Çankırı Karatekin Üniversitesi
İktisadi ve İdari Bilimler
Fakültesi Dergisi
Y.2014, Cilt 4, Sayı 2, ss.121-136

Çankırı Karatekin University
Journal of The Faculty of Economics
and Administrative Sciences
Y.2014, Volume 4, Issue 2, pp.121-136

Renewable Energy and Proven Oil Reserves Relation: Evidence from OPEC Members

Sevgi Eda TUZCU

Ankara University, Faculty of Political Sciences, Department of Business Administration, stuzcu@politics.ankara.edu.tr

Arcan TUZCU

Correspondence Author, Ankara University, Faculty of Political Sciences, Department of Business Administration, tuzcu@politics.ankara.edu.tr

Abstract

The well documented literature on the relation between energy consumption and climate change has been extended by the addition of renewable energy consumption. Several studies show its impact on technical efficiency, per capita income or carbon dioxide (CO_2) emission levels for developed and developing countries. However, to the extent of our knowledge, very few of them state the importance of renewable energy for the countries where the main type of fossil fuels, oil, is exported. This study aims to explore the association between renewable energy, real gross domestic product (GDP), CO_2 emission level, real oil prices as well as the proven oil reserves for seven members of Organization of the Petroleum Exporting Countries (OPEC). The analyses are conducted using panel data techniques, namely fixed effect – random effect tests. Our results show a positive and significant relation between renewable energy consumption, and real GDP and CO_2 emission level. A statistically not significant coefficient is found for the relation between renewable energy and the proven oil reserves. The relation between energy and real oil prices is also insignificant.

Keywords: Renewable Energy, The Petroleum Exporting Countries, Proven Oil Reserves, Per Capita CO_2 Emission, Real Oil Prices, Panel Data Technique.
JEL Classification Codes: O13, P28, Q42

Yenilenebilir Enerji ile Kanıtlanmış Petrol Rezervleri Arasındaki İlişki: OPEC'den Bulgular

Öz

Enerji tüketimi ve küresel ısınma arasındaki ilişkiyle ilgili literatür yenilenebilir enerji tüketiminin eklenmesiyle genişlemiştir. Birçok çalışma, bu ilişkinin gelişmiş ve gelişmekte olan ülkelerde teknik etkinlik, kişi başına gelir veya karbondioksit salınım düzeyleri üzerindeki etkilerini göstermektedir. Ancak hiçbiri fosil yakıt ihraç eden ülkeler için yenilenebilir enerjinin önemine vurgu yapmamıştır. Bu çalışma, yenilenebilir enerji ile reel Gayri Safi Yurt İçi Hasıla (GSYİH), karbondioksit salınım düzeyi, reel petrol fiyatları ve kanıtlanmış petrol rezervleri arasındaki ilişkiyi Petrol İhraç Eden Ülkeler Örgütünün yedi üyesi için açıklamaya amaçlamaktadır. Analizler, sabit etki-rastsal etki testleri olarak bilinen panel veri tekniği kullanılarak yürütülmektedir. Bulgularımız kişi başına yenilenebilir enerji tüketimi ile kişi başına reel GSYİH ve kişi başına karbondioksit tüketimi arasında pozitif ve anlamlı bir ilişkinin varlığına işaret etmektedir. Hem kanıtlanmış petrol rezervleri hem de reel petrol fiyatları ile yenilenebilir enerji tüketimi arasında anlamlı bir ilişki bulunamamıştır.

Anahtar Kelimeler: Yenilenebilir Enerji, Petrol İhraç Eden Ülkeler, Kanıtlanmış Petrol Rezervleri, Kişi Başı CO_2 Emisyonu, Reel Petrol Fiyatları, Panel Veri Tekniği.
JEL Sınıflandırması: O13, P28, Q42

Atıfta bulunmak için…|
Cite this paper |
Tuzcu, S.E. & Tuzcu, A. (2014). Renewable Energy and Proven Oil Reserves Relation: Evidence from OPEC Members. *Çankırı Karatekin Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 4(2), 121-136.

1. Introduction

The negative impacts of climate change on the environment and human life have been well discussed so far. Stern (2007) defines climate change as "*the greatest and widest – ranging market failure".* Asif & Muneer (2007) point out the world's energy demand satisfied mainly by fossil fuels as one of the main reasons behind the climate change. Given the strong relation between energy consumption and economic growth put forth in many papers such as Soytaş & Sarı (2003), Sarı & Soytaş (2009), Apergis & Payne (2010), the reduction in the energy consumption would be out of the question. Instead, one needs sustainable solutions for climate change issues. Regarding the criticisms to the nuclear energy plants, the renewable enery usage will be a suitable alternative. Hence, this paper aims to examine the roles of real income, carbon dioxide (CO_2) emission level, real oil prices, as well as the proven oil reserves in determining the renewable energy consumption for the OPEC members.

