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Renewable Energy Consumption and Economic Growth in Member of OIC Countries

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Abstract

This study examines the causal relationship between economic growth, renewable energy consumption and oil prices using the data of 29 OIC (Organization of Islamic Cooperation) countries. The data are taken from 1990 to 2014. The study applies panel co-integration and causality in order to evaluate the long run and the causal relationship between the variables. Additionally, the empirical results suggest the existence of co-integration between the variables. The impact of renewable energy consumption on economic growth is positive and significant. The panel granger causality reveals the unidirectional causality between renewable energy consumption, oil prices and economic growth.

Keywords: Pedroni Co-integration, Panel Causality Test, FMOLS, DOLS

Introduction

Energy plays a vital role in the economic growth of a country. In the recent decade, the demand for energy has increased dramatically in the agriculture and manufacturing sector as it increases the efficiency of the factors of production (Huang et al. 2008). Energy can be derived from renewable and non-renewable sources. In the world of globalization, demand for energy increases day by day. While, its shortage severely affects economic growth (Sadorsky, 2009). Shortage of energy along with exorbitant prices lowers the economic growth in many countries. The energy crises of 1970 and 1973 due to disaster in oil producing states and crises in central Asia in 2008 are evidence that energy consumption and economic growth are interrelated. These crises had a great impact on many economies. The energy crises of 1970 affected the prices of oil that was the main ingredient for development at that time. So, many industrial economies had to reduce their energy consumption which adversely affected their economic progress (Altinay and Karagol, 2004).

Muslim countries are rich in energy reserves, including a number of OIC (Organization of Islamic Cooperation) countries. OIC member countries have 63% of world crude oil and 62% of natural gas production. Saudi Arabia is largest oil producing country (by holing 18% of world total oil reserves). While, Iran, Iraq, Kuwait and UAE are also among the top oil producing countries. The average growth rate of energy production in OIC member countries was 2.4% and average primary energy consumption rate was 4% in (2000-09)[1]. Degradation of environment quality from natural gas is less as compared to oil. Iran, Qatar, Turkmenistan, Saudi Arabia and UAE provide 70% of natural gas reserves of OIC. Coal is an another major source of energy that is providing energy from the 18th century, but OIC member countries are not very rich in it as they possess merely 5% of world total coal reserves. (Haktanir, 2004).

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[1] Current Stance of Energy Resources and Potential in OIC Member Countries, 2012

However, some non-renewable energy consumption degrades the environment quality like oil, coal, etc., while the renewable energy sources are a better option in this regard. To make the future generation better off from the present generations the renewable energy is a better substitute.

The investment in renewable energy sources is increasing day by day as it has reached $211 billion in 2010[2].Wind and hydro energy are the main renewable energy sources. The global growth rate of wind power was 22% in 2011 with 2.2GW installed in OIC countries. In 2010, Turkey installed a highest number of wind turbines among all the countries around the globe. However, Egypt, Morocco, Iran and Tunisia are also rich in consumption of wind energy. Repetitive nature of renewable energy sources has impressive advantages. In addition, in 2009 the hydroelectric power generation in the world was 30% higher as compared to 1999. Hydro energy production in OIC countries was 50% higher in 2010 as compared to 1990. Their annual growth rate of hydro energy production is 2% higher than European Union countries. The countries, rich in hydro energy are Turkey, Pakistan, Mozambique, Egypt and Tajikistan.[3]

Mostly, countries which are rich in fossil fuels lack capital and technology to explore them. Another problem with the use of non-renewable resources is environmental degradation. The 66.5% of global carbon dioxide, 80% of global sulfur dioxide and 70% of nitrogen oxide is generated by transport sectors[4]. Higher energy consumption may cause the existence of environmental Kuznets curve (EKC). EKC shows inverse u-shape relationship between per-capita income and environmental quality (Stern, 2000). Fodha and zaghboud (2010) estimate the EKC for Turkey, for the period of 1961-2004. They revealed that EKC exists in the case of SO_2 but for CO_2 there exists positive relationship. Another study by Shahzad et al (2013) finds the presence of EKC for CO_2 in the case of Turkey from 1970 to 2010. However, Jebli and Yousef (2015) conducted a study in Tunisia about energy consumption and environmental quality by using the data from 1980 to 2009. They concluded that an increase in trade and non-renewable energy consumption leads to an increase in CO_2. They recommended the use of renewable recourses in Tunisia; to lessen the effect of pollutants.

Furthermore, the relationship between energy consumption and economic growth varies in different regions of the world. Apergis and Payne (2009) examine the causal relationship between energy consumption and economic growth by adding labor and capital in the production function. The study considers six countries of Central America for the period of 1980-2004. Empirical results revealed the existence of a long run and the short run relationship between energy consumption and real GDP. Energy consumption affects the economic growth directly and indirectly by improving the performance of labor and capital. Another study of Apergis and Payne (2010) investigates the relationship between the renewable energy consumption and real GDP by using the data of 13 countries of Eurasia for the period of 1992-2007. Their results support the findings of their previous study in 2008. However, Jobert and Karanil (2007) examine the causal relationship between GNP and energy consumption in turkey by using the data of 1960-2003. The results support the neutrality hypothesis in GNP and industrial sector level. So, according to this study, energy saving policy can be implemented without having a bad impact on economic growth.

This study extends the literature on renewable energy consumption and economic growth in two ways. First, Islamic countries contribute more in the production of energy sources as compared to rest of the world. This study incorporates OIC (Organization of Islamic Cooperation) countries. So, it is more comparable study than previous literature in order to analyze the relationship between

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[2] Bloomberg (2011)

[3] Current Stance of Energy Resources and Potential in OIC Member Countries, 2012

[4] Sovacool (2014)

renewable energy consumption and economic growth. Second, this paper investigates the aggregate version of renewable energy consumption. Whereas, the previous studies integrate the renewable sources of electricity consumption as a proxy of renewable energy consumption. This study revealed an important role in renewable energy and environmental policy for Muslim majority countries.

The remaining part of the paper is discussed as follows: Section 2, discusses the brief review of literature on empirical studies, Section 3 describes the empirical model and the data source, Section 4 presents the estimation methodology, Section 5 gives empirical investigation of results and the last section concludes the study.

