ANALYZING OF THE VALIDITY OF ENERGY-GROWTH HYPOTHESIS IN N-11 COUNTRIES

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ABSTRACT

This study aims to determine which energy-growth hypothesis is valid in Next-11 countries. We adopt a panel estimation techniques for the period of 1984-2010 to examine the possibility of growth, conservative, feedback, or neutrality hypotheses for Next-11 countries. Firstly, second generation unit root test are used to investigate stationarity properties of the variables because of the cross-sectional dependence.Then a panel cointegration and panel causality approach are proposed to examine the causal relationship between the variables. Finally, panel vector autoregression model, impulse-response and variance decomposition analysis are applied using generalized moment methods.

The findings obtained from panel Granger causality test suggests that there is evidence of uni-directional causality between renewable energy consumption and economic growth in the short-term, which is consistent with the growth hypothesis. It is also found that the responses of growth to a shock of renewable energy consumption are positive. Since there is evidence indicating that renewable energy consumption may trigger economic growth.

Keywords:*Renewable Energy, Economic Growth, CO_2 Emissions, Panel VAR, Next-11 Countries*

JEL Classification: *C33, Q43, C23, P28 O47*

1. INTRODUCTION

The issue of economic growth and energy consumption relationship becomes a hot topic and it has been comprehensively examined by researchers and scientists. As known economic growth is closely related to energy consumption since more energy consumption leads to higher economic growth (Halicioglu, 2009). Policy makers need to know the direction of this relationship in order to implement an appropriate environmental and energy policies that will contribute to sustainable development. After the pioneer seminal work of Kraft and Kraft (1978) who examined the causal relathionship between energy consumption and economic growth for United States, numerous studies have been conducted to establish the nexus between these variables by applying various estimation methods. The empirical outcomes of these studies are mixed and have not reached a consensus yet. The literature bring forward four hypotheses depending on the direction of causality tests (Chen et al., 2007; Ozturk, 2010). The growth hypothesis postulates that energy consumption contributes to economic growth. The feedback hypothesis rests on the assumption that there is bi-directional causal link between energy consumption and economic growth. The neutrality hypothesis implies that there is no causality between energy consumption and economic growth. According to conservation hypothesis there is unidirectional causality running from economic growth to energy consumption.

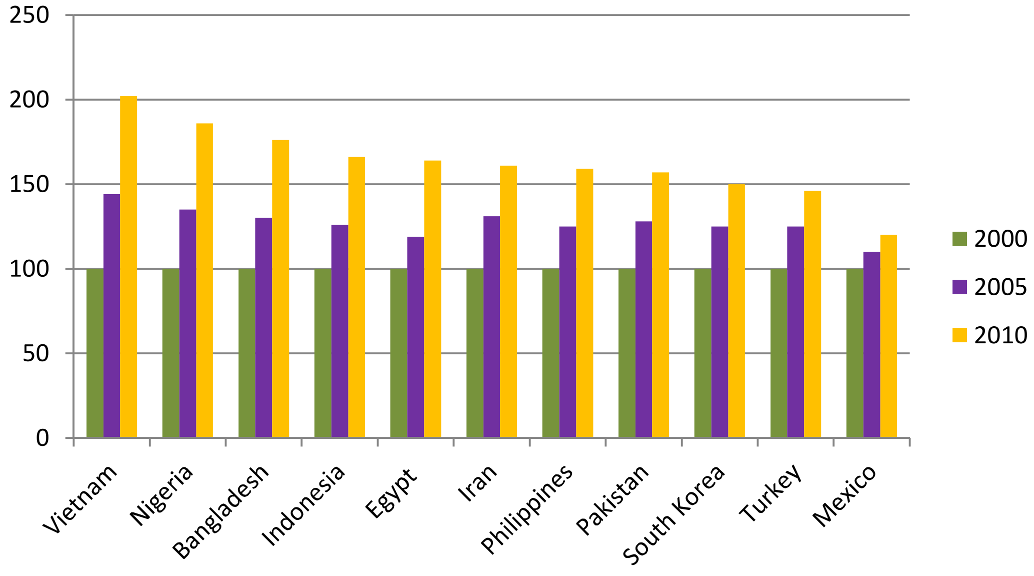
In light of the above mentioned hypotheses, the main objective of this study is to determine which energy-growth hypothesis is valid in case of N-11 countries. The annual data for 1984-2010 period for South Korea, Indonesia, Iran, Mexico, Philippines, Turkey, Bangladesh, Egypt, Nigeria, Pakistan, Vietnam used in the analysis. The relationship between renewable energy consumption, economic growth and carbon dioxide emissions is examined by employing Panel Vector Autoregressive Models. In addition, in order to determine the effect of the shock between variables impulse- response functions and variance decomposition analysis have been conducted.

The rest of the paper organised as follows: next section is devoted to the renewable energy potential in Next-11 countries. Section 3 briefly reviews the literature related to the causal relationship between renewable energy consumption and economic growth. Section 4 presents data and variable used. Methodology and empirical results are discussed in section 5. Finally section 6 provides conclusions and policy implications.

2. ECONOMIC GROWTH, CO2 EMISSIONS AND RENEWABLE ENERGY IN NEXT-11 COUNTRIES

In 2005 Goldman Sachs identified eleven countries (South Korea, Indonesia, Iran, Mexico, Philippines, Turkey, Bangladesh, Egypt, Nigeria, Pakistan, Vietnam) by taking them into the same groupings as the “Next-11” (Wilson and Stupnytska, 2007). According to Lawson et al. (2007) 7% of the world economy constitute N-11 countries. GDP growth rates of these countries (base year 2000) is shown in Figure 1. As shown in Figure 1 continuous increase in the GDP growth rate was recorded in all countries. It is extremely important to ensure the growth conditions to capture the high growth rates. The fulfillment of these conditions depends on political and macroeconomic stability in these countries (Sachs, 2011). These countries are predicted to make up 17% of global GDP towards 2050 (Sachs, 2013).