Sadorsky (2009a) and Marques, Fuinhas & Manso (2010) suggest that the economic burden of importing the oil is a main driver in replacing fossil fuels with renewables. This study, on the other hand, attempts to model the determinants of renewable energy usage for the OPEC members. As is well known, OPEC members are the chief oil exporters in the world. As a result, contrary to the previous findings, real oil prices may not be a major concern that stimulates the usage of renewable energy. However, as Sarı & Soytaş (2009) indicate, these are countries that are open most to the climate change related problems. OPEC (2010) explains clearly that they have responsibilities in the mitigation of climate change both in the production and the usage stages by encourages technological achievements. These technological achievements do not only consider the efficiency increases in fossil fuels, but also the alternative energy supply methods. From this perspective, it is important to examine the attitude of OPEC members towards renewable energy consumption.

Next, we aim to control for the depletion of oil by adding the proven oil reserves into the model, which may allow us to understand the position of these countries to the future fossil fuel problems. BP (2010) reports the highest decline in the OPEC oil production in 2010. Renewable energy consumption may be a sustainable solution for the constant decrease in these reserves as well. Hence, we include the amount left in the oil reserves as another explanatory variable in our model.

Although renewable energy consumption is discussed widely for developed and developing countries, to the extent of our knowledge, the above points have left uninvestigated in the energy literature so far. As mentioned in the Stern Review (2007), the impact of climate change and the attitudes of countries must be estimated to correctly evaluate its consequences. Since the precautions against the climate change need a global action, this study is important to show the perspective of OPEC members.

Many studies indicate the superiority of the multivariate models over bi-variate approaches with respect to their ability to eliminate spurious relations and to provide better economic analysis. Regarding to their common economic decision making process, OPEC members constitute a natural panel. Based on these reasons, panel regression analysis is chosen as the main method of this paper. Seven OPEC members are selected as the unit of analysis. The period covered in this analysis is from 1985 to 2007 due to data limitations. The findings mainly indicate a long run relation among renewable energy, per capita income, CO_2 emissions, real oil prices and proven oil reserves. However, in the short run, no relation between proven oil reserves and renewable energy consumption can be detected. This finding can be explained by the argument put forth in Asif & Muneer (2007), suggesting that OPEC members have not suffered from the depletion in oil reserves like USA or UK.

The organization of the paper is as follows: the next section outlines the energy literature, while the third section shows the data and the methodology as well as the findings. The last section concludes.

2. Literature Review

Energy literature can be divided into two broad parts: (1) the relation between energy consumption and economic growth, and (2) the energy consumption and climate change. The first category is a well investigated topic, but the findings can be country or time specific, or even contradictory (Öztürk, 2010). One of the first studies that examine the link between energy usage and economic growth belongs to Soytaş & Sarı (2003). They explore the direction of the causality between them for G-7 countries, and top emerging markets by the aid of Granger causality method. The annual data for the years from 1950 to 1992 is employed in this analysis. Although their findings indicate different directions of causality for different countries, they suggest that cutting down the energy consumption may damage the economic growth if the causality is from energy consumption to GDP.

The analysis of Soytaş & Sarı (2003) is broadened to a world-wide extend in the study of Chontanawat, Hunt & Pierse (2008). They examine more than 100 OECD and non-OECD countries to understand whether the economic growth depends on energy consumption. They employ a combination of three methods, namely the Granger causality, error correction models, and the Hsiao technique for the years between 1971 and 2000. Contrary to the expectations, their results suggest that developed countries would be more affected in cases of a reduction in energy consumption levels than developing countries. Therefore, China and India-two biggest developing economies-may participate in climate change aggrements without the hesitation of recession.

The long run income-energy consumption relation for the OPEC members is investigated in the study of Sarı & Soytaş (2009). They use autoregressive distributed lag (ARDL) framework for the years between 1971 and 2002. Their results indicate that the relation between energy consumption, real GDP and labor can be country specific. Only one of the OPEC members, Saudi Arabia, shows long term dependence to energy consumption. The other countries do not forego the economic growth while diminishing the CO_2 emissions. Besides, different countries may apply different policies of economic growth depending on the nature of the relation between national income and energy usage.

Recently, Apergis & Payne (2010) explore the linkage of income and coal consumption for 15 emerging markets for the period between 1980 and 2006 through panel error correction approach. As in the paper of Soytaş & Sarı (2009), this study also controls for fixed capital investments and labor changes while investigating the long run cointegration between coal consumption and the economic growth. They confirm the equilibrium in the long term for all the variables in the model. The causality between income and coal consumption is found to be bidirectional in short and long terms. Nevertheless, they argue that real GDP is inversely affected from an increase in coal consumption in the short run. This result has great importance since it implies that unnecessary coal consumption can be harmful for the economy as well as for the environment. Apergis & Payne (2010) suggest that alternative energy sources, for instance, renewable energy, might reduce the coal dependency of these economies.