Literature review

Energy is considered as the main driver of growth. It not only brings a reduction in utility cost, but also improves revenues through productivity (Odularu and Nigeria, 2009). Payne and Apergis (2009) confirm the bidirectional causality between energy consumption and economic growth in the long run while in the short run, it shows the unidirectional causality from energy consumption to economic growth. Altinaya and Karagol (2004) empirically investigate the relationship between economic growth and energy consumption. They found the unidirectional association from energy consumption to economic growth by using Granger causality test from the period of 1950 to 2000. On contrary to (Altinaya and Karagol. 2004), Lise and Montfort (2007) empirically proved the unidirectional causality from economic growth (Gross Domestic Product) to energy consumption by using time series data from 1970 to 2003. Reynolds and Kolodzieji (2008) find the relationship between natural gas production, oil, coal and GDP by using formal ganger causality test and prove the unidirectional relationship from oil production to GDP. They also confirm the unidirectional relationship from GDP to coal production and natural gas production respectively. Apergis and Payne (2009) confirm the bidirectional causality between energy consumption and economic growth. In the short run, they find the unidirectional causality from energy consumption to economic growth.

As non-renewable energy is finite, require heavy capital and has the characteristics of environmental damage. That is why, Sadorsky (2009) estimate the bidirectional causality economic growth and renewable energy consumption for 18 emerging market economies by using panel error correction model. Apergis and Payne (2010c) show the bidirectional causality between renewable energy consumption and economic growth in both long run and short run for panel of six American countries. Payne (2011) shows the one sided relationship from biomass energy consumption to economic growth. Sari and Soytas (2008) empirically investigate the positive relationship between industrial production, hydroelectric, waste and wind energy and negative relationship between industrial production and solar energy. This study also confirms the statistical insignificant association between wood energy consumption and industrial production by using ARDL (Auto Regressive Distributed Lag Model).

Energy plays an important role in improving GDP growth because it has a strong impact on both demand and supply sides (Chontanawat et al, 2008). Squalli (2007) develops a hypothesis that economy is energy dependent if increase in energy consumption leads to increase in growth of GDP. In such scenario, polices in reduction of energy consumption will affect the growth of real GDP. Yang (2000) estimates the causality between GDP and energy consumption for Taiwan from 1954 to 1997 period. He found the bidirectional causality between energy consumption and GDP. Nachane et.al. (1988) estimates the data from 1950 to 1985 and found the unidirectional causality from energy consumption per capita to real GDP per capita. They employ Engle Granger bivariate error correction model. However, Chontanawat et al. (2008) supports the hypothesis of Squalli (2007) that increase in energy consumption will increase the growth of real GDP for eighty two countries with a different income level for the period of 1972 to 2002. Contrary to the above studies, Huang et al. (2008) elucidates that increase in energy consumption will increase the growth of real GDP in middle income countries, while in low income increase in energy consumption will not affect the growth of real GDP. Stern (2000) estimates the unidirectional causality from energy consumption to income while Soytas and Sari (2003) found no relationship between energy consumption and income.

Every economy wants faster economic growth. But, one of the difficulty, they have to face is the declining environment quality that may cause by Energy consumption (Bozkurt and Aiken, 2014). Shahbaz et al. (2014) confirms the U shaped EKC by empirically investigate the relationship between GDP, Per capita CO_2 emission, energy consumption and trade openness for Tunisia. Ang (2007) empirically investigate the causality between economic growth, energy consumption and CO_2 emission. He finds that causality running from economic growth to energy consumption and CO_2 emission in the long run, while in short run energy consumption leads to increase in economic growth. However, Ghosh (2010) states that there is no long run relationship between CO_2 emission and economic growth, but he finds the bivariate causality in case of India. Lean and Smyth (2010) confirm the short run causality running from energy consumption to CO_2 emission. However, in the long run the causality running from energy consumption and CO_2 emission to economic growth.

Over the past few decades, the association between economic growth, trade and environmental degradation has been the subject of intense research. Many of empirical studies suggested that there is the inverse U shaped relationship between per capita income and environmental features[5]. Lindmark (2002) states that cross section studies provide only the general understanding of how variables are related to each other. Akbostanci et al. (2009) elucidates that only time series analysis of single country provides an answer for the presence of the Environmental Kuznet Curve for different number of pollutants. They employ three different pollutants (CO_2, SO_2 and PM10) for empirical investigation of EKC for Turkey from 1968 to 2003. The results of the study did not find any support in favor of EKC hypothesis. Fodha and Zaghdoud (2010) find the association between pollutant emission (CO_2, SO_2) and economic growth in Tunisia by using time series data using co-integration approach. They confirm the monotonically increasing relationship between CO_2 emission and GDP and show the inverse U shaped association between GDP and SO_2.

Soytas and Sari (2007) estimate the association between income, CO_2 emission and energy consumption for the period of 1960 to 2000 in Turkey. He employs Toda-Yamamoto approach in order to find the causality between the variables. They found that CO_2 emission ganger causes the energy consumption. However, they also find the long run causation between CO_2 emission and income. Egli (2002) estimates the EKC for the period of 1966 to 1988 in case of Germany. He employs eight different pollutants which affect the environment (SO_2, CO, PM, NMVOC, NOx, CO_2, NH_3, CH_4). He finds the existence of EKC for very few pollutants. Lekakis (2000) found the increase in agriculture related pollution, air pollution and decrease in fish stock for the period of 1970 to 1980. He argues that EKC should be studied by using single country experience. In addition to that Focacci (2003) tests the association between energy, CO_2 emission and income for the past 40 years. He Investigates the EKC for the six developed countries and found the existence of the EKC.

Facacci (2005) also test the hypothesis of EKC for India between a span of 1960 to 1997. He also investigates EKC for Brazil and China between time periods of 1969-1997. He states that EKC is not valid for these three countries. He employs two variables CO_2 emission and per capita income. Perman and Stern (2003) estimate the relationship between sulfur emission and income for the panel

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[5] Seldon and Song (1994), Galeotti (2003)

of 74 countries for the period of 1960 to 1999. They employ the panel co-integration and do not find the support of EKC hypothesis. They find the U-shaped or monotonic relationship between sulfur emission and income. Harbaugh et al. (2001) claim that there is no pure theoretical guidance for the correct specification of EKC, however it is an empirical phenomena. He also asserts that the evidence of EKC is less robust than previously claimed studies. However, Khanna and Plassmann (2004) estimate the demand for environmental quality for the country US in 1990. Considering the pollution cost and consumer preference, they find the equilibrium relationship between pollution and income.

Akbostanci et al. (2008) uses the data of the 58 provinces of Turkey from 1968 to 2003, In order to check the causality between environmental deprivation and income. SO_2 emission is used as proxy of environmental degradation. They check the causality over stages of development by using PM10. The empirical results show the inverted U shaped association when they use SO_2 and PM10 as environmental degradation, but found the long run relationship between income and CO_2 emission. Jobert et al. (2007) elucidates that EKC holds in the case of Turkey. While, the EKC is sensitive with respect to countries. By using the Bayesian empirical model, they found the relationship between CO_2 emission, economic growth and energy consumption for the data of 50 countries including Turkey. Milimet et al. (2003) used semi-parametric and parametric partially linear regression model separately in order to estimate the EKC. They use NO_2 and SO_2 emission as proxy of environmental quality. The found inverted U shape of EKC especially in case of SO_2 but for SO_2 is sensitive to the assumption of the model. Moreover, Lise (2006) does not effectively find any EKC in case of Turkish data. She estimates the relationship between CO_2 emissions on agriculture and industry for the period of 1980-2003 by using energy consumption. He finds the quadratic curve for the data of CO_2, but the quadratic coefficient is not significant in the case of Turkey.