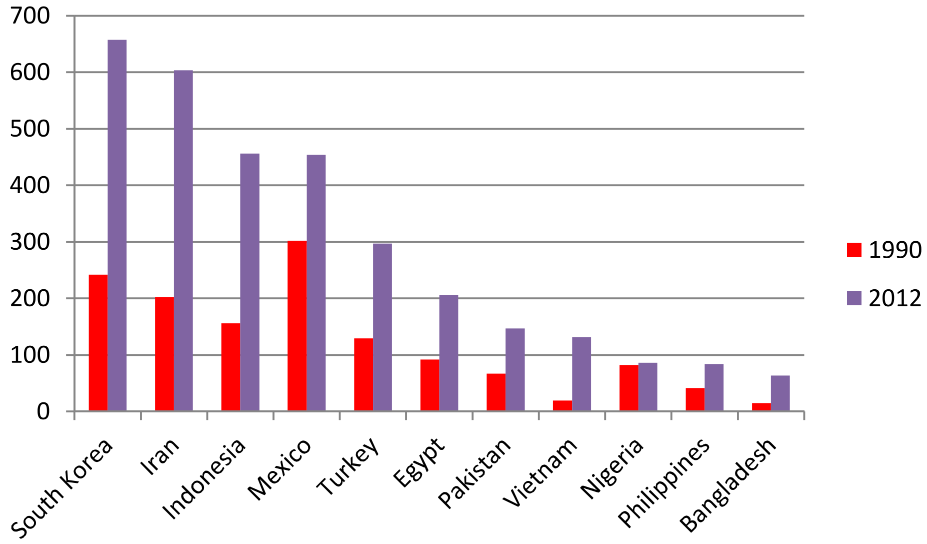
Figure 1. GDP growth in Next-11 countries



Source: World Bank

While in 2006 the N-11 countries accounted for 6% of total emissions, this ratio has increased to 10% by 2012. As can be seen from Figure 2 South Korea, Iran, Indonesia, Mexico and Turkey are the largest emitters compared to other countries.

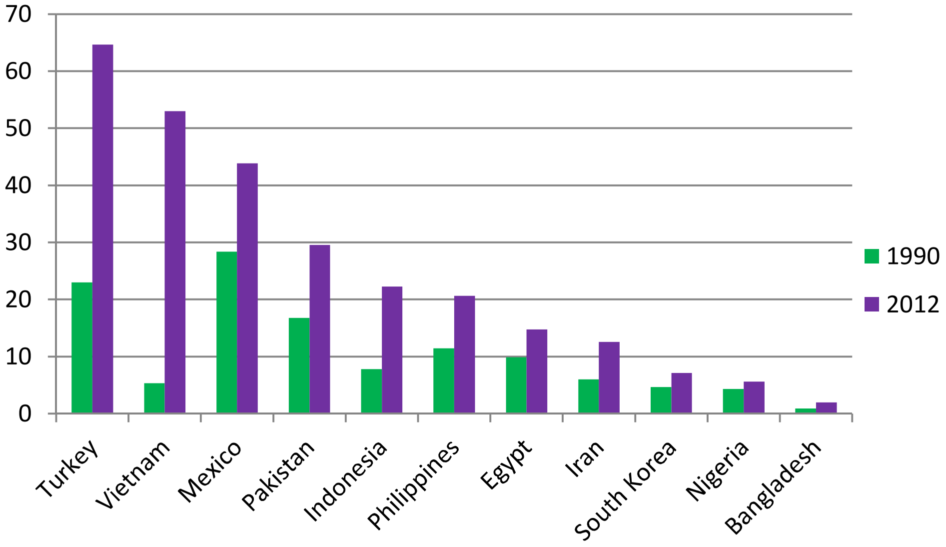
Figure 2. CO2 emissions in Next-11 countries



Source: US Energy Information Administration (EIA) 2015

In 2012 6% of the world's renewable energy was consumed in these countries (EIA, 2015). According to Figure 3 it can be observed that Turkey, Vietnam and Mexico are the countries with the highest renewable energy consumption. In addition it can be seen that in 2012 renewable energy consumption in all countries increased compared to 1990.

Figure 3. Renewable energy consumption in Next-11 countries



Source: US Energy Information Administration 2015

Next -11 countries are endowed with a huge solar, geothermal and wind energy potential, and the exploitation of this potential could bring various benefits to the region. For example, Mexico is highly rich in renewable energy sources (solar, wind, biomasss, hydropower and geothermal). However, this kind of energy has not been fully exploited. Hydropower is the most widely used form of renewable energy (11,603 MW installed capacity within the country), while geothermal power capacity (958 MW) makes Mexico to be ranked 4th in the use of this energy worldwide. Mexico has a wind energy potential of 71,000 MW, although only 1.7% of this potential is currently in use (Mexico Energy Policy, Laws and Regulations Handbook, 2015). Wind energy potential is concentrated in five different zones, mainly in the state of Oaxaca, and solar energy has a high potential due to Mexico's ideal location in the so called Solar Belt with annual global solar radiation (5.6-6.1 KWh/m^2-day). Biomass energy has the highest potential (2635 to 3771 PJ/year) also (Alemán-Nava et al., 2014).

With 100,000 MW of potential installed capacity, Iran’s wind power potential could compete with France and Britain. Thereby Iranian government understanding the importance of this type of energy over other renewable energy sources. The south, northwest and southeast regions receive around 300 days of sun per year, they are unequivocally suited for solar energy. Iran has also begun development on the Middle East’s first geothermal power plant. A study conducted by researchers at Stanford University, for instance, emphasizes that development of geothermal energy in Iran is possible in 14 separate geographies, covering almost the entire country (Wheeler and Desai, 2016).

As for Indonesia, the country is home to 40 percent of the world’s known geothermal resource and offers opportunities in wind, solar, biomass, and hydropower. By 2025, Indonesia wants to install 6.7 gigawatts (GW) of new renewable energy capacity by increasing the proportion of renewables from 7 percent to 15 percent of total energy production (International Trade Administration, 2010).

Egypt is acknowledged as having some of the world's best wind resources, especially in the Gulf of Suez area, with essential extra potential along the east and west banks of the Nile. According to the Egypt Wind Energy Association, 700 km^2 have been set aside for new wind projects in the Gebel el-Zayt area (Norton Rose Fulbrıght, 2013). Owing to its location, topography and climate, Egypt has an average level of solar radiation of between 2,000 to 3,200 kWh/m^2 a year, giving it significant potential for taking advantages of this form of renewable energy (Energy Research Center, 2006).