The concerns about the climate change bring into the picture the second category of the energy literature. The relation between energy consumption and real GDP is extended through the addition of greenhouse gas emission levels. In fact, these gasses are the biggest driver of climate change, and their emission mostly arises from energy usage (Arrow, 2007). Asif & Muneer (2007) note that global energy demands have been almost fully satisfied by fossil fuels, including oil, coal and gas, which creates the unavoidable relation between energy consumption level and climate change. The precautions, such as Kyoto protocol or the United Nations Framework Convention on Climate Change (UNFCCC)), are usually insufficient in dealing with the issue (Sathaye Shukla & Ravindranath, 2006; Chien & Hu 2008). Reducing energy consumption as a solution for this environmental problem would be inapplicable due to its possible adverse impacts on economic growth (Soytaş & Sarı, 2003; Sarı & Soytaş, 2009; Apergis & Payne, 2010). At this point, other energy supply methods, such as nuclear energy and renewable energy can be considered as the alternatives to satisfy the global energy demands. Nuclear energy usage, itself, is subject to criticisms because of its serious impacts on ecological balance. Renewable energy, on the other hand, can be considered as a sustainable solution for climate change problem via reducing CO_2 emissions without decreasing the energy consumption level. In addition, its production costs have a declining trend, while the cost of producing fossil fuels, most importantly oil, has been increasing due to the significant decrease in their reserves (Asif & Muneer, 2007).

Despite being an alternative and environment-friendly solution, the impacts of renewable energy have seldom been investigated. An interesting study of Chien & Hu (2007) on this area explores its relation with technical efficiency in 45 OECD and non-OECD countries for the years between 2001 and 2002. They benefit from the data envelopment analysis, in which the real GDP is the only output, and the energy consumption, labor and capital investments are inputs of the model. The results indicate that as the portion of renewable energy in the total energy production increases, technical efficiency will significantly enhance. Chien & Hu (2007) also highlight that the technical efficiency increase is not provided by enlarging the total input of energy, but instead by substituting traditional energy with renewable ones. The positive linkage between renewable energy and economic growth is also confirmed by the study of Chien & Hu (2008), in which 116 different countries are examined through structural equation modelling technique.

Soytaş & Sarı (2009) also discuss the negative consequences of reducing energy consumption on national income in order to diminish the greenhouse gas emission. They apply the Granger causality method to examine the relation between national income, CO_2 emissions and energy usage in Turkey for the years 1960 to 2000, while the impact of capital investments and labor changes is considered by Toda-Yamamoto technique. Their findings cannot confirm the Granger causality from energy consumption to income in the long term for Turkey. In other words, the results indicate that the economic growth does not need to be sacrificed in order to reduce the CO_2 emission. However, Soytaş & Sarı (2009) still suggest that Turkey necessitates sustainable fossil fuel technologies in order to diminish both the CO_2 emissions and the dependence to the imported energy, since the major energy supply of Turkish economy is coal power plants, which release many more greenhouse gasses relative to natural gas plants.

The main contribution to the literature comes from the studies of Sadorsky (2009a; 2009b), where the relation between renewable energy and GDP is examined in emerging countries as well as the G-7 countries. For emerging markets, it is found that as the per capita income increases, renewable energy consumption per capita is significantly and positively affected (Sadorsky, 2009a). Moreover, the income elasticity of renewable energy is found to be elevated in comparison to the elasticity for electricity consumption. These results are important to suggest that one may expect relatively large increases in the renewable energy usage as a result of relatively small per capita income enhancements. It is also possible to argue that as the income per capita increases, the ecological sensitivity improves, and so the renewable energy consumption enlarges. The examination of the developed countries (Sadorsky, 2009b) provides similar conclusions as well. Sadorsky (2009b) points out the increase in the income per capita and CO_2 emissions per capita as the key forces of renewable energy consumption.

Following Sadorsky (2009a; 2009b), the drivers of renewable energy usage by the European Union (EU) countries is investigated in the paper of Marques et al. (2010). This study examines the 1990-2006 period through fixed effects vector decomposition. In order to control for supporting and deterring aspects for renewable energy usage, they add political, socio-economic and country specific factors. Their results, first of all, point out that the EU membership in 2001 is a significant factor for renewable energy consumption. The major drivers, however, are the policy implications in order to reduce energy dependency as well as the CO_2 emissions.

Besides the CO_2 emission levels that triggers climate change, it is clear that fossil fuel supply has vital sustainability problems. Although there is extensive literature stating the gravity of worldwide energy problems, it is interesting to note that including the amount left in the oil reserves to the analyses is not common. Dorian, Franssen & Simbeck (2006) discuss the problems of fossil fuels production in their paper, including reserve depletion, security, sustainability and environmental issues. They conclude that even when the OPEC members produce oil in full capacity, they cannot meet the global rising demand. A non–fossil fuel solution and governmental policies are a must, in this respect.

Similarly, Asif & Muneer (2007) examine energy demands of the UK, USA, Russia, China and India. They conclude that regarding climate change and the depletion in the oil reserves; we need cleaner forms of energy supply, in particular renewable energy. Some conclusions of Owen, Inderwildi & King (2010) are also in line with the above mentioned studies. They note the negative impact of oil prices on the macro - economy. In addition, they predict that the demand and supply will diverge between 2010 and 2015 if demand does not decrease with a recession due to supply constraints. Hence, we need more investments to alternative energy sources.

