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DETERMINANTS OF USING RENEWABLE ENERGY RESOURCE: PANEL DATA ANALYSIS

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ABSTRACT

Although there are many studies upon questioning the relation between the economic growth and environmental quality, there are a few studies which questioned relationship between the institutional quality, environmental quality and human development index. For this reason aim of this study is to analyze relationship between renewable energy usage and per capita income, educational expenditure, institutional quality index and human development index. The datum for countries which belong to middle income group which covers the period between the years from 2001 to 2012 was examined by the panel data analysis method. The obtained results support that there is a bilateral causality relationship between renewable energy resources and human HDI in the short run. In the long run, it was shown that income level, educational expenditure institutional quality and human development index cause of renewable energy resources.

Key words: Renewably energy resources, Institutional Quality, Human development index, Panel Data Analysis.

1. INTRODUCTION

While macroeconomic policies aim to increase production, they does not have the necessary precaution for environmental degradation. Policies that pay attention to environmental degradation take more carbon emissions into account. The primary reason for considering carbon emissions is global warming. Many international programs are seeking solutions to the global warming problem. Particularly after the Second World War, developments in production technologies initiated the era of mass production and the high energy needed in this process also initiated the global warming process. The rapid increase in CO_2 emissions with the use of primary energy sources has triggered global warming. Thus, the increase in global warming is at the top of the list of problems to be solved by threatening human life.

Today, the most important reason of global warming is the use of fossil fuels such as coal, oil and gas. Fossil fuels, which are responsible for 80% of global warming, contribute to the formation of Green House Gas (GHG) which is seen as the most important reason behind seasonal changes. 60% of GHG is generated by the carbon-oxygen combination resulting from the use of fossil fuels (IEA, 2013). CO2 gas is a gas formed entirely of human activities. (Soytas and Sarı, 2009). While the environmental degradation caused by the use of fossil fuels affect the quality of life negatively, in the long-term, health expenditure and the economic expenditure may increase by increasing the amount of expenditure required to overcome environmental degradation and it may affect the economic performance negatively.

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Since the institutional arrangements of developed countries are complete and the undeveloped countries do not have sufficient factor equipment for production, the creation of environmental pollution is more likely to occur in developing countries. For this reason, global warming prevention programs are mostly directed towards developing countries. In particular, incentives of governments to use renewable energy sources form the basis of these programs. The aim of this study is to analyze the determinants of renewable energy use econometrically. For this reason, unlike other studies, including the use of renewable energy, per capita national income, education expenditures, and analysis, the institutional quality and human development index has also been included in the study. In the analysis, countries in the middle income group were used because they were seen as developing responsible for environmental degradation. The data of the 13 countries in the middle income group, which can be accessed within the scope of the study, were analyzed by panel data analysis method for the period from 2001 to 2012. In the next part of the study, the previous studies on the subject will be presented, and in the third part information about the data included in the study and the method used will be given. In the fourth chapter the findings obtained will be presented and the study will be finalized with results and policy recommendations.

2. RELATED LITERATURE

In the studies in which the relationship between the environmental degradation and economic growth is examined, CO_2 emission and per capita income variants are more likely to be used and the relationship is explained in the context of the Environmental Kuznets Curve (EKC)) hypothesis. S. Kuznets (1955) emphasizes that in the countries in the development process income inequality with development will initially increase but then trend in income inequality will decrease and stop as economic development continues.

In the development process with per-capita income, the curve “U” showing at first an increasing and then declining tendency between growth and income inequality appeared in the literature as "Kuznets Curve" (Panayotou (1993). Later, Kuznets' this study was adapted for environmental degradation and the Environmental Kuznets Curve (EKC) was obtained when the income distribution axis in the standard Kuznets Curve was replaced by environmental deterioration.