Concerning Vietnam, experts from the World Bank have concluded that country has the ability to generate 513,360 megawatts annually through wind power. Nowadays, there are more than 20 wind power projects in Vietnam (Nhan and Ha-Duong, 2009).

According to the estimation of World Bank if 5 percent of convenient land in central and northern Nigeria was designated for solar thermal then there was a theoretical potential of 42,700 MW of power production (Uzoma et al., 2011;GENI, 2014).

According to the Department of Energy, the Philippines is the world's second-biggest geothermal producer next to the United States of America. It is also the first among the members of the Association of Southeast Asian Nations (ASEAN) to invest in large-scale solar and wind technologies. With the country's untapped renewable energy potential, the Philippines is predicted to be the world leader in geothermal energy, the largest producer of wind power, and the solar manufacturing center in Southeast Asia (Senate Economic Planning Office (SEPO), 2014).

Bangladesh is a subtropical country, 70% of year sunlight is dropped in Bangladesh. For this reason, solar panels can be used to produce electricity largely. Bangladesh receives an average daily solar radiation of 4-6.5 kWh/m^2 (Rahman et al., 2013). Also Bangladesh is a major rice producing country. It produces on the average about 35,000,000 MT of Paddy per Year. If only 20% of this paddy i.e. 7,000,000 MT could be made useful through the gasification technology; then the Power generation from rice husk could attain substantial amount (Chowdhury et al., 2012).

Solar mapping conducted by National Renewable Energy Laboratory (NREL), in collaboration with USAID, has pointed out a potential of 2.9 million MW in Pakistan. It is predicted that approximately 40,000 remote villages will be electrified through solar energy (Mirza et al., 2011).

The government of South Korea aims to produce 6.1% of energy from renewables by 2020. And by 2030 targets to double this ratio. South Korea has the largest tidal power plant of the world, The Shihwa Lake. Its capacity is 254 MW and can generate 552 million kWh per year. This amount is sufficient to provide 500,000 houses with energy. Moreover it is estimated that South Korea has wind power potential of 186.5 TWh per year. In 2010 the installed capacity was about 350 MW. Due to successfully completed solar energy project on the Korean Island of Donggwang, each house has solar panels on it; schools are independent in energy (GENI, 2012).

Turkey is a country with 48,000 MW of wind, Mwt 31,500 of geothermal, 8.6 Mtoe (million tonnes of oil equivalent) of biomass capacity and average annual 1,500 kWh/m^2 of the Global Solar Radiation (Kaplan, 2015).

As can be seen from the above mentioned Next -11 countries have abundant renewable energy resources. By promotion and support of renewable energy, these countries can reduce their dependence on oil and natural gas. Furthermore, they can take environmental benefits from renewable energy resources.

3. LITERATURE REVIEW OF ENERGY-GROWTH HYPOTHESIS

The energy-growth literature contains numerous discussions on the causal link between energy consumption and economic growth. The direction of causality is very important for policy makers. The relationship between energy consumption and economic growth can be described in four different hypotheses (Squally, 2007; Apergis and Payne, 2011b; Apergis and Payne, 2012; Shahbaz et al., 2012) which are called feedback, neutrality, conservation and growth hypothesis. Each hypothesis has its own policy implication. There is abundant empirical literature that focuses on the relationship between renewable energy consumption and economic growth for developing and developed countries. And different econometric techniques have been used in these studies. In this section we elaborate on multi-country studies in which only panel estimation techniques have been employed.

According to *feedback hypothesis* there is a bi-directional causal relationship between energy consumption and economic growth. It implies that there exist interdependence between energy consumption and economic growth since both variables affect each other. In this case implementation of energy expansionary policies for long run sustainable economic growth is suggested. For example, Chang et al. (2015) investigate causal relationship between renewable energy consumption and economic growth across the G7 countries, using annual data for the period of 1990–2011 by employing panel causality methodology. The empirical results support the existence of a bi-directional causal relationship between economic growth and renewable energy for the overall panel. Al-mulali et al. (2014) employed panel estimation techniques to explore the effect of renewable and non-renewable electricity consumption on economic growth in 18 Latin American countries. The results revealed the existence of feedback causality between the variables. Ohler and Fetters (2014) examine the causal relationship between economic growth and electricity generation from renewable sources (biomass, geothermal, hydroelectric, solar, waste, and wind) across 20 OECD countries over 1990 to 2008 by adopting panel error correction model. Their results found a bidirectional relationship between aggregate renewable generation and real GDP. Apergis and Payne (2012) examine the relationship between renewable and non-renewable energy consumption, real gross fixed capital formation, the labor force and real GDP by adopting panel error correction model for 80 countries. The results reveal that the feedback hypothesis is valid in other words there is bidirectional causality between renewable and non-renewable energy consumption and economic growth. Apergis and Payne (2011a) examine the relationship between renewable energy consumption and economic growth for a panel of six Central American countries over the period 1980–2006 by applying panel error correction model. Their results found bidirectional causality between renewable energy consumption and economic growth in both the short- and long-run. Apergis and Payne (2010a) employed panel cointegration test to examine the causal relationship between renewable energy consumption and economic growth for 13 countries within Eurasia over the period 1992–2007 within a multivariate panel data framework. The empirical findings indicate bidirectional causality between renewable energy consumption and economic growth in both the short-run and long-run. Using panel of 20 OECD countries, Apergis and Payne (2010b) applied panel estimation techniques to examine the relationship between renewable energy consumption and economic growth over the period 1985–2005. Their empirical investigation confirmed the existence of bidirectional causality between renewable energy consumption and economic growth in both the short- and long-run. Apergis et al. (2010) examine the causal relationship between CO2 emissions, nuclear energy consumption, renewable energy consumption and economic growth for 19 developed and developing countries for 1984-2007 time period. The empirical investigation revealed the bidirectional causality between renewable energy consumption and economic growth so the feedback hypothesis is valid.

Neutrality hypothesis points out no causality between energy consumption and economic growth, implying neither energy conservation or expansion policies will affect the economic growth. Menegaki (2011) investigates the nexus between economic growth and renewable energy for 27 European countries in a multivariate panel framework for the 1997-2007 time period. The results indicate the evidence of the neutrality hypothesis.