The literature investigates well the relation between growth and energy consumption for different countries (for instance, Chontanawat, Hunt & Pierse, 2008; Apergis & Payne, 2010). The evidence is mixed, but mostly indicates the causality between these two variables in the short and long term. Further, the relation between energy consumption and climate change is shown as in Soytaş & Sarı (2009). Reducing energy consumption would decrease the CO_2 emission, since energy production is mostly provided by fossil fuels. However, considering its side effects on economic growth, it cannot be a sustainable solution. Furthermore, Sadorsky (2009a) reports that emerging markets as well as developed economies face the problem of inadequate supplies of non - renewable resources. Renewable energy, in this regard, can be thought as a sustainable and environment friendly solution for the concerns on climate changes. In addition, as indicated in the study of Chien & Hu (2007), replacing traditional methods with renewable energy increases the efficiency in total energy production. The rest of the literature mostly centers on the relation between income and renewable energy (for example, Chien & Hu, 2008; Sadorsky, 2009a, 2009b). Among many others, Dorian et al. (2006); Asif & Muneer (2007) and Owen et al. (2010), all report that depletion, security and sustainability of oil reserves are serious problems, and sustainable, non-fossil fuel energy sources, such as renewables, should be developed. In a similar fashion, Marques et al. (2010) indicate the dependency to oil exporters as a major driver behind the renewable energy consumption.

OPEC members are the ones that are least affected from inadequate supply. Nevertheless, it is known that fossil fuel resources, even in these countries, are not infinite. BP reports (2010) indicate a continuous decrease in reserves. The highest decline in OPEC oil production since 1983 has been observed in 2010, by 7.3%, (BP, 2010). However, to the extent of our knowledge, the energy literature has not mainly concentrated on OPEC members, or on the depletion in reserves. Moreover, as stated in the paper of Sarı & Soytaş (2009), most of the OPEC members are exposed to climate change as well. Hence, the need for examining their point of view about renewable energy is clear. In this respect, this paper seeks to model renewable energy, economic growth and climate change issues in seven OPEC members based on the previous study of Sadorsky (2009b). In addition, we extend the previous literature in this area by insert the proven oil reserves as a new variable. In sum, the novelty of this paper is two-fold: investigating OPEC members with panel data techniques regarding to their renewable energy attitudes, and including proven oil reserves into the analysis.

3. Data and Methodology

The energy consumption is typically modeled as the relation between the energy prices, income level and an alternative energy type as a substitute (Soytas & Sarı, 2003; Sadorsky, 2009a, 2009b). Besides including these variables, this paper also considers the impact of proven oil reserves on the renewable energy consumption.

According to International Energy Agency (2006), the main force behind the GDP growth is energy demand. Therefore, real per capita GDP is determined as the proxy of income. The price of oil, which is the mostly used fossil fuel type, is added into the model as an alternative for renewable energy (International Energy Agency, 2006; Sadorsky, 2009b). To reflect the impact of climate change, CO_2 emissions levels are included. In addition, different from literature, one may note that another driving force of renewable energy usage is the depletion in oil reserves. Thus, this paper accounts for the proven oil reserves as another explanatory variable for renewable energy usage. In sum, the model which aims to detect the relation between climate change and renewable energy consumption has the following variables: per capita real GDP, oil prices as a substitute for renewable energy, CO_2 emissions and renewable energy consumption per capita. A composite index, which includes solar, biomass, tidal etc, is used for renewable energy consumption in this paper.

As indicated in Sarı & Soytaş (2009); OPEC has a vital role in the markets for energy; even its power shrinks in recent years because of other sources of oil supply, that is non-OPEC producers. Hence, the analysis is conducted on seven OPEC members, namely, Algeria, Angola, Ecuador, Iran, Nigeria, Venezuela and Indonesia. The period covered in this paper is from 1985 to 2007. Although Indonesia is currently a non – OPEC country, it did not suspend its membership in this period, which allow us to include it into the model without hesitation. The country choice is based on the data availability. Because we cannot access a complete data set, other OPEC members are not considered in the analysis. Annual data is employed for renewable energy consumption, real GDP per capita, CO_2 emissions, oil prices, and proven oil reserves. Renewable energy consumption and CO_2 emissions can be obtained from the U.S. Energy Information Administration. Renewable energy consumption is reported as a composite index, including geothermal, tidal, solar, biomass etc and measured as electricity net generation (billion kilowatt-hours). CO_2 emission per capita, on the other hand, is measured in metric tons per capita per year. Yearly GDP data in US dollars is obtained from World Bank Statistics. Finally, yearly crude oil prices and proven oil reserves are included in the model. Spot prices on West Texas Intermediate crude oil are employed for the analysis, whereas proven oil reserves are reported in thousands million barrels (BP, 2010). All variables used in the model are transformed via the natural logarithm.