First, Grossman and Krueger concluded that the relationship between income level and environmental quality has been related to the fact that income growth increases environmental damage to a certain level and decreases environmental degradation after the threshold level (Grossman and Kruger, 1991). In his work on the relationship between institutional quality and environmental degradation, Panayatou has argued that economic growth will prevent environmental degradation and that this will be achieved through effective actuation of institutions. (Panayotou 1997) Panayotou has used institutional quality indicators created by Knack and Keefer in a panel data analysis that he has done for 30 countries. With the emergence of the new institutional economics literature, the relationship between institutions and many variables has begun to be questioned. One of the relations that are questioned is the environmental interaction with the institutions. In this process, the effective process of institutions creates institutional quality and reduces environmental degradation (Leitaou, 2010; Culas, 2007; Bhattari and Hamming, 2001; Knack and Keefer, 1995; Panayotou, 1997). The development of institutional quality slows down environmental degradation by reducing opportunism and corruption (Gagliardi, 2008: 3).In economies with opportunistic rant seeking,while transaction costs are increasing, resources are shifting from productive areas to nonproductive areas (Knack and Keefer, 1997).The understanding of production, which is prevalent in economies where corruption and bribery are occurring, is based on the consumption of resources in a short period of time rather than the effective consumption of resources.

It is thought that there is a negative relation between environmental deterioration and education level. This interaction can take place through two mechanisms. First, level of higher education facilitates the formation of social consciousness and facilitates the solution of common problems together. Higher education level increase the power and efficiency of civil society organizations and create pressure on the implementation of environmental standards (Bimonte, 2002; Dasgupta, Laplante, Wang, & Wheeler, 2002; Wheeler, 2001). Secondly, the higher level of education provides the creation of environmentally sensitive technologies, in particular the human capital necessary for the use of renewable energy. In Aytun (2014) study, he stated that the increase in the level of higher education has the effect on reducing carbon dioxide emissions by allowing the use of renewable energy.

3. DATA AND MODEL

In the implementation part of the study, countries included in the middle income group according to the World Bank criteria were included in the analysis. This is why the effect of the institutional quality can be better observed. The fact that the countries in the upper income group have largely completed their institutional development and the institutional spheres in the countries in the lower income group are very weak is an effective factor in the selection of this sample. The institutional quality levels of countries have only begun to be measured regularly since the 1990s. This limits the time range of the work done and the methods that can be used. In the

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study World Governance Indicator which was created by the World Bank, was used as a corporate quality indicator. Other variants included in the study such as the use of renewable energy sources, per capita income, education expenditures and data used for the human development index are derived from the World Bank Database. In the formation of the institutional quality index, data on the level of corruption in the country, the effectiveness of the government, political stability, the quality of the regulations, the rule of law, freedom of thought and accountability level were used and the geometric means of these data were taken.

The methodology of Amartya Sen (1999) was followed in the formation of human development index. The explanations and sources of data for the period between 2001 and 2012 are presented in Table 1.

Table 1: Variables used in the study

KOD	DESCRIPTION	SOURCE
LREN	Renewable energy usage (Metric tons per capita)	WDI[a]
LGDP	National income per capita (With 2005 prices US$)	EFW[b]
LEDUX	Education expenditure per capita- (With 2005 prices)	WDI[a]
LIQ	Institutional Quality Index	WDI[a]
LHDI	Human development index	WDI[a]
[a]The World Bank World Development Indicators: http://databank.worldbank.org [b] Economic Freedom of The World 2014 Annual Report: http://www.cato.org/economic-freedom-world		

In this study, panel data analyses were used to estimate the determinants of the use of renewable energy sources. Panel data analysis is seen as a stronger analysis than the time series analysis because it monitors both the time-specific effect and the country-specific effects. The determinants of renewable energy sources are estimated within the model set out below.