An uni-directional causality from energy consumption to economic growth corresponds with *growth hypothesis*, which argues that energy consumption contributes to economic growth. In other words it means that the economy is energy dependent and in this case energy conservation policies may have an adverse impact on economic growth. Bhattacharya et al. (2016) in their study investigate the effects of renewable energy consumption on the economic growth of 38 countries by employing panel estimation techniques. The results indicate that renewable energy consumption has a significant positive impact on the economic output for 57% of selected countries. Saidi and Mbubarek (2016) applied panel Granger causality test to investigate the causal relationship between nuclear energy consumption, CO2 emissions, renewable energy and real GDP per capita for nine developed countries over the period 1990–2013. Results revealed a unidirectional causality running from renewable energy consumption to real GDP per capita for the whole panel at short run. In the long run, there exists also a bidirectional causality between renewable energy consumption and real GDP per capita. Inglesi-Lotz (2016) estimates the impact of the renewable energy consumption on economic welfare by employing panel data techniques. The results show that the influence of renewable energy consumption or its share to the total energy mix on economic growth is positive and statistically significant. In case of MENA countries Çağlayan Akay et al. (2015) also utilized PVAR approach to investigate the relationship between renewable energy consumption, economic growth and carbon dioxide emissions over the period of 1988–2010. The finding of this study shows that there exists a bi-directional causality between growth and renewable energy consumption, which is consistent with the feedback hypothesis in terms of the energy consumption-growth nexus. Likewise, Jebli and Youssef (2015) applied panel cointegration techniques to examine the causal relationship between output, renewable and non-renewable energy consumption, and international trade for a sample of 69 countries during the period 1980–2010. Their results confirmed that renewable, non-renewable energy consumption and trade have a positive and statistically significant impact on economic growth. Tiwari (2011) employed PVAR approach to analyze the relationship between renewable energy consumption, non-renewable energy consumption, economic growth and CO2 emissions in case of Europe and Eurasian countries using the data over the period of 1965–2009. The impact of renewable energy is found to be positive on the growth rate of GDP, thus supporting the growth hypothesis.

Uni-directional causality running from economic growth to energy consumption supports the *conservation hypothesis*. Conservation hypothesis advocates for an implementation of conservative energy policy. Because energy conservation policies have no adverse effects on economic growth. Sadorsky (2009a) applied panel cointegration test to investigate the causal relationship between renewable energy consumption and economic growth using a panel of 18 emerging countries for the period of 1994–2003. Empirical findings tends to support the conservation hypothesis. Sadorsky (2009b) applied panel cointegration test to explore the long run relationship between renewable energy consumption, oil prices, economic growth and energy pollutants for the G7 countries. The empirical investigation revealed uni-directional causal relationship running from economic growth to renewable energy consumption.

Omri et al. (2015) investigate the causal relationship between two types of energy variables and economic growth using dynamic simultaneous-equation panel data models for 17 developed and developing countries. The results for the renewable energy and economic growth show that there is a unidirectional causality running from renewable consumption to economic growth in Hungary, India, Japan, Netherlands, and Sweden, while there exist a unidirectional running from economic growth to renewable consumption in Argentina, Spain, and Switzerland. A bidirectional relationship is supported in Belgium, Bulgaria, Canada, France, Pakistan, and the USA, while no causality exists in Brazil, Finland, and Switzerland. Also it has been found the existence of a bidirectional causality between nuclear consumption and economic growth; and a unidirectional causality running from economic growth to renewable energy consumption for the global panel. Salim et al. (2014) examine the dynamic relationship between renewable and non-renewable energy consumption and industrial output and GDP growth in OECD countries using data over the period of 1980–2011 by employing panel cointegration technique. The empirical evidence showed bidirectional short-run relationship between GDP growth and non-renewable energy consumption and unidirectional causality between GDP growth and renewable energy consumption. Aïssa et al. (2014) employed panel cointegration techniques to examine the relationship between renewable energy consumption, trade and output in a sample of 11 African countries covering the period 1980–2008. The empirical investigation validated that in the short-run, there is no evidence of causality between output and renewable energy consumption and between trade (exports or imports) and renewable energy consumption. However, in the long-run, it has been found that renewable energy consumption and trade have a statistically significant and positive impact on output. Apergis and Payne (2011c) examine the relationship between renewable and non-renewable electricity consumption and economic growth for 16 emerging market economies within a multivariate panel framework over the period 1990–2007. The results from the panel error correction model reveal unidirectional causality from economic growth to renewable electricity consumption in the short-run and bidirectional causality in the long-run. Furthermore, there is bidirectional causality between non-renewable electricity consumption and economic growth in both the short-run and long-run.

4. DATA AND VARIABLES

In this study to test the validity of energy-growth hypothesis in case of N-11countries, annual data for the period of 1984-2010 are used and the relationship between renewable energy consumption (REC, in billion kilowatt hours), carbon dioxide emissions (CO2, in metric tons per capita) and economic growth (GDP, in constant 2005 US dollars) are examined. Data are collected from the World Bank and EIA database. All variables are measured in the natural logarithmic form. Since this study focuses on the investigation of the dynamic casual relationship among considered variables PVAR approach was applied. PVAR model is estimated by GMM and impulse-response, variance decomposition analysis have been conducted.

5. ECONOMETRIC METHODOLOGY AND RESULTS

Firstly panel unit root test and panel cointegration tests have been applied in order to determine the integration properties and investigate the presence of long-run relationships among variables. Before employing unit root analysis it should be identified whether cross section dependence exist or not. Cross-sectional dependence in panel data can significantly affect the inference obtained (Breusch and Pagan, (1980); Pesaran, 2004). To test cross-sectional dependence CD (Cross-Section Dependence) test was implemented, proposed by Pesaran (2004) and the results are summarized in Table 1.

Table 1. Results of Pesaran (2004) CD test

Variables	Test Statistics	Probability
LGDP	37.35	0.000
LREC	25.54	0.000
LCO2	23.00	0.000

Test statistics : $CD = \sqrt{\frac{1}{N(N-1)}}\sum_{i=j}^{N-1}\sum_{i=j+1}^{N}(T\hat{\rho}_{ij}^{2} - 1) \sim N(0,1)$

$H_0: \rho_{ij} = cor(u_{it}, u_{jt}) = 0 \quad i \neq j$ there is cross-sectional independence. ρ_{ij} is a simple correlation coefficient between residuals derived from the least squares estimation of each equation.