First, the data is examined for its time series characteristics. Since the data set is not sufficient for the individual examination, and most importantly OPEC members compose a natural panel due to their common economic decisions, panel data analysis techniques are employed. To test the stationary features, the unit root tests are as follows: Levin, Lin & Chu (2002) introduce a model for panel data based on the ADF test. Contrary to Im, Pesaran & Shin (2003), it assumes homogeneity for autoregressive coefficients of panel units. In the test of Im et al. (2003), on the other hand, the heterogeneity is permitted. Levin et al. (2002) and Breitung (2000) design the null hypothesis to test for a common unit root. Im et al. (2003), Fisher ADF and Fisher PP tests, following Maddala & Wu (1999), are conducted to check the existence of individual unit roots across the cross-sections, however. The hypotheses for these tests are designed in the same way with Levin et al. (2002) and Breitung (2000). Finally, the test introduced by Hadri (2000) is performed, where the null hypothesis is no unit root.

Table 1 presents the unit root results. First, it is allowed for intercept, and then intercept and trend are tested together.

Table 1: Unit Root Results

Unit Root Test Results (Levels)

		LL		Breitung		IPS		ADF		PP		Hadri	
		Statistics	Prob	Statistics	Prob	Statistics	Prob	Statistics	Prob	Statistics	Prob	Statistics	Prob
RENEW	Intercept	-178394	0.0000	-104281	0.0000	-166373	0.0000	1943610	0.0000	663893	0.0000	-0.2745	0.6081
CO2		102558	10000	-58857	0.0000	-113639	0.0000	1233950	0.0000	11232300	0.0000	-12856	0.9007
GDP		-65357	0.0000	-55908	0.0000	-89391	0.0000	1155140	0.0000	5284590	0.0000	0.8425	0.1998
Price		-10723	0.1418	0.9245	0.8224	0.3898	0.6517	107567	0.7050	126263	0.5561	64114	0.0000
RES		-14611	0.0720	-61428	0.0000	-129206	0.0000	1428980	0.0000	872123	0.0000	-18473	0.9676
RENEW	Intercept and Trend	-159793	0.0000	-51011	0.0000	-153732	0.0000	1462430	0.0000	566196	0.0000	56527	0.0000
CO2		207549	10000	-23987	0.0082	-88679	0.0000	883457	0.0000	12623700	0.0000	0.0702	0.4720
GDP		186709	10000	0.3717	0.6449	-70197	0.0000	723467	0.0000	16887900	0.0000	22199	0.0132
Price		0.1088	0.5433	-10760	0.1410	0.9029	0.8167	118428	0.6189	139625	0.4525	45893	0.0000
RES		27294	0.9968	-31155	0.0009	-111547	0.0000	1107150	0.0000	645173	0.0000	-12956	0.9024

Unit Root Test Results (First Differences)

		LL		Breitung		IPS		ADF		PP		Hadri	
		Statistics	Prob	Statistics	Prob	Statistics	Prob	Statistics	Prob	Statistics	Prob	Statistics	Prob
RENEW	Intercept	-58774	0.0000	-56642	0.0000	-112443	0.0000	1207970	0.0000	1814300	0.0000	42863	0.0000
CO2		769052	10000	-53309	0.0000	-48140	0.0000	514523	0.0000	18437400	0.0000	-13979	0.9189
GDP		862346	10000	-40540	0.0000	-47379	0.0000	537683	0.0000	18437400	0.0000	-15861	0.9436
Price		-64466	0.0000	-106957	0.0000	-82214	0.0000	834272	0.0000	858663	0.0000	0.3203	0.3744
RES		-51197	0.0000	-42924	0.0000	-117288	0.0000	1258690	0.0000	1854960	0.0000	-20341	0.9790
RENEW	Intercept and Trend	-29324	0.0017	-64796	0.0000	-91599	0.0000	905997	0.0000	1836720	0.0000	194857	0.0000
CO2		917547	10000	-58711	0.0000	-30074	0.0013	335625	0.0024	18437400	0.0000	13048	0.0960
GDP		1045890	10000	-44191	0.0000	-28322	0.0023	372851	0.0007	18437400	0.0000	0.4842	0.3141
Price		-94918	0.0000	-104403	0.0000	-72744	0.0000	677369	0.0000	722273	0.0000	15628	0.0590
RES		-21106	0.0174	-45307	0.0000	-97778	0.0000	964673	0.0000	1510760	0.0000	-14139	0.9213

The results mostly show the existence of a unit root in levels, but the null hypothesis of the existence of unit root is rejected at 0.01 level, and each variable is integrated of order one. Hence, one may conclude that the first difference of all the variables is stationary.

The panel cointegration test is also conducted to observe the existence of long-run relationship. The linear relationship between these variables can be seen below:

$$RENEW_{it} = \alpha_{0i} + \alpha_{1i} GDP_{it} + \alpha_{2i} CO_{2_{it}} + \alpha_{3i} \Pr ice_t + \alpha_{4i} RES_t + u_{it} \ldots(1)$$

Where i denotes countries (i = 1,…, 7) and t denotes years (t = 1985,…, 2007).

