they test the null hypothesis of $\rho_i = \rho = 0$ for all i, against the alternative of $\rho_1 = \rho_2 = ... = \rho < 0$ for all i, with the test statistics $t_{\hat{\rho}} = \hat{\rho} / S.e(\hat{\rho})$, where $\hat{\rho}$ is estimated from the auto-regressive model as follows:

(2) $$\Delta y_{it} = \alpha_i + \rho y_{it-1} + \sum_{k=1}^{p} \theta_{ik} \Delta y_{it-k} + \varepsilon_{it}$$

for (*i=1,…,N*) and (*t=1,…,T*). This panel-based ADF test restricts the coefficients ρ_i by keeping them homogenous across all units of the panel. The limitation of the LL test is the assumption of homogeneity and independent error terms across cross-sectional units.

The second test presented here is the well-known IPS test which relaxes the assumption of the identical first order auto-regressive coefficients of the LL test and allows varying across regions under the alternative hypothesis. IPS test the null hypothesis of $\rho_i = 0$ for all i, against the alternate of $\rho_i < 0$ for all i. Thus, instead of pooling the data, IPS uses separate unit root tests for the N cross-section units. Their test is based on the (augmented) Dickey–Fuller statistics averaged across groups. Then the average of the t_{ρ_i} statistics can be used to perform the following Z_{t-bar} statistic:

(3) $$Z_{t-bar} = \sqrt{N}(\bar{t} - E(\bar{t})) / \sqrt{Var(\bar{t})}$$

Where, $\bar{t} = (1/N)\sum_{i=1}^{N} t_{\rho_i}$, the terms $E(\bar{t})$ and $Var(\bar{t})$ are, the mean and variance of individual specific t-statistic. Based on the Monte Carlo experiment results, IPS demonstrates that their test has more favorable finite sample properties than the LL test. Both LL and IPS tests are asymptotically distributed as standard normal with left-sided rejection area. Table 2 reports the results of panel unit root tests. At the 5% significance level, both the LL test, and the IPS tests show that all series are non-stationary in level. The results show that these panels have heterogeneous unit roots, or are integrated of order one (i.e. they are symbolically I(1)).

TABLE 2
Panel Unit Root Tests

Variables	LL	IPS
Y	21.18	15.02
RE	-0.31	-0.87
NRE	7.53	9.35
L	11.20	13.38
K	7.68	6.77
ΔY	-4.55*	-5.44*
ΔRE	-17.53*	-15.68*
ΔNRE	-7.95*	-8.13*
ΔL	-1.72*	-2.34*
ΔK	-6.91*	-7.21*

* The rejection of the null of nonstationary at the 5% level of significance.

3.2.2. PANEL COINTEGRATION TEST

Given that each of the variables contains a panel unit root, we proceed to examine whether there is a long-run relationship between the variables using the Johansen Fisher panel cointegration test proposed by Maddala and Wu, (1999). The Johansen Fisher panel cointegration test is a panel version of the individual Johansen, (1988) cointegration test. Based on the same principles underpinning the Fisher ADF panel unit root test described above, the Johansen Fisher panel cointegration test aggregates the p-values of individual Johansen maximum eigenvalue and trace statistics. If π_i is the p-value from an individual cointegration test for cross-section *i*, under the null hypothesis for the panel:

$$(4) \qquad -2\sum_{i=1}^{N}\log(\pi_i) \rightarrow X_{2N}^2$$

The value of the chi-square statistic is based on the MacKinnon (1996) p-values for Johansen's cointegration trace test and maximum eigenvalue test. In the Johansen type panel cointegration test, results are known to depend heavily on the VAR system lag order. The reported results in Table 3 support existence of cointegrating vectors.

TABLE 3
Panel Cointegration Test

Hypothesized No. of CE(s)	Fisher Stat. (from trace test)	Fisher Stat. (from max-eigen test)
None*	651.5	314.0
At most 1*	441.9	1394.0
At most 2*	209.3	191.2
At most 3*	36.9	53.1
At most 4	3.2	3.2

* The rejection of the null hypothesis at the 5% level of significance.