It is evident from Table 1 that null hypothesis is rejected at the 1% significance level for all variables. Accordingly, it can be concluded that there is cross-section dependence among variables. İn this case the stationarity property of the series should be analyzed by employing second generation CADF (Cross-Sectionally Augmented Dickey Fuller) test proposed by Pesaran (2007), which take into account cross-sectional dependence.The results of Pesaran (2007) CADF unit root tests are reported in Table 2.

Table 2. Results of Pesaran (2007) unit root test

	Level(constant + trend)			First Difference(constant+ trend)		
	LGDP	LREC	LCO2	ΔLGDP	ΔLREC	ΔLCO2
tbar statistic	-2.324	-2.669	-2.611	-2.643***	-4.213***	-3.346***
zbar statistic	-0.015	-1.244	-1.038	-2.986***	-8.353***	-5.389 ***
probability	0.494	0.107	0.150	0.001	0.000	0.000

Notes. (i)*** t bar statistics indicates statistical significance at the 1% level
(ii) critical values obtained from Pesaran (2007)

According to the results obtained it is clear that all the variables contain unit roots (at 1% sicnificance level), they are not stationary at level. In other words variables are stationary at the first difference, that is, all variables are I(1). As series are integrated to the same order, co-integration technique has been implemented in order to investigate long-run relationship between variables. Co-integration of variables has been analyzed by employing second generation panel cointegration test proposed by Westerlund (2007), which allows for cross-sectional dependence. In the presence of cross-sectional dependence bootstrap p-values should be calculated. Panel cointegration test suggested by Westerlund (2007) consist of four panel cointegration test. While two of the four tests are (G_τ ve G_α) group mean and the other two tests are (P_τ ve P_α) panel tests. It is essential to determine lag/lead length. The objective of the tests are to investigate the presence of cointegration by determining whether error correction exists for individual panel units.

Table 3. Results of Westerlund (2007) test

Statistics	Group Mean		Panel	
	G_t	G_a	P_t	P_a
Test statistic	-2.736	-8.564	-8.849	-7.928
Probability	(0.206)	(0.989)	(0.081)	(0.896)

Notes. (i) regression contains intercept and trend terms
(ii) lag and lead length calculated based on 4*(T/100) 2/9

The results indicate that the null hypothesis of no cointegration can not be rejected by four test statistics. According to the results it can be concluded that there is no cointegration across the cross sectional units. Thus, Westerlund (2007) tests provide strong evidence against the existence of equilibrium long-run relationship between the variables.

Since series are not cointegrated then Granger causality test defined as follows will be performed:

$$\Delta Y_{i,t} = \theta_{1i} + \sum_{k=1}^{p} \theta_{11ik}\, \Delta Y_{i,t-k} + \sum_{k=1}^{p} \theta_{12ik}\, \Delta X_{i,t-k} + u_{1i,t} \quad (1)$$

$$\Delta X_{i,t} = \theta_{2i} + \sum_{k=1}^{p} \theta_{21ik}\, \Delta X_{i,t-k} + \sum_{k=1}^{p} \theta_{22ik}\, \Delta Y_{i,t-k} + u_{2i,t} \quad (2)$$

This method is used in the analysis of short-term relationship. Results of Panel Granger causality test are displayed in Table 4.

Table 4. Results of causality test

Direction of causality	χ2 test statistics	Probabilities	Outcomes
ΔLGDP → ΔLCO2	1.518767	0.4680	Does not Granger cause
ΔLREC → ΔLCO2	4.686491	0.0960	Does not Granger cause
ΔLCO2 → ΔLGDP	10.62990	0.0049	Granger causes
ΔLREC → ΔLGDP	7.025001	0.0298	Granger causes
ΔLCO2 → ΔLREC	1.682486	0.4312	Does not Granger cause
ΔLGDP → ΔLREC	0.213825	0.8986	Does not Granger cause

Note. The null hypothesis: there is no causality

The results reported in Table 4 show that there is evidence of uni-directional causality between renewable energy consumption and economic growth (REC→ GDP). These results provide empirical evidence in favor of the validity of growth hypothesis between economic growth and renewable energy consumption. Furthermore, it can be seen that there is uni-directional causality running from carbon dioxide emissions to growth (CO_2 → GDP).

In order to examine the nexus between renewable energy consumption, economic growth and carbon dioxide emissions PVAR approach has been applied using GMM. Also impulse-response and variance decomposition analysis have been conducted.The impulse response functions and variance decompositions are often centred in PVAR analyses, which allow us to gain a clear picture of the dynamic relationships among variables of interest.

The most influential variable on one macroeconomic variable is determined by variance decomposition analysis and whether this variable can be used as an effective policy tool is determined by the impulse-response functions (Lütkepohl, 2009). PVAR model estimation is performed by using GMM approach, which uses the lagged values of the regressors as instrumental variables (Love and Zicchino, 2006).

Following to Abrigo and Love (2015), we apply the consistent moment and model selection criteria for GMM models proposed by Andrews and Lu (2001), based on Hansen's

(1982) J statistics of overidentifying restrictions. These criteria are called MBIC, MAIC and MQIC. In order to determine the number of lags in the PVAR model we report in Table 5 the overall coefficient of determination (CD) and from the moment and model selection criteria.

Table 5. Lag length

Lag	CD	J	J pvalue	MBIC	MAIC	MQIC
1	0.2717	24.5397	0.6002	-122.4055	29.4602	-66.9483
2	0.2944	18.1633	0.4449	-79.8001	-17.8366	-42.8286
3	0.2952	12.9216	0.1661	-36.0601	-5.0783	-17.5744

According to the Table 5, the first order panel VAR is preferred model since this has the smallest MBIC, MAIC and MQIC. PVAR models with one lag are estimated using GMM in the study. GMM is well suited for obtaining efficient estimators in a panel context where a model like ours contains lagged dependent variables along with unobserved effects (Arellano and Bond, 1991). In the next step, three-variable Panel VAR model was estimated and results are suumarized in Table 6.