Renewable energy is denoted by RENEW, while GDP is for real GDP per capita; CO_2 is for carbon dioxide emissions, Price is for real oil prices, and RES is for proven oil reserves.

For cointegration tests, Pedroni (1999, 2004) technique is used. These tests have two parts: First, within dimension tests including Panel v – statistic, Panel rho – statistic, Panel PP statistic, and Panel ADF statistic are considered. These analyses take into account across country heterogeneities and common time factors. This is why they are less restrictive. Second, the group tests are Group rho – statistic, Group PP statistic, and Group ADF statistic. Both tests use the residuals from Eq. (1). Table 2 reports the findings of panel cointegration test.

Table 2: Cointegration Results

Alternative hypothesis: common AR coefs. (within-dimension)

			Weighted	
	Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	-2332813	0.9902	-0.957355	0.8308
Panel rho-Statistic	-0.246744	0.4026	-0.226292	0.4105
Panel PP-Statistic	-9425476	0.0000	-7505661	0.0000
Panel ADF-Statistic	-7041479	0.0000	-6229864	0.0000

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	0.524416	0.7000
Group PP-Statistic	-1.076.212	0.0000
Group ADF-Statistic	-8.597.452	0.0000

The results provided in Table 2 are mixed. Two of the four panel statistics indicate a cointegration at 1 % level, which shows that at least one country has a long run cointegration. Nevertheless, between dimension statistics demonstrate that only Group rho-statistic fails to reject the null hypothesis of no cointegration, whereas the other statistics are significant at 1 % level. To summarize, between dimension statistics indicate the existence of cointegration. As a whole, the results reflect some evidence of long run association among renewable energy consumption and GDP, oil prices, CO_2 emissions, and oil reserves. Our findings are somewhat similar to the results in Sadorsky (2009a, 2009b), which show the existence of at least some level of cointegration between renewable energy and other variables except oil reserves for G-7 countries.

Further, the relation between the renewable energy and exogenous variables is investigated by employing fixed effects-random effects model. We will use a

Güz/Fall 2014
Volume 4, Issue 2, pp.121-136

fixed effect model, when each country needs an investigation by its own characteristics. In other words, the country specific features may impact the exogenous variables, which are needed to be controlled. Fixed effects will be decided if renewable energy is affected by real oil prices, GDP, CO_2 emissions, and oil reserves on each country basis. In contrast, if a random effects model is used, the variation between the OPEC members will be assumed to be random and uncorrelated with the exogenous variables in our model. Random effects also permit to generalize the findings beyond the sample. Nevertheless, the selection of this model will allow making inferences for the OPEC members that are not taken into the sample due to lack of data. The choice between the fixed effects and random effects models will be determined according to the Hausman (1978) Test results. Before this choice is made, one may control for the contemporaneous correlation within the panel. To observe whether contemporaneous correlation exists, we run Pesaran (2004) cross sectional dependence test. This test cannot reject the null hypothesis of no cross sectional dependence (with a p value of 0.3517). Hence, we do not need to use another estimator to control for this impact. Yet, the modified Wald statistic for group-wise heteroskedasticity yields that the data is not homoskedastic. To deal with this issue, White robust standard errors are computed. As a possible alternative to fixed effects – random effects modeling, pooled regression is also employed. The results of pooled regression, fixed effects and random effects models with robust standard errors can be seen in Table 3.

Table 3: Findings from Pooled Regression, Fixed Effects and Random Effects

	(1)	(2)	(3)
VARIABLES	Pooled Regression	Fixed Effects	Random Effects
GDP	0.0765	0.382**	0.361***
	(0.143)	(0.126)	(0.111)
CO2	-0.0672	0.780***	0.743***
	(0.173)	(0.155)	(0.138)
Price	0.170	0.0221	0.0384
	(0.171)	(0.0918)	(0.0772)
RES	0.471***	0.0566	0.0721
	(0.0644)	(0.0911)	(0.0914)
Constant	-0.869	-2.037**	-1.955*
	(0.739)	(0.606)	(1.121)
Observations	161	161	161
R-squared		0.475	
Number of id	7	7	7
Country FE		YES	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Pooled regression is used when the data has different sub samples for each time period. Then, the time-based effects must be controlled. In our case, however, we observe the patterns of same OPEC members for the each year in the period covered, which constitutes the panel structure. The comparison between fixed and random effects through Hausman test yields that random effects is more suitable for this analysis. It shows that the null hypothesis of no systematic difference in coefficients is failed to reject, since the probability of 0.5967 provides an insignificant test coefficient at 1% level. To check the robustness of our inferences from the Hausman test, Breusch Pagan Lagrangian multiplier test for random effects, whose null hypothesis is zero variance across countries, is also conducted. The findings indicate a strong rejection of the null hypothesis at 1% level with a p level of 0.000. Thus, there are significant differences across countries, and random effects model is the suitable choice. Putting it differently, OLS estimations would not give the correct inferences.