Developing or less developed countries affected more than developed ones by the climate change. It is widely believed that whenever there is climatic abnormality, the countries have fewer resources face more difficulty because of poorer people. In developed economies the pollution reduction efforts overcome the scale effect because growth rate is lower of developed countries. Bradford et al. (2000) confirms that most of the developed countries are at the upper part of EKC while most developing countries are below the turning point of the EKC. In developed countries, economic growth affects the environment degradation, but this effect is irretrievable and thus the environmental degradation cannot restore the initial environment situation. The relationship between pollution and income also depend upon the capacity of integration and the stock of environment of each country. According to Stern et al. (1996), the historical experience of the individual country regarding relationship between environment and economic growth is more useful by using econometric and also qualitative historical analysis. Liddle (2001) pointed out that increase in income lead to strictness in the environmental regulation, therefore more energy efficient technologies were adopted in order to save the environment from degradation.

Globalization leads more integration among the economies. Trade is the main engine, In order to enhance the domestic production by efficient use of resources. Trade openness helps in mobilization for factors of production among the different countries. However, dirty industries which create more pollution can also be shifted to developing countries because of movements of factor of production. Antweiler et al. (2001) investigate the relationship between trade and environment quality. He introduces composition scale and technological effects. He shows that when the technological effect is greater than scale and composition effect, this will make people richer because of an increase in their income and induces the people to import less polluting techniques to enhance the production. Copeland and Taylor (2005) elucidates that trade has a positive impact on environmental quality through the capital labor channel. The reason is that trade will shift the production of pollution intensive goods from developed to developing regions.

Shahbaz et al. (2012) empirically investigates the correlation between CO_2 emission and trade openness and found the negative relationship between them, while on contradictory to the above study, Copeland and Taylor (1995) pointed out that factor endowment in each country also affects the trade. Depending upon the environment policy of the country, comparative advantage also affects the environmental degradation. Magani (2004) verified empirically that with a 1% increase in trade openness will lead to 0.58% of carbon emission. He used the data of 63 developed and developing regions. However, Dean (2002) found the relationship between environmental quality and trade openness in the case of China and states that trade openness worsen the environment quality. Liddle (2001) pointed out that increase in income lead to strictness in the environmental regulation, therefore more energy efficient technologies were adopted in order to save the environment from degradation. Grossman and Krueger (1991) empirically investigate the relationship between free trade agreements and the environment in North America by using cross-section and panel data.

Methodology and Estimation Procedure

Data Source

Annual data of the following variables from 1990 to 2014 were obtained from world development indicators. List of OIC countries has been represented in Appendix. The modeling framework of production is as follows:

$$\mathrm{Y_{it} = f(RE_{it}, In_{it}, Lf_{it}, K_{it})}$$

$\mathrm{Y_{it}}$ shows the real GDP of constant 2005 US$, $\mathrm{RE_{it}}$ defines the renewable energy consumption in million kilowatt hours, $\mathrm{Lf_{it}}$ represents the labor force in millions, gross capital fixed formation,$\mathrm{K_{it}}$shows in constant 2005 US$ and $\mathrm{In_{it}}$ denotes the annual oil prices.

Panel unit roots

This study incorporates Levin et al. (1993) (LLC), Im et al. (1997) (IPS), Maddala& Wu (1999) (MW, ADF) and Maddala and Wu (1999) (MW, PP) panel stationary test in order to test the problem of Unit root in a variables. Above mentioned test apply to balanced panel test but heterogeneous test represented by IPS, pooled panel unit root test considered by LLC and non-parametric test is considered by MW.

LLC unit root test

Taking account of the several specifications, which is conditional upon the behavior of singular definite intercepts and time trend, Levin et al. (1993) introduces number of panel unit root test. Their test verifies the presence or absence of stationarity problem by imposing homogeneity on the autoregressive coefficients. Moreover, in every separate series, intercept and trend are different. Considering the regression of ADF, LLC unit root test investigates the problem of stationarity as given below.

1. For each country, they consider a distinct ADF equation:

$$\Delta \mathrm{Y_{i,t}} = \partial_{\mathrm{i}} + \rho_{\mathrm{i}} \mathrm{Y_{i,t-1}} + \textstyle\sum_{\mathrm{j=1}}^{\mathrm{p_i}} \partial_{\mathrm{ij}} \Delta \mathrm{Y_{i,t-j}} + \epsilon_{\mathrm{i,t}} \qquad (1)$$

For individual countries, they incorporate lag order $\mathrm{p_i}$. Taking account of the maximum lag order, the appropriate lag length is chose than smaller lag length is preferred for *ij*.

2. Save the residuals by running two distinct equations

$$\Delta \mathrm{Y_{i,t}} = \tau_{\mathrm{i}} + \textstyle\sum_{\mathrm{j=1}}^{\mathrm{p_i}} \vartheta_{\mathrm{i,t-j}} \Delta \mathrm{Y_{i,t-j}} + \mu_{\mathrm{i,t}} \rightarrow \ddot{\mu}_{\mathrm{i,t}} \qquad (2)$$

$$\mathrm{Y_{i,t-1}} = \alpha_{\mathrm{i}} + \textstyle\sum_{\mathrm{j=1}}^{\mathrm{p_i}} \vartheta_{\mathrm{i,t-j}} \Delta \mathrm{Y_{i,t-j}} + \omega_{\mathrm{i,t-1}} \rightarrow \ddot{\omega}_{\mathrm{i,t-1}} \qquad (3)$$

Regress the standard residuals,$\ddot{\mu}_{i,t}$,$\ddot{\omega}_{i,t-1}$ and the standardize error will recommended by LLC process. The above ADF equation becomes:

$$\ddot{\mu}_{i,t} = \frac{\ddot{\mu}_{i,t}}{\hat{\varphi}_{\epsilon_i}}, \qquad \ddot{\mu}_{i,t-1} = \frac{\ddot{\mu}_{i,t-1}}{\hat{\varphi}_{\epsilon_i}} \tag{4}$$

3. Panel test statistics compute by running the regression following equation 3.

$$\ddot{\mu}_{i,t} = \partial_i \ddot{\mu}_{i,t-1} + \gamma_{it} \tag{5}$$

The null hypothesis:

$H_\circ: \rho_1, .. = \cdots \rho_n = \rho = 0$

The alternative hypothesis

$H_A:, \rho = \cdots \rho_n = \rho < 0$

IPS unit root test

In a background of heterogeneous panel, Im et al. (1997) present panel unit root test. In this test ADF applies on distinct series and allow each series to have its own short run dynamics. The arithmetic mean of all distinct countries represents the overall t value. ADF represents a series as follows

$$\Delta X_{i,t} = \delta_j + \delta_i X_{i,t-1} + \sum_{j=1}^{p_i} \vartheta_{ij} \Delta X_{i,t-j} + \gamma_{it} \tag{6}$$

For each country, ADF has dissimilar lag structure in finite sample. Tabulate value of $E(t_T, P_i)$ and $var(t_T, P_i)$ replace the terms $E(t_T)$ and $var(t_T)$. Taking account of the alternative hypothesis, the IPS test permits the heterogeneity in the value of w_i. This test is more authentic as compare to single time series test. The regression equation of IPS unit root test is given below.

$$t_{NT} = \frac{1}{N} \sum_{i=1}^{N} t_{it} (P_i) \tag{7}$$

The *t* statistics of ADF for the unit root of specific country is represented by $t_{i,t}$. In ADF regression P_i represents the lag order and test statistics calculated as follows.

$$B_t = \frac{\sqrt{N(T)}[\bar{t}_T - E(t_T)]}{\sqrt{var(t_T)}} \tag{8}$$

The results of Monte Carlo simulation; carried out by IPS represents the value of $E[t_{iT}(P_i,0)]$. Lag structure of various time periods can be calculated with the help of tabulated and calculate value. Average tabulated value of $E(t_T,P_i)$ and $var(t_T,P_i)$ replace the terms with $E(t_T)$ and $var(t_T)$in the equation, when ADF has different augmentation lags P_i. Monte Carlo simulation determines the power of panel stationarity test. The null hypothesis is that difference series is stationary because each series contains the problem of unit rot. However, the null hypothesis in IPS test is that individual series in the panel do not have the problem of unit root. They also find that "presence or absence of power against the alternative where a subset of the series is stationary has serious implications for empirical work. If the tests have high power, a rejection of the unit root null can be driven by few stationary series and the whole panel may inaccurately be modeled as stationary. If, on other hand, the tests have low power it may incorrectly concluded that the panel contains a common unit root even if a majority of the series is stationary." (P.254), (Karlsson and Lothgren, 2000)

MW unit root test

Maddala and Wu (1999) introduce the Fisher type test. In this test cross section of every country I, pools out the probability values; which contains from unit root test. This test is also known as non-parametric test and ensuring the chi square distribution with 2nd degree of freedom. However, *n* represents the number of countries in a panel. Following the test statistics are:

$$\pi = -2 \sum_{i=1}^{n} log_e(P_i) \sim \chi_{2n}^{2} (\text{df}) \tag{9}$$

Pi represents the probability value, which is derived from ADF unit root test for unit i. I a single ADF regressions, the MW stationarity test is sensitive to lag length selection. That's why the MW stationarity test is better as compare to IPS.

Panel co-integration test

Traditional cointegration test expected to have low power than advance panel cointegration test. In order to test the long run examination, some tests are developed by Pedroni (1999, 2004) and Larsson et al. (2001).

However, the following cointegration used by Pedroni (1999),

$$X_{i,t} = \beta_i + \gamma_i + \Omega_{1i}W_{1i,t} + \cdots + \Omega_{mi}W_{mi,t} + \mu_{it} \tag{10}$$

We assume that two series "X" and "W" are integrated of order one. However, Ω_{1i}**,** Ω_{2i}**,** Ω_{3i}**, …** Ω_{mi} are slope coefficients; which differs along individual members of panel, while the term intercept is represented by β_i. Taking account of the heterogeneous panel, Pedroni (1999, 2004) suggested seven different statistics in order to test the co-integration relationship. Partially endogenous regressors were introduced for the correction of biasness. However, Pedroni suggested the addition of time dummies in the presence of cross sectional dependence. The classification of Pedroni seven tests are between the dimension and within the dimension statistics. Panel co-integration statistics are represented by within dimension statistics, while between dimension statistics referred as group mean panel co-integration statistics. The null hypothesis of no co-integration for all statistics test is represented as H_0: γ_i= 1for all i = 1, 2, 3 …., n. Keeping in view the within dimension and between the dimension; the alternative hypothesis is different as compare to null hypothesis. Taking account of the between dimension; the alternative hypothesis is represented as H_b:γ_i< 1for all i = 1, 2, 3 …... n. For Within dimension; the alternative hypothesis is H_b :γ_i = γ for all i = 1, 2, 3 …... n. Take out the residuals from the hypothesized co-integration equation and compute the regression. The seven test statistics of Pedroni can be written as

1. $W_v = T^2 n^{\frac{3}{2}} \left(\sum_{i=1}^{n} \sum_{t=1}^{T} \hat{k}^{-2}{}_{11,i} \hat{\mu}_{it-1}^2\right)^{-1}$ (Panel v statistics)

2. $W_p = T\sqrt{n} \left(\sum_{i=1}^{n} \sum_{t=1}^{T} \hat{k}^{-2}{}_{11,i} \hat{\mu}_{it-1}^2\right)^{-1}$ (Panel ρ statistics)

$$\sum_{i=1}^{n} \sum_{t=1}^{T} \hat{k}^{-2}{}_{11,i} (\hat{\mu}_{it-1} \Delta\hat{\mu}_{it} - \hat{\rho}_i)$$

3. $W_t = \left(\hat{\sigma}^2 \sum_{i=1}^{n} \sum_{t=1}^{T} \hat{k}^{-2}{}_{11,i} \hat{\mu}_{it-1}^2\right)^{-1/2}$ (Panel t statistics) (non-parametric)

$$\sum_{i=1}^{n} \sum_{t=1}^{T} \hat{k}^{-2}{}_{11,i} (\hat{\mu}_{it-1} \Delta\hat{\mu}_{it} - \hat{\rho}_i)$$

4. $W_t^* = \left(\hat{S}_{nT}^* \sum_{i=1}^{n} \sum_{t=1}^{T} \hat{k}^{-2}{}_{11,i} \hat{\mu}_{it-1}^2\right)^{-1/2}$ (Panel t statistics)(parametric)

$$\sum_{i=1}^{n} \sum_{t=1}^{T} \hat{k}^{-2}{}_{11,i} (\hat{\mu}_{it-1})^2 \Delta\hat{\mu}_{it}^*$$