Table 6. Results of three-variable panel VAR model

	Equations		
Variables	$\Delta LGDP_{it}$	$\Delta LREC_{it}$	$\Delta LCO2_{it}$
$\Delta LGDP_{it-1}$	0.2320	0.2185	0.0978
(t-stat)	(1.6361)	(0.3805)	(0.4057)
$\Delta LREC_{it-1}$	0.0031	-0.1013	0.0244
(t-stat)	(0.2753)	(-1.4352)	(0.9305)
$\Delta LCO2_{it-1}$	-0.0457	-0.1717	-0.0606
(t-stat)	(-1.6540)	(-1.6099)	(-0.7039)

PVAR results provide us with the information concerning the direction of relationship between variables. Table 6 demonstrates that when GDP is taken as a dependent variable renewable energy consumption takes positive values. In other words coefficients of first lag is 0.0031, which shows shocks occurring in renewable energy consumption have positive impact on economic growth. It can be inferred that renewable energy consumption can boost economic growth. When renewable energy consumption is taken as a dependent variable it was observed that economic growth positively affects renewable energy consumption. When carbon dioxide emission is taken as a dependent variable it can be seen that impact of economic growth on carbon dioxide emission is positive.

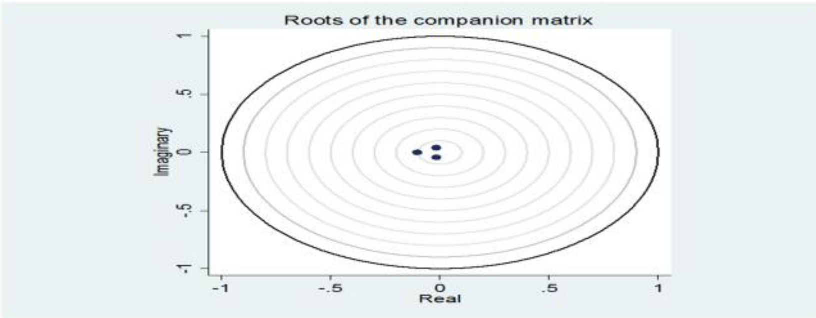
In both Table 8 and in Figure 4 we report evidence on the stability properties of the estimated PVAR model. Lütkepohl (2005) and Hamilton (1994) both show that if modulus of each eigenvalue, strictly less than one, the estimates satisfy the eigenvalue stability condition, thus the estimated PVAR model is stable.

Table 8. Eigenvalue stability condition

Eigenvalue		Modulus
Real	Imaginary	
-0.1041	0	0.1041
-0.0151	0.0416	0.0443
-0.0151	-0.0416	0.0443

Specifying the figure option produced a graph of eigenvalues with the real components on the x axis and the complex components on the y axis. The Figure 4 indicates visually that these eigenvalues are well inside the unit circle.

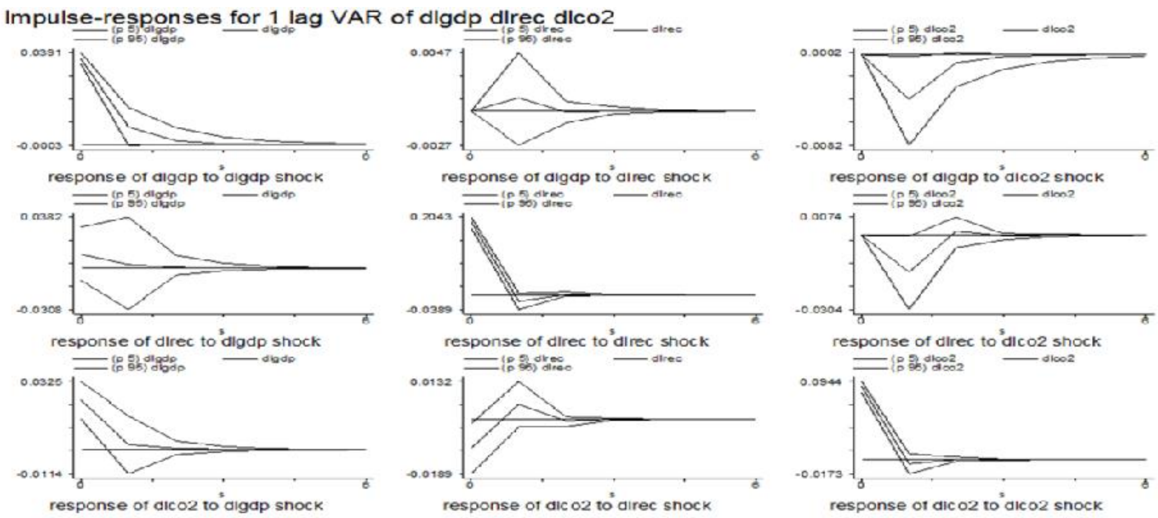
Figure 4. Unit circle



The estimated results and the PVAR stability condition check suggests that the model satifies the stability condition due to the fact that all of the roots lie inside the unit circle told us implementing impulse response analysis of the VAR methodology.

Impulse response shows response of a variable to shock in fundamental determinants (Lütkepohl, 2009). The impulse response analysis is a device to display the dynamics of the variables tracing out the reaction of each variable to a particular shock at time t. The magnitude of theshocks and the resulting impulse responses are measured in terms of one standard deviation. The impulse response functions are presented in Figure 5.

Figure 5. Impulse-response functions



Impulse responses are obtained within a band representing a 95 percent confidence interval estimated by Monte Carlo simulation with 500 repetitions. According to the results the responses of both renewable energy consumption and carbon dioxide emissions in one standard deviation shock in economic growth are positive. Further, response of economic growth in one standard deviation shock in carbon dioxide emissions is negative while the response of renewable energy consumption is negative initially and positive in the forthcoming periods. Response of economic growth in one standard deviation shock in renewable energy consumption is positive. Response of carbon dioxide emissions in one standard deviation shock in renewable energy consumption is positive initially and negative in the forthcoming periods.

In order to determine the source of changes in the variance of the variables variance decompositions analysis is used in PVAR framework. It shows which percentage of a change occurring in the examined variables are explained by itself and which are by other variables. If the significant part of the changes emerge from the shock occurring in the variable itself, it indicates that this variable is acting as exogenous (Enders, 1995). The results of variance decomposition analysis are summarized in Table 9.

Table 9. Results of the variance decomposition analysis

Variables	LGDP	LREC	LCO2
LGDP	0.9873	0.0007	0.0118
LREC	0.0031	0.9906	0.0061
LCO2	0.0657	0.0150	0.9191

Note.The results of the variance decomposition for 10 periods ahead

Results presented in Table 9 indicate that a change in REC is explained fully by its own innovations. Further, we found that GDP and CO2 emissions respectively explains about 98% and 2% of total variation 10 periods ahead in GDP. Finally, REC, GDP and CO2 emissions respectively explains about 2%, 6% and 92% of total variation 10 periods ahead in CO2 emissions. It was determined that the second variable affecting the growth is carbon dioxide emissions and this variable was followed by renewable energy.