According to Wald test results, not reported in the table, the model is well specified at 1% level. In other words, it demonstrates that at least one of the coefficients in the model is different than zero. The R^2 findings indicate that our model explains 0.47 % of the variation within the countries through the time. However, it cannot explain much the variation across different members of OPEC. Regarding the diverse characteristics of these countries in terms of their population, natural and economic resources, this finding can be expected. Consistently, the rho statistic indicates that 92% of the unexplained variance is due to the differences across the OPEC members. Both the R^2 and rho findings are actually in line with the results reached by Sarı & Soytaş (2009). They note that different OPEC members should apply different policies to decrease the CO_2 emission levels, and to benefit from the other sustainable energy options.

The results confirm that, as expected, CO_2 emission and per capita real income significantly and positively impact the consumption of renewable energy, and it is consistent with the findings of Sadorsky (2009a, 2009b). An interesting finding comes from the real oil prices which do not have a statistically significant coefficient. Putting it differently, real oil price changes have no influence on renewable energy consumption. The insignificant coefficient of real oil prices is in fact consistent with the nature of OPEC members, since they are net exporters of oil. Marques et al. (2010) point out the need to import the oil from other countries as the main reason for renewable energy consumption. However, this is not the case for the OPEC members.

Another interesting finding indicates that CO_2 emission level has the highest coefficient among the other variables. In other words, the consumption of renewable energy in the OPEC members is mostly driven by the amount of CO_2 released to the atmosphere from these countries. As in many mentioned studies, this would be a consequence of environmental concerns. This finding is somewhat similar to the ones reported in the paper of Sarı & Soytaş (2009) as well, which shows that except for Saudi Arabia, there is no long run association between energy consumption and income for the observed OPEC members. These countries do not need to forgo their economic growth by reducing CO_2 emission level, so they can focus on climate change easier than those countries that have a positive long run relationship between GDP and fossil fuel consumption.

Last but not least, we show that the proven oil reserves have no impact on the consumption of renewable energy. Asif & Muneer (2007) indicate that OPEC members are mostly in the beginning of reserve depletion in contrast to some developed countries such as the US and the UK. This may be the reason that OPEC members have not been concerned about the amount left in the reserves, supporting the lack of significance in the coefficient of proven oil reserves. The confliction between the inferences of CO_2 emission levels and proven oil reserves may be clarified as such: OPEC is consisted of developing countries. Sadorsky (2009a, 2009b) emphasizes that enviromental issues become more pronounced the more developed the countries are. As their development level increases through the time, they will be more interested in the amount left in the reserves. Moreover, the fixed effect – random effect analyses provide inferences for the short run. OPEC members may consider the possible effects of CO_2 emission level, since its consequences are visible right now, but they do not need to evaluate the possible outcomes of reserve depletion for the period analyzed in this study. However, consistent with the cointegration tests, oil prices and the amount left in the reserves can be a distress for these countries as well in the long run.

3. Conclusion

The literature extends the well documented GDP – energy consumption relation (for instance, Apergis & Payne, 2010; Sarı & Soytaş, 2009; Soytaş & Sarı, 2003; 2009) by the inclusion of renewable energy (Chien & Hu, 2007, 2008; Sadorsky 2009a, 2009b; Marques et al., 2010), which can be considered as an environment – friendly and a less costly alternative of fossil fuels. The primary motivation of this study is to broaden the previous literature by analyzing the role of renewable energy in the oil exporting countries. To do so, first, the long run cointegration relation through Pedroni (2004) tests is assessed. The results show a failure of rejection of the null hypothesis of no cointegration individually and as a group. In other words, in the long run, there is a linkage among renewable energy, per capita income, CO_2 emissions, real oil prices and proven oil reserves. Further, to investigate the relation deeper, a fixed effect – random effect regression model is computed. To be able to distinct the most suitable one, both Hausman (1978) Test and Breusch Pagan Lagrangian Multiplier Test are conducted. The findings indicate the random effects regression model as the suitable one. The results state a positive and significant impact of real per capita income and CO_2 emissions, while real oil prices and proven oil reserves are found to be insignificant. The insignificance of real oil prices can be explained by the nature of the OPEC members, since they are net exporters of oil, but not importers. Literature mainly suggests the strongest motive for the oil importing countries is that they are dependent to fossil fuel producers (Sadorsky, 2009a, 2009b; Marques et al., 2010). However, such a dependency is not a case for OPEC members. It is also similar to the findings of Sarı & Soytaş (2009), in which a long run association among energy, income and labor is failed to be shown for the observed OPEC members except for Saudi Arabia.