5. $\hat{W}_p = Tn^{-1/2} \sum_{i=1}^{n} \left(\sum_{t=1}^{T} {}_1\hat{\mu}_{it-1}^2\right)^{-1}$ (Group ρ statistics)

$$\sum_{t=1}^{T} (\hat{\mu}_{it-1} \Delta\hat{\mu}_{it} - \hat{\rho}_i)$$

6. $\hat{W}_t = n^{-1/2} \sum_{i=1}^{n} \left(\hat{\sigma}_i^2 \sum_{t=1}^{T} {}_1\hat{\mu}_{it-1}^2\right)^{-\frac{1}{2}}$ (Group t statistics)(non-parametric)

$$\sum_{t=1}^{T} (\hat{\mu}_{it-1} \Delta\hat{\mu}_{it} - \hat{\rho}_i)$$

7. $\widehat{W}_t^* = n^{-\frac{1}{2}}\sum_{i=1}^{n}\left(\sum_{t=1}^{T}\hat{S}^{*^2}\,\hat{\mu}_{it-1}^{2*}\right)^{-\frac{1}{2}}$ (Group t statistics)(parametric)

$$\sum_{t=1}^{n}\hat{\mu}_{it-1}^{*}\,\Delta\hat{\mu}_{it}^{*}$$

Where $\hat{\rho}_i = 1/2\left(\hat{\sigma}_i^2 - \hat{S}_i^2\right)$and $\hat{S}_{n,T}^{*^2} = 1/n\sum_{i=1}^{n}\hat{S}^{*^2}$

The last three represented the between dimension statistics, while the first four represents the within dimension statistics. However, Pedroni (1999) presents seven test statistics. (Pedroni, 1999; P. 658) shows that “the first of the simple panel cointegration statistics is a type of non-parametric variance ratio statistics. The second is a panel version of an on parametric statistics that is analogous to the familiar Phillips–Perron rho-statistics. The third statistics is also non-parametric and is analogous to the Philips and Perron t-statistics. The fourth statistics is the simple panel cointegration statistics which is corresponding to the augmented Dickey–Fuller-statistics”. However, the rest of the statistics were built on group mean approach. “The first of these is analogous to the Philips and Perron rho-statistics and the last two analogous to the Phillips and Perron statistics and the augmented Dickey–Fuller statistics, respectively”, (Pedroni, 1999; P. 658). Taking account of the seven test statistic, Pedroni (2004) scrutinized the properties of small power. For T > 100, he showed power is high but distortion size is small. Followed by panel ADF; group ADF test has the best power properties for the small values of T. Johansen (1995) average of individual likelihood ratio of test statistics helps in deriving the panel Larrson et al. (2004) likelihood ratio test statistics. Investigations of each individual cross section system autonomously, in such a way that allows heterogeneity in each cross sectional unit root for the said panel is promised by the multivariate cointegration trace test of Johansen (1988, 1995). However, the heterogeneous VAR model helps in data generating process of each group as,

$$\mathbf{Z_{i,t=}\sum_{j=1}^{P_i}\Delta_{i,j}\,Z_{i,t-j}+\varepsilon_{i,t}} \tag{11}$$

$\varepsilon_{i,t}$ are considered as identical, independent and normally distributed, while for each, one value of $Z_{i,-j+1}$, ……$Z_{i,0}$ is reflected as fixed. However, the vector error correction model can be derived from Eq. (8) as,

$$\Delta \boldsymbol{Z_{i,t}} = \Pi_{\boldsymbol{i}}\boldsymbol{Z_{i,t-1}} + \sum_{j=1}^{P_{i-1}}\boldsymbol{\beta_{i,j}}\Delta\,\boldsymbol{Z_{i,t-j}} + \boldsymbol{\varepsilon_{i,j}} \tag{12}$$

The order of Π_i matrix is (k × k), while $\Pi_i = \Delta_{i1}+.....+\Delta_{p,1}-1$ and $\delta_{i,j}= \Delta_{i,j}- \Delta_{i,j-1}$. Rank $\Pi_i = \delta_i$, if Π_i is reduced rank matrix. Error correction form represented as full column rank; however β_i and Ω_i are of order ($k\times \delta_i$). While, the null hypothesis of Larson et al. (2001) panel rank test statistic are as,

H0: = rank (Πi) = $\delta i< \delta$ for all i = 1, 2, 3 …. n, against

Hb = rank (Πi) = k for all i = 1, 2, 3 …. n.

The process is similar to the individual trace test procedure for the determination of co-integration rank. First, we test the null hypothesis of no co-integration (H_0: = rank (Π_i) = $\delta_i< \delta$, $\delta=0$). However, acceptance of null hypothesis shows that in all groups of cross section for the said panel, there is no co-integration relationship (rank (Π_i) = $\delta_i = 0$). The null hypothesis of $\delta=1$ is tested if the first null hypothesis is not accepted. We will continue until null hypothesis is accepted and $\delta = k-1$ is rejected, sustaining the same sequence of procedure. There is at least one cross sectional rank unit in the panel; rank (Π_i) = $\delta > 0$ with the acceptance of null hypothesis (Π_i) = $\delta \leq 0$ ($0 < \delta < k$) and the acceptance of co-integration hypothesis $\delta = 0$. For the group i, the likelihood ratio of trace statistics; given below,

$$\mathbf{LR_{it}\left[\frac{H(\beta)}{H(k)}\right] = -2lnQ_{i,T}\left[\frac{H(\beta)}{H(k)}\right] = -T\sum_{l=\beta+1}^{p}ln(1-\rho_{li})} \tag{13}$$

However, l^{th} highest eigen value in the i^{th} cross section unit is represented by ρ_{li} while, the average of individual trace statistics is calculated by LR-Bar statistics.

$$\mathbf{L\bar{R}_{iT}\left[\frac{H(\beta)}{H(k)}\right] = 1/n \sum_{i=1}^{n} LR_{it}\left[\frac{H(\beta)}{H(k)}\right]} \tag{14}$$

Finally the above equation can be modified as

$$\boldsymbol{\rho_{L\bar{R}}\left[\frac{H(\beta)}{H(k)}\right] = \frac{\sqrt{n}\left(L\bar{R}\quad_{nT}\left[\frac{H(\beta)}{H(k)}\right]\right) - E(W_k)}{\sqrt{Var(W_k)}}} \tag{15}$$

Mean and variance of asymptotic trace statistics represented by $E(W_k)$ and $Var(W_k)$. Mean and variance can be obtained from simulation. However, Larson et al. (2001) prove the central limit theorem for the LR-Bar statistics by keeping in view the null hypothesis, $\rho_{L\bar{R}} \rightarrow N(0,1)$ as N and T approaches to infinity in a way that $\sqrt{NT^{-1}} \rightarrow 0$. Taking account of the assumption that there is no correlation in the error term, is given below

$$E(\varepsilon_{i,t}) = 0 \text{and} E(\varepsilon_{i,t}, \varepsilon_{j,t}) = \{ \begin{matrix} \Omega_i \\ 0 \end{matrix} \text{ for i= j and i} \neq \text{j}$$

It is necessary that T approaches to infinity because each individual test statistics to converge to its asymptotic distribution while, for central limit theorem N approaches to infinity is necessary.