6. CONCLUSION

This study attempts to investigate the validity of energy-growth hypothesis in case of N-11 countries. For this purpose by using annual data for the period 1984-2010 Panel VAR approach has been implemented. A second generation unit root and co-integration tests are employed because of the existence of cross-sectional dependence.

In accordance with causality results we found evidence of uniderectional causal relationship between growth and renewable energy consumption. This result indicate the validity of growth hypothesis between economic growth and renewable energy consumption. Furthermore, evidence shows that there is unidirectional causality running from CO2 emissions to economic growth

In general in terms of considered period and countries it is seen that the most important determinants of renewable energy is itself. In addition, it was found that shock occurring in the renewable energy consumption has enhancing effect on the growth. This result can be interpreted as renewable energy may contribute to the economic growth.

The findings of this study may provide researchers and policy makers with information on the implementation of appropriate energy and environmental policy.

REFERENCES

ANDREWS, D.W.K. and LU, B., 2001, Consistent model and moment selection procedures for GMM estimation with application to dynamic panel data models. *Journal of Econometrics*, 101(1), 123-164.

ABRIGO, M. R.M. and LOVE, I., 2015, Estimation of panel vector autoregression in Stata: a package of programs. http://paneldataconference2015.ceu.hu/Program/Michael-Abrigo.pdf

AÏSSA, M.S., JEBLI, M.B. and YOUSSEF, S.B. 2014, Output, renewable energy consumption and trade in Africa. *Energy Policy*, 66, 11-18

AL-MULALI, U., FEREIDOUNI, H. G. and LEE JANICE, Y.M. 2014, Electricity consumption from renewable and non-renewable sources and economic growth: Evidence from Latin American countries, *Renewable and Sustainable Energy Reviews*, 30, 290-298.

ALEMÁN-NAVA, S.G., CASIANO-FLORES, V.H., CÁRDENAS-CHÁVEZ, D. L., DÍAZ-CHAVEZ, R., SCARLAT, N., MAHLKNECHT, J., DALLEMAND, J.F. and PARRA, R. (2014). Renewable energy research progress in Mexico: A review. *Renewable and Sustainable Energy Reviews*, 32, 140–153.

APERGIS, N., PAYNE, J.E., MENYAH, K. and WOLDE-RUFAEL, Y. 2010, On the causal dynamics between emissions, nuclear energy, renewable energy, and economic growth. *Ecological Economics* 69, 2255–2260.

APERGIS, N. and PAYNE, J.E. 2010a, Renewable energy consumption and growth in Eurasia. *Energy Economics*, 32(6), 1392–1397.

APERGIS, N. and PAYNE, J.E. 2010b, Renewable energy consumption and economic growth: evidence from a panel of OECD countries. *Energy Policy*, 38(1), 656–660.

APERGIS, N. and PAYNE, J.E. 2011a, The renewable energy consumption-growth nexus in Central America. *Applied Energy*, 88(1), 343–347.

APERGIS, N. and PAYNE, J.E. 2011b, On the causal dynamics between renewable and non -renewable energy consumption and economic growth in developed and developing countries. *Energy Systems*, 2(3), 299-312.

APERGIS, N. and PAYNE, J.E. 2011c, Renewable and non-renewable electricity consumption–growth nexus: Evidence from emerging market economies. *Applied Energy*, 88(12), 5226-5230.

APERGIS, N. and PAYNE, J.E. 2012, Renewable and non-renewable energy consumption growth nexus: evidence from a panel error correction model. *Energy Economics*, 34, 733–738.

ARELLANO, M. And BOND, S. 1991, Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, 58(2), 277-297.

BHATTACHARYA, M., PARAMATI, S. R., OZTURK, I. and BHATTACHARYA, S. 2016, The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied Energy*, 162, 733–741

BREUSCH, T. S. and PAGAN, A. R. 1980, The Lagrange multiplier test and its applications to model specification in econometrics. *Review of Economic Studies*, Blackwell Publishing, 47(1), 239-253.

CHEN, S.-T., KUO, H.-I. and CHEN, C-C. 2007, The relationship between GDP and electricity consumption in 10 Asian Countries. *Energy Policy*, 35, 2611–2621.

CAGLAYAN AKAY E., ABDIYEVA R. and OSKONBAEVA Z. 2015, The causal relationship between renewable energy consumption, economic growth and carbon dioxide emissions: Evidence from Middle East and North Africa Countries. Paper presented at the *International Conference on Eurasian Economies*, Kazan/Russia, pp.628-636.

CHANG, T., GUPTA, R., INGLESI-LOTZ, B., SIMO-KENGNE, D. and SMITHERS, A. 2015, Trembling renewable energy and growth: Evidence from heterogeneous panel of G7 countries using Granger causality. *Renewable and Sustainable Energy Reviews*, 52, 1405-1412.

CHOWDHURY, N. REZA, S. E., NITOL, T. A., and MAHABUB, A.A. 2012, Present scenario of renewable energy in Bangladesh and a proposed hybrid system to minimize power crisis in remote areas. *Internatıonal Journal of Renewable Energy Research*, 2(2), 280-288.

ENDERS, W. 1995, *Applied econometric time series*, John Wiley and Sons Inc., New York.

ENERGY RESEARCH CENTER. 2006, *Renewable energy sector in Egypt*. Final Report, Volume (I).

GLOBAL ENERGY NETWORK INSTITUTE GENI. 2012, How is 100% renewable energy possible in South Korea by 2020?

GLOBAL ENERGY NETWORK INSTITUTE GENI. 2014, How is 100% renewable energy possible for Nigeria?

HALICIOGLU, F. 2009, An econometric study of CO2 emissions, energy consumption, income and foreign trade inTurkey. *Energy Policy*, 37, 1156–1164.

HAMILTON, J.D. 1994, *Time series analysis*. Princeton: Princeton University Press.

HANSEN, L.P. 1982, Large sample properties of generalized method of moments estimators. *Econometrica*, 50(4), 1029-1054.