3.2.3. PANEL COINTEGRATION ESTIMATION

Given the evidence of panel cointegration, the long-run relations can be further estimated by several methods for panel cointegration estimation, e.g. the bias-corrected OLS (BCOLS) estimator, the fully modified OLS (FMOLS) estimator proposed by Phillips and Moon, (1999) and Pedroni, (1995), and the dynamic OLS (DOLS) estimator proposed by Kao and Chiang (2000). The choice of the preferred methods has been discussed in McCoskey and Kao (1998) and Kao and Chiang (2000). They pointed out that the latter two estimators have a non-negligible bias in small samples. Moreover, time effects can be included in the panel dynamic regression without affecting the sequential asymptotic variance of the estimator (Mark and Sul, 2003). Therefore, we base our following inferences mainly on the DOLS estimators with time effects. The DOLS estimator is fully parametric and offers a computationally convenient alternative to the FMOLS estimator proposed. Consider a cointegrated regression for homogeneous panels as follows:

$$(5) \qquad \begin{aligned} y_{it} &= \alpha_i + \lambda_i t + \theta_t + \beta' x_{it} + u_{it} \\ x_{it} &= x_{it-1} + v_{it} \end{aligned}$$

for ($i=1,\ldots,N$) and ($t=1,\ldots,T$). x_{it} is a $k\times 1$ vector composed of the regressors. α_i, $\lambda_i t$ and θ_t represent individual specific effect, individual specific linear trend, and common time effect, respectively. The second equation in “(5)” states that the independent variables are an integrated process of order one for all i so that their first differences are stationary. The estimator is based on the error decomposition

$$(6) \quad u_{it} = \sum_{j=-p}^{q} \gamma'_j \Delta x_{it-j} + \varepsilon_{it}$$

Where *p* and *q* are respectively the number of lead and lag, and ε_{it} is orthogonal to all leads and lags of the first difference of the variables x_{it}. Inserting "(6)" in the regression "(5)" yields.

$$(7) \quad y_{it} = \alpha_i + \beta X_{it} + \sum_{j=1}^{p} \eta_j \Delta X_{i,t-j} + \sum_{j=1}^{p} \varsigma_j \Delta X_{i,t+j} + e_{it}$$

The OLS estimator for β in "(7)" is known as a panel dynamic OLS estimator. The DOLS estimator is straightforward to compute, and relevant test statistics have standard asymptotic distributions (Mark and Sul, 2003).

TABLE 4
Panel Cointegration Estimation

Variable	Coefficient	t-Statistics
Intercept	19.89*	55.11
RE	0.10*	6.14
NRE	0.69*	43.29
L	0.59*	11.75
K	0.58*	8.99
Adjusted R^2	0.99	

***** The estimator of a parameter is significant at 1% level of significance.

Table 4 reveals that the coefficients are positive and statistically significant at the 1% level for renewable energy consumption, non-renewable energy consumption, real gross fixed capital formation, and the labor force respectively. Accordingly, estimated coefficients indicate that an increase in renewable and non-renewable energy consumption increases real GDP, but the impact of non-renewable energy is more than that of renewable energy. This happens because the cost of electricity generation from renewable energy is high. Also, investment in the renewable energy sector and support policies of this sector is inadequate. On the other hand, because of the geographical features of some countries and the limitation of renewable energy sources, the possibility of expansion of this sector is low. This result implies a policy that countries need to concentrate more on renewable and non-renewable energy consumption for higher real GDP. Although the impact of renewable energy on economic growth is less than non-renewable energy, the use of government policies to enhance the development of the renewable energy sector reduces greenhouse gas emissions.

4. CONCLUSIONS AND POLICY IMPLICATIONS

This study considers the simultaneous use of renewable and non-renewable energy consumption in order to differentiate the relative impact of each in the economic growth process in selected OIC countries within a multivariate panel data framework over the period 1990-2010. In addition to renewable and non-renewable energy consumption measures, the model includes the measures of the real gross capital formation and the labor force.

The results of unit root tests indicate that all series are non-stationary in level and integrated of order one. Afterwards, the panel cointegration test results show that there are cointegrating relationships between real GDP, renewable energy consumption, non-renewable energy consumption, real gross fixed capital formation, and the labor force. As a result of the existence of long-run cointegration, normal estimation methods for the panel data model should be bias-corrected in econometrics and thus the DOLS estimator is adopted. The results show that renewable and non-renewable energy consumption have a positive and significant effect on GDP but the impact of non-renewable energy is more than renewable energy. Also, the impact of real gross fixed capital and the labor force on economic growth is positive and statistically significant.

The relationship between renewable and non-renewable energy consumption and economic growth shows that although renewable energy consumption has emerged as an important energy source in the world energy consumption mix, the non-renewable energy sources cannot be ignored and both types of energy sources are important for economic growth. The difference between the two energy sources depends on the emission of greenhouse gases. Thus, policy makers should use government policies such as renewable energy production tax credits and installation rebates for renewable energy systems that enhance the development of the renewable energy sector to reduce the use of non-renewable energy sources and greenhouse gas emissions.

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