Estimation of Panel Cointegration Regression

The coming step is to empirically estimate the long run co-integration indicators if all variables co-integrated. OLS estimator will be unbiased and inconsistent in the presence of co-integration due to which several estimators will be proposed. Kao and Chiang (2000) introduced the panel dynamic OLS estimators that pooled out the data along within the dimensions of panel. DOLS estimators are good for small samples and exhibits good results in general co-integrated panels. Furthermore, in the alternative hypothesis, DOLS did not take account of the cross sectional heterogeneity. Cross sectional heterogeneity creates the problem of endogeneity and serial correlation in order to obtain consistent and unbiased estimates of co-integrating vectors. For co-integrating panels, Pedroni (2000, 2001) introduced group mean fully modified OLS (FMOLS) estimators for co-integrated panels.

However, in the presence of endogeneity and heterogeneity Pedroni (2001) FMOLS provide consistent estimates in a small group of samples and it does not create a problem of large size distortions. FMOLS estimator for the coefficient of Ω is as follows

$$\widehat{\Omega} = N^{-1} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} (Z_{it} - \bar{Z})^2\right)^{-1} \left(\sum_{t=1}^{T} (Z_{it} - \bar{Z})\right) W_{it}^* - T\hat{\tau}_i \tag{16}$$

Where

$$W_{it}^* = W_{it} - \bar{W} - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta Z_{it} \hat{\tau}_i = \hat{\delta}_{21i} + \widehat{\Omega}_{21i}^0 - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \left(\hat{\delta}_{22i} + \widehat{\Omega}_{22i}^0\right)$$

However, the lower triangular decomposition of Ω_i is represented by $\hat{L}_i$ while, the associated t statistics is as follows

$$t_{\widehat{\Omega}^*} = N^{-1/2} \sum_{i=1}^{N} t_{\widehat{\Omega}^*}, i$$

Where, $t_{\widehat{\Omega}^*}, i = \left(\widehat{\Omega}_i^* - \Omega_0\right)\left[\widehat{\Omega}^{-1} 11_i \sum_{t=1}^{T} (Z_{it} - \bar{Z})^2\right]^{1/2}$

Panel Vector Error Correction Model Causality

Pesaran et al. (1999) introduced panel error correction model in the presence of co-integration. ECM also estimated the panel co-integration tests. The presence of co-integration shows that there exists a unidirectional relationship, (Granger, 1969). Co-integration results are important because it confirmed the presence of error correction process. Due to which the changes in explained variables are the function of changes in explanatory variables plus the level of disequilibrium in the co-integrating relationship. In order to test the causality between the variables following VECM model are as follows,

$$\Delta \mathrm{Y}_{\mathrm{it}} = \alpha_{3\mathrm{j}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \alpha_{\mathrm{im}}\, \Delta \mathrm{Y}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \delta_{\mathrm{im}}\, \mathrm{RE}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \beta_{\mathrm{im}}\, \mathrm{In}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{Lf}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{K} + \epsilon_1 \mathrm{ECT}_{\mathrm{t-1}} + \varepsilon_{1\mathrm{t}} \tag{17}$$

$$\Delta \mathrm{RE}_{\mathrm{it}} = \alpha_{3\mathrm{j}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \alpha_{\mathrm{im}}\, \Delta \mathrm{RE}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \delta_{\mathrm{im}}\, \mathrm{Y}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \beta_{\mathrm{im}}\, \mathrm{In}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{Lf}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{K} + \epsilon_1 \mathrm{ECT}_{\mathrm{t-1}} + \varepsilon_{1\mathrm{t}} \tag{18}$$

$$\Delta \mathrm{In}_{\mathrm{it}} = \alpha_{3\mathrm{j}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \alpha_{\mathrm{im}}\, \Delta \mathrm{In}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \delta_{\mathrm{im}}\, \mathrm{Y}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \beta_{\mathrm{im}}\, \mathrm{RE}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{Lf}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{K} + \epsilon_1 \mathrm{ECT}_{\mathrm{t-1}} + \varepsilon_{1\mathrm{t}} \tag{19}$$

$$\Delta \mathrm{Lf}_{\mathrm{it}} = \alpha_{3\mathrm{j}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \alpha_{\mathrm{im}}\, \Delta \mathrm{Lf}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \delta_{\mathrm{im}}\, \mathrm{Y}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \beta_{\mathrm{im}}\, \mathrm{RE}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{In}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{K} + \epsilon_1 \mathrm{ECT}_{\mathrm{t-1}} + \varepsilon_{1\mathrm{t}} \tag{20}$$

$$\Delta \mathrm{K}_{\mathrm{it}} = \alpha_{3\mathrm{j}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \alpha_{\mathrm{im}}\, \Delta \mathrm{K}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \delta_{\mathrm{im}}\, \mathrm{Y}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \beta_{\mathrm{im}}\, \mathrm{RE}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{In}_{\mathrm{it-m}} + \sum_{\mathrm{m}=1}^{\mathrm{p}} \vartheta_{\mathrm{im}}\, \mathrm{Lf} + \epsilon_1 \mathrm{ECT}_{\mathrm{t-1}} + \varepsilon_{1\mathrm{t}} \tag{21}$$

ECT_{t-1} and Δ represents the lagged error term and lag operator in above mentioned model. In order to check the long run causality between the variables; lagged error term is used. However, various hypotheses have been tested that check the short run relationship. For example causality for the short run has been tasted from Y to REN by testing the following hypothesis H_0:δ_{im}= 0 for all i = m. The acceptance of above mentioned hypothesis shows that REN causing Y in short run. However, the same procedure is applied for the following hypothesis and the short run relationship can be verified by Granger causality F tests. The significance of error correction terms can be verified in each of the following equation by using t test.

Empirical results and analysis

Panel unit root tests

In first step of our analysis, Table 1 represents the result of unit root test at difference and first difference. Three unit root test are applied: LLC, IPS and MW in order to check the stationarity of each selected variable with trend and without trend. Our empirical results suggest that at level form; all variables are non-stationary. However, at first difference; all variables are stationary. Thus, null hypothesis of non-stationary at 5% level of significance has been rejected and concludes that all variables are stationary at first difference for the panel of 29 OIC countries.