Contrary to the expectations, this study cannot find a relation between proven oil reserves and renewable energy consumption. This finding can be explained by the argument put forth in Asif & Muneer (2007), suggesting that OPEC members have not suffered from the depletion in oil reserves like USA or UK. However, the findings as a whole may indicate a long run relation, which is not observable in the short run, since OPEC members will face the difficulties of the dependence on fossil fuels when the reserves will decline more. Yet, the high variation within the features of OPEC members impedes a unique policy suggestion. Either directly or indirectly, the more efficient ways of energy consumption can be encouraged. The countries distinctive characteristics in terms of population, economic growth and technology level must be taken into account while applying policies that reduce the fossil fuel consumption. The usage of sustainable and clear energy supply methods, such as renewables, must be supported, because in the long run these countries are likely to suffer from the lack of fossil fuels.

References

Apergis, N., & Payne, J.E. (2010). The Causal Dynamics Between Coal Consumption And Growth: Evidence From Emerging Market Economies. *Applied Energy*, 87, 1972–1977.

Arrow, K.J. (2007). Global Climate Change: A Challenge to Policy. *The Economists' Voice*, 4, 1-5.

Asif, M., & Muneer, T. (2007). Energy supply, Its Demand and Security Issues for Developed and Emerging Economies. *Renewable and Sustainable Energy Reviews*, 11, 1388-1413.

BP. (2010). *BP Statistical Review of World Energy*.

Breitung, J. (2000). *The Local Power of Some Unit Root Tests for Panel Data*. pp. 161 -178 in Advances in Econometrics Vol. 15, Nonstationary Panels, Panel Cointegration and Dynamic Panels, edited by B.H. Baltagi. Amsterdam: JAI Press.

Chien, T., & Hu, J. (2007). Renewable Energy and Macroeconomic Efficiency of OECD and non-OECD Economies. *Energy Policy*, 35, 3606-3615.

Chien, T., & Hu, J. (2008). Renewable Energy: An Efficient Mechanism to Improve GDP. *Energy Policy*, 36, 3045-3052.

Chontanawat, J., Hunt, LC. & Pierse, R. (2008). Does Energy Consumption Cause Economic Growth?: Evidence from a Systematic Study of Over 100 Countries. *Journal of Policy Modeling*, 30(2), 209-220.

Dorian, J., Franssen, H. & Simbeck, D. (2006). Global Challenges in Energy. *Renewable Energy*, 34, 1984-1991.

Hadri, K. (2000). Testing for Stationarity in Heterogeneous Panel Data. *The Econometrics Journal*, 3, 148-161.

Hausman, J.A. (1978). Specification Tests in Econometrics. *Econometrica: Journal of the Econometric Society*, 46, 1251-1271.

Im, K, Pesaran, M. H. & Shin, Y. (2003). Testing for Unit Roots in Heterogeneous Panels. *Journal of Econometrics*, 115, 53-74.

International Energy Agency. (2006). World Energy Outlook 2006.

Levin, A., Lin, C.U. & Chu, C. (2002). Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties. *Journal of Econometrics*, 108, 1-24.

Maddala, G.S. & Wu, S. (1999). A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test. *Oxford Bulletin of Economics and Statistics*, 61, 631-652.

Marques, C., Fuinhas, A. & Manso, J. (2010). Motivations Driving Renewable Energy in European Countries: A Panel Data Approach. *Energy Policy*, 38, 6877-6885.

Owen, N., Inderwildi, A. & King, D. (2010). The Status of Conventional World Oil Reserves — Hype or Cause for Concern?, *Energy Policy*, 38, 4743-4749.

OPEC. (2010). *OPEC Long Term Strategy*. Vienna, Austria.

Öztürk, İ. (2010). A Literature Survey on Energy–Growth Nexus. *Energy Policy*, 38(1), 340-349.

Pedroni, P. (1999). Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors. *Oxford Bulletin of Economics and Statistics*, 61, 653-670.

Pedroni, P. (2004). Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis. *Econometric Theory*, 20, 597-625.

Pesaran, M.H. (2004). *General Diagnostic Tests for Cross Section Dependence in Panels*, Cambridge Working Papers in Economics 0435, Faculty of Economics, University of Cambridge.

Sadorsky, P. (2009a). Renewable Energy Consumption and Income in Emerging Economies. Energy Policy, 37, 4021-4028.

Sadorsky, P. (2009b). Renewable Energy Consumption, CO_2 Emissions and Oil Prices in the G-7 Countries. *Energy Economics*, 31, 456–462.

Sarı, R. & Soytaş, U. (2009). Are Global Warming and Economic Growth Compatible? Evidence from Five OPEC Countries?. *Applied Energy*, 86, 1887-1893.

Sathaye, J., Shukla, P.R. & Ravindranath, N.H. (2006). Climate Change, Sustainable Development and India: Global and National Concerns. *Current Science*, 90, 314-325.

Soytaş, U. & Sarı, R. (2003). Energy Consumption and GDP: Causality Relationship in G-7 Countries and Emerging Markets. *Energy Economics*, 25, 33-37.

Soytaş, U. & Sarı, R. (2009). Energy Consumption, Economic Growth, and Carbon Emissions: Challenges Faced by an EU Candidate Member. *Ecological Economics*, 68, 1667–1675.

Stern, N. (2007). The Economics of Climate Change – Executive Summary. *Stern Review*. 1-27.