INGLESI-LOTZ, R. 2016, The impact of renewable energy consumption to economic growth: A panel data application. *Energy Economics*, 53, 58–63.

INTERNATIONAL TRADE ADMINISTRATION. 2010, *Renewable Energy Market Assessment Report: Indonesia*. pp.1-8.

JEBLI, M.B. and YOUSSEF, S.B. 2015, Output, renewable and non-renewable energy consumption and international trade: Evidence from a panel of 69 countries. *Renewable Energy*, 83, 799-808.

KAPLAN D. 2015, *Renewable energy Turkey opportunity*. Embassy of the Kingdom of the Netherlands

KRAFT, J. and KRAFT, A. 1978, On the relationship between energy and GNP. *Journal of Energy Development*, 3, 401–403.

LAWSON, S., HEACOCK, D. and STUPNYTSKA, A. 2007, *Beyond the BRICS: a look at the 'Next -11.'* Retrieved from http://www.goldmansachs.com/our-thinking/archive/archive-pdfs/brics-book/brics-chap-13.pdf

LOVE, I., and ZICCHINO, L. 2006, Financial development and dynamic investment behavior: Evidence from a panel VAR. *The Quarterly Review of Economics and Finance*, 46, 190-210.

LUTKEPOHL, H. 2005, *New introduction to multiple time series analysis*. New York: Springer.

LÜTKEPOHL, H. 2009, Econometric analysis with vector autoregressive models. *In Handbook of Computational Econometrics*. Eds: D.A. Belsley and E.J. Kontoghiorghes, John Wiley and Sons, Ltd., UK.

MENEGAKI, A.N. 2011, Growth and renewable energy in Europe: a random effect model with evidence for neutrality hypothesis. *Energy Economics*, 33(2), 257–263.

MEXİCO ENERGY POLİCY, LAWS AND REGULATİONS HANDBOOK. 2015, Volume 1 Strategic information and basic laws. International Business Publication, USA.

MIRZA, I.A, AHMED, S. and SHAHID KHALIL, M. 2011, Renewable Energy in Pakistan: Opportunities and challenges. *Scientific journal of Comsats – Science Vision*, 16-17, 13-20.

NHAN N.T. and HA-DUONG M. 2009, Economic potential of renewable energy in Vietnam's power sector. *Energy Policy*, 37(5), 1601–1613.

NORTON ROSE FULBRIGHT, 2013, *Renewable energy in Egypt: hydro, solar and wind.*

OMRI, A., MABROUK, N. B. and SASSI-TMAR, A. 2015, Modeling the causal linkages between nuclear energy, renewable energy and economic growth in developed and developing countries. *Renewable and Sustainable Energy Reviews*, 42, 1012-1022.

OHLER, A. and FETTERS, I. 2014, The causal relationship between renewable electricity generation and GDP growth: A study of energy sources. *Energy Economics*, 43, 125-139.

OZTURK, I. 2010, A literature survey on energy-growth nexus. *Energy Policy,* 38, 340–349.

PESARAN, M. H. 2004, *General diagnostic tests for cross section dependence in panels*. Working Paper, No: 0435 University of Cambridge, pp.1-39.

PESARAN, M. H. 2007, A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics,* 22, 265–312.

RAHMAN, Md. S., SAHA, S. K., KHAN, Md. R. H., HABIBA, U. and CHOWDHURY, S. M. H. 2013, Present situation of renewable energy in Bangladesh: Renewable energy resources existing in Bangladesh. *Global Journal of Researches in Engineering Electrical and Electronics Engineering*, 13(5), 1-7.

SACHS, G. 2011, It is time to re-define emerging markets. Strategy series. Asset Management.

SACHS, G. 2013, N-11 Equity Portfolio. People. Potential. Possibilities. http://www.goldmansachs.com/gsam/docs/funds_international/brochures_and_sales_aids/fund_literature/advisor_brochure_n-11_en.pdf. (01.06.2015)

SADORSKY, P. 2009a, Renewable energy consumption and income in emerging economies. *Energy Policy*, 37, 4021–4028.

SADORSKY, P. 2009b, Renewable energy consumption, CO2 emissions and oil prices in the G7 countries. *Energy Economics*, 31, 456–462.

SAIDI, K. and MBAREK, M.B. 2016, Nuclear energy, renewable energy, CO_2 emissions, and economic growth for nine developed countries: Evidence from panel Granger causality tests. *Progress in Nuclear Energy,* 88, 364–374.

SALIM, R.A., HASSAN, K. and SHAFIEI, S. 2014, Renewable and non-renewable energy consumption and economic activities: Further evidence from OECD countries. *Energy Economics*, 44, 350-360.

SENATE ECONOMIC PLANNING OFFICE SEPO. 2014, *Renewable energy at a glance.* AG-14-02, pp.1-3.

SHAHBAZ, M., ZESHAN, M. and AFZA, T. 2012, Is energy consumption effective to spur economic growth in Pakistan? New evidence from bounds test to level relationships and Granger causality tests. *Economic Modelling*, 29, 2310–2319.

SQUALLI, J. 2007, Electricity consumption and economic growth:Bounds and causality analyses of OPEC members. *Energy Economics*, 29, 1192–1205.

TIWARI, A.K. 2011, Comparative performance of renewable and nonrenewable energy source on economic growth and CO_2 emissions of Europe and Eurasian countries: a PVAR approach. *Economics Bulletin*, 31(3), 2356–2372.

UZOMA, C. C., NNAJi, C. E, IBETO, C.N., OKPARA, C.G., NWOKE, O.O., OBI, I.O., UNACHUKWU, G. O. and OPARAKU, O. U. 2011, Renewable energy penetration in Nigeria: A study of the South-East Zone. Continental J. Environmental Sciences, 5(1), 1 – 5.

US ENERGY INFORMATION ADMINISTRATION (EIA). 2015. http://www.eia.gov

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

WILSON, D. and STUPNYTSKA, A. 2007, *The N-11: More than an acronym* (Global Economics Paper No. No:153). GS Global Economic Website: Goldman Sachs.(Next-11).

WHEELER, E. and DESAI, M. 2016, Iran's renewable energy potential. Middle East Institute. http://www.mei.edu/content/article/iran%E2%80%99s-renewable-energy-potential.

WORLD BANK DATABASE http://www.worldbank.org