Panel co-integration results

The order of integration at first difference helps us to apply panel co-integration technique to estimate the long run relationship between the variables of choice panel. However, the results of Pedroni (1999, 2004) panel co-integration are represented by Table 2. Pedroni incorporates three panel statistics; between the dimension and four panel statistics; within dimension to check whether the selected panel data are co-integrated. In addition, based on the estimators, which pooled the autoregressive coefficients across the different cross sections for the unit root test on the estimated residuals; within dimension statistics contains the estimated value of test statistics. On the other hand, between the dimensions shows the estimated value of test statistics, which is based on the average of individually, estimated coefficients for each cross section. However, the results of between dimension and within dimension tests reveal the rejection of null hypothesis of no co-integration in most of the cases. Therefore, renewable energy consumption, income growth, oil prices, labor force and gross capital formation are co-integrated in the panel of 29 OIC countries

FMOLS and DOLS estimations

Table 3 and Table 4 represent the estimates of FMOLS and DOLS at individual level. However, the difference between these two approaches is not very remarkable in terms of magnitude and sign of the coefficients. In case of Azerbaijan, Bangladesh, Iraq, Libya, Maldives, Mauritania, Niger, Saudi Arabia, Sudan, Syrian, Tajikistan, Tunisia, Turkey, Turkmenistan, Middle east (Developing) and Middle east (All income level); the renewable energy consumption is negative and significant. Negative and significant sign reveals that increase in renewable energy consumption decreases the income of selected OIC. However, increase in oil prices leads to decrease the income growth in case of Bangladesh, Egypt, Gambia, Libya, Maldives, Mauritania, Morocco, Niger, Saudi Arabia, Senegal, Turkey, Turkmenistan and Yemen. In addition, the grouped results of FMOLS and DOLS are reported in Table 5. However, Table 5 reports the results of grouped FMOLS and DOLS. Results reports that all variables are statistically significant and their signs are according to economic theory. Increase in renewable energy consumption leads to income level. Results suggests that increase of 1% in renewable energy consumption leads to 0.07% increase in income growth, while 1% increase in oil prices will increase 0.04% of income growth.

Table 1: Panel unit root test

Variables	At Level				At difference			
	Without trend	P Value	With trend	P Value	Without trend	P value	With trend	P value
LLC Test								
Y	9.32	1.00	1.27	0.89	-3.41	0.00	-5.05	0.00
K	8.24	1.00	1.61	0.94	-2.68	0.00	-5.03	0.00
Lf	4.64	1.00	0.33	0.63	-3.20	0.00	-5.51	0.00
RE	17.26	1.00	58.82	1.00	-284.38	0.00	-119.90	0.00
In	-1.98	0.02	3.17	0.99	-1.91	0.02	-1.39	0.08
IPS								
Y	13.19	1.00	6.16	1.00	-4.47	0.00	-6.71	0.00
K	11.34	1.00	6.335	1.00	-4.06	0.00	-5.31	0.00
Lf	12.63	1.00	1.02	0.84	-1.91	0.02	-190	0.02
RN	1.46	0.93	0.57	0.71	-7.32	0.00	-6.13	0.00
In	-0.87	0.19	-0.93	0.34	-4.38	0.00	-1.39	0.02
ADF MW								
Y	5.61	1.00	15.94	1.00	116.60	0.00	148.79	0.00
K	6.67	1.00	22.326	1.00	124.55	0.00	133.19	0.00
Lf	16.24	1.00	62.09	0.33	90.48	0.00	86.35	0.00
RN	45.21	0.89	58.38	0.46	154.78	0.00	127.25	0.00
In	65.34	0.18	43.32	0.85	117.72	0.00	83.04	0.00

Table 2: Pedroni panel cointegration

Test	Panel υ-Statistics	Panel *rho* Statistics	Panel *ρρ*-Statistics	Panel *adf* Statistics	Grouped *rho* Statistics	Grouped *ρρ*-Statistics	Grouped *adf* Statistics
Statistic	0.76	2.03	-2.67	-4.06	4.83	-6.51	-4.85
P value	0.22	0.97	0.00	0.00	1.00	0.00	0.00

Table 3: DOLS (country specific)

Country	variables	K	In	Lf	RE
Afghanistan	Coefficients	0.16	0.07	4.33	0.01
	P value	0.00	0.00	0.00	1.34
Algeria	Coefficients	0.77	0.01	0.43	0.06
	P value	0.00	1.45	0.00	1.47
Azerbaijan	Coefficients	0.77	0.12	3.60	-0.60
	P value	0.00	0.00	0.00	0.00
Bangladesh	Coefficients	0.64	-0.01	-1.42	-1.39
	P value	0.00	1.38	0.00	0.00
Comoros	Coefficients	0.09	0.02	1.99	0.40
	P value	0.00	0.04	0.00	0.00
Djibouti	Coefficients	0.18	0.01	1.07	0.36
	P value	0.00	0.04	0.00	0.00
Egypt	Coefficients	0.74	-0.02	1.94	0.68
	P value	0.00	0.03	0.00	0.00
Gambia	Coefficients	0.01	-0.07	0.46	0.34
	P value	1.23	0.00	0.00	0.00
Iraq	Coefficients	0.10	0.19	6.39	-0.02
	P value	0.00	0.00	0.00	1.47
Iran	Coefficients	0.92	0.04	0.006	0.11
	P value	0.00	0.00	2.37	0.01
Jordan	Coefficients	0.32	0.04	1.59	0.52
	P value	0.00	0.00	0.00	0.00
Libya	Coefficients	0.38	-0.19	-1.24	-1.03
	P value	0.00	0.00	0.00	0.00
Maldives	Coefficients	0.13	-0.01	1.57	-0.16
	P value	0.00	1.34	0.00	0.03
Mauritania	Coefficients	0.23	0.008	0.70	-1.24
	P value	0.00	1.67	0.00	0.00
Morocco	Coefficients	0.77	-0.02	0.19	0.12
	P value	0.00	0.03	0.01	0.02
Niger	Coefficients	0.57	-0.03	-0.56	-0.52
	P value	0.00	0.00	0.00	0.00
Pakistan	Coefficients	0.58	0.02	1.53	1.05
	P value	0.00	0.03	0.00	0.00
Saudi Arabia	Coefficients	0.70	0.004	0.37	-0.07
	P value	0.00	1.34	0.05	1.13
Senegal	Coefficients	0.96	-0.02	-0.21	0.45
	P value	0.00	0.03	0.01	0.00
Sudan	Coefficients	0.19	0.09	1.38	-3.12
	P value	0.00	0.00	0.00	0.00
Syrian	Coefficients	0.94	0.07	0.37	0.05
	P value	0.00	0.00	0.05	1.32
Tajikistan	Coefficients	0.30	0.05	3.11	-1.30
	P value	0.00	0.00	0.00	0.00
Tunisia	Coefficients	0.70	0.04	1.20	-0.19
	P value	0.00	0.00	0.00	0.00
Turkey	Coefficients	0.56	-0.07	0.69	-0.73
	P value	0.00	0.00	0.00	0.00
Turkmenistan	Coefficients	1.35	0.01	0.43	0.005
	P value	0.00	1.21	0.00	2.13
Uzbekistan	Coefficients	0.72	0.02	0.84	0.11
	P value	0.00	0.03	0.00	0.01
Yemen	Coefficients	0.61	-0.06	1.64	0.72
	P value	0.00	0.00	0.00	0.00

Table 4: FMOLS (country specific)

Country	variables	K	In	Lf	RE
Afghanistan	Coefficients	-0.316	0.06	7.92	0.17
	P value	0.00	0.00	0.00	0.00
Algeria	Coefficients	0.70	0.02	0.58	0.01
	P value	0.00	0.05	0.00	0.23
Azerbaijan	Coefficients	0.70	0.12	4.0	-0.42
	P value	0.00	0.00	0.00	0.00
Bangladesh	Coefficients	0.54	-0.01	-1.46	-1.69
	P value	0.00	0.25	0.00	0.00
Comoros	Coefficients	0.12	0.02	2.23	0.44
	P value	0.00	0.05	0.00	0.00
Djibouti	Coefficients	0.18	-0.03	1.18	0.44
	P value	0.00	0.00	0.00	0.00
Egypt	Coefficients	0.80	-0.009	2.42	1.29
	P value	0.00	0.94	0.00	0.00
Gambia	Coefficients	0.09	-0.07	0.25	0.78
	P value	0.00	0.00	0.01	0.00
Iraq	Coefficients	0.12	0.02	5.28	-0.17
	P value	0.00	0.05	0.00	0.00
Iran	Coefficients	0.86	0.01	0.07	0.13
	P value	0.00	0.12	0.11	0.04
Jordan	Coefficients	0.26	0.03	1.66	0.57
	P value	0.00	0.00	0.00	0.00
Libya	Coefficients	0.27	-0.15	-0.48	-0.11
	P value	0.00	0.00	0.00	0.03
Maldives	Coefficients	0.17	-0.009	1.53	-0.12
	P value	0.00	0.13	0.00	0.04
Mauritania	Coefficients	0.27	-0.005	0.53	-1.65
	P value	0.00	0.12	0.00	0.00
Morocco	Coefficients	0.76	-0.02	0.10	0.02
	P value	0.00	0.05	0.15	0.15
Niger	Coefficients	0.49	-0.005	-0.23	-1.13
	P value	0.00	0.13	0.01	0.00
Pakistan	Coefficients	0.64	0.025	1.54	1.54
	P value	0.00	0.00	0.00	0.00
Saudi Arabia	Coefficients	0.73	-0.005	0.29	-0.08
	P value	0.00	0.14	0.03	0.01
Senegal	Coefficients	0.97	-0.02	-0.13	0.69
	P value	0.00	0.05	0.15	0.00
Sudan	Coefficients	0.17	0.09	1.47	-3.07
	P value	0.00	0.00	0.00	0.00
Syrian	Coefficients	0.96	0.13	0.16	-0.001
	P value	0.00	0.00	0.13	1.35
Tajikistan	Coefficients	0.27	0.057	3.35	-1.35
	P value	0.00	0.00	0.00	0.00
Tunisia	Coefficients	0.74	0.047	1.13	-0.27
	P value	0.00	0.00	0.00	0.00
Turkey	Coefficients	0.55	-0.057	0.60	-0.80
	P value	0.00	0.00	0.00	0.00
Turkmenistan	Coefficients	1.24	-0.009	-0.12	-0.09
	P value	0.00	1.53	1.25	0.01
Uzbekistan	Coefficients	0.70	0.03	1.06	0.09
	P value	0.00	1.45	0.00	0.01
Yemen	Coefficients	0.72	-0.08	1.59	0.85
	P value	0.00	0.00	0.00	0.00

Table 5: FMOLS and DOLS panel

Variables	FMOLS		DMOLS	
	Coefficients	P value	Coefficients	P value
K	0.987	0.00	0.959	0.00
RE	0.077	0.00	0.070	0.00
In	0.045	0.02	0.041	0.04
Lf	0.099	0.00	0.145	0.00

Table 6: VECM based granger causality

	Dependent variables	ΔY	ΔRE	ΔIn	ΔLf	ΔK	ECM(-1)
Eq. 20	ΔY		6.4 (0.03)	1.62 (0.44)	15.03 (0.00)	4.31 (0.11)	-0.05 (0.00)
Eq. 21	ΔRE	2.72 (0.25)		1.17 (0.55)	0.46 (0.79)	3.41 (0.18)	0.01 (0.50)
Eq. 22	ΔIn	4.40 (0.11)	7.13 (0.02)		5.46 (0.06)	0.78 (0.67)	0.11 (0.25)
Eq. 23	ΔLf	0.78 (0.67)	2.76 (0.25)	4.83 (0.08)		1.0009 (0.60)	0.08 (0.00)
Eq. 24	ΔK	12.43 (0.00)	0.53 (0.76)	3.69 (0.15)	1.96 (0.37)		0.08 (0.00)
P values in parenthesis							

Results of panel causality

The long run and short run test of Granger causality are reported in Table 6. Taking account of the equation 20, the coefficient of lagged error correction term is negative and significant at 1% level. The significance and negative sign of error correction term reveals the existence of long run and short run Granger causality which runs from renewable energy consumption, capital formation, oil prices and labor force to income growth. The presence of unidirectional causality supports the hypothesis that renewable energy causes economic growth. However developed economies make policies, which enhance the greater use of renewable energy consumption. However many countries take initiative like renewable energy production tax credits, rebates for renewable energy system in order to facilitate the greater use of renewable energy sources.

Conclusion

Renewable energy consumption considered as energy source which may eliminate the high and unstable energy prices and reliance on energy source of other country. However, as compared to previous studies in the field of energy, this study incorporates the impact of renewable energy consumption on economic growth process. In addition to the renewable energy consumption, the model of our study also considers measures of capital, labor and oil prices within multivariate error correction model for the panel of 29 OIC from 1990 to 2014.

In addition, Pedroni (1999, 2004) panel co-integration results show the presence of long run relationship between real GDP, renewable energy consumption, real gross fixed capital formation, labor force and oil prices. Their long run elasticity estimates are significant and positive. However, there is not much difference between the estimates of FMOLS and DOLS. Furthermore, the results of panel error correction model reveal the unidirectional causality from renewable energy consumption to economic growth.

The dependence of renewable energy consumption and economic growth suggests the usage of renewable energy consumption is important for economic growth in Islamic countries. However, in order to meet the certain objectives of policy maker; the development of energy sector may act as motivation to improve the economic growth. Economic growth can further act as an engine in order to improve the research and development in renewable technologies. Policy maker should develop different mechanism for the improvement and market access of renewable energy.

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