While in Equation 1 “i” expresses the countries included in analysis and “t” expresses the time period, the expression "L" in front of the variables indicates that all variables are subject to analysis in logarithmic form.

$$LREN_{i,t}= \alpha_i+ \beta_1 LGDP_{i,t} + \beta_2 LEDUX_{i,t}+\beta_3 LIQ_{i,t} + \beta_3 HDI_{i,t} +\varepsilon_{it,} \quad (1)$$

A positive relationship is expected between education expenditure and institutional quality and the use of renewable energy sources in the equation created. The direction of the relationship between per capita income and the use of renewable energy may vary. Especially in the underdeveloped countries, the energy needed for fast growth targets is being tried to be met by the primary sources and the investments for the use of renewable energy required high cost can be neglected.

4. METHOD

The use of the estimation and error correction (ECM) model of the long-run relationships among the variables within the context of the analysis is carried out in four stages (Pao and Tsai, 2011). The first stage is the unit root test. In order to perform the cointegration tests between the variables, the series must be stationary at the same level. For this purpose, four unit root tests were applied in the analysis. These tests are Phillips Perron and Levin Lin Chu unit root tests of Im, Pesaran Shin (2003), Fisher-type Augmented Dickey-Fuller (F-ADF) (Maddala and Wu, 1999: Choi, 2001).

In the second stage, cointegration tests will be applied if the series are stationary at the same level. Cointegration analyzes are used to question the existence of long-term equilibrium relations between the series. Engle and Granger (1987) stated that linear combinations of nonstationary series may be stable in long-term in their work. The most preferred method in the literature for the cointegration analysis of the series of panel data analyzes is the method developed by Pedroni (1999, 2004).

4.1. Panel Cointegration Test

Pedroni panel cointegration test is a two-stage test based on Engle-Granger (1987). In Pedroni (1999) cointegration analysis, it is tested whether there is a long term cointegration relation between variables by looking at the stability of ε_{it} residue in equation (1). In the second stage the error terms obtained are again estimated by OLS in Eq. (2).

$$\varepsilon_{it}=\phi_i \, \varepsilon_{it-1}+\nu_{it} \quad (2)$$

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The tests that Pedroni has some advantages. These tests allow multiple explanatory variables to be included in the analysis. In addition, the tests also allow the predicted cointegration vector vary along the different parts of the panel and the faults to be heterogeneity along the cross-sectional units. Pedroni has developed a test statistic with a total of seven and the H_o hypothesis cointegration "no co-integration". These tests are divided into two separate groups. The first category includes four tests pooled in the "within" dimension, and the second category contains three other tests in the "between" dimension (Asteriou and Hall, 2007). The first three of the four tests in the within test group are non-parametric tests. The first of these tests is a statistic of variance ratio type. The second is similar to the statistical Phillips-Peron (PP) (rho) statistic, and the third statistic is similar to the PP (t) statistic. The last statistic in the Within group is a parametric statistic similar to the Augmented Dickey Fuller (ADF) (t) statistic. The three statistics in the Between group use the averages of the estimated individual coefficients of each country. The first of the three tests in the second category is similar to the PP (rho) statistic, while the other two are similar to the PP (t) and ADF (t) statistics (Güvenek and Alptekin, 2010; Nazlıoglu, 2012).

4.2. Panel Coalescence Estimation (FMOLS)

The third stage to be followed after cointegration is the prediction phase of the Panel Cointegration model. Fully Modified OLS (FMOLS) is widely used in estimating cointegrated heterogeneous series in panel data analysis (Pedroni, 2000). Panel FMOLS estimator for each time series is $\hat{\beta}^*_{GFM} = N^{-1}\sum_{i=1}^{N}\beta^*_{FMi}$ obtained by using β^*_{FMi} the results obtained from Equation 1.

4.3. Granger Causality Test

While the sign of the coefficients obtained after the cointegration tests gives information about the direction of the relationship between the series, it does not give information about the direction of the causality relation. Causality analysis is needed to determine the direction of causality between the series (Nazlioglu and Soytas, 2012). For this reason, the analysis of causality was made in the fourth stage. The existence of the cointegration relationship between variables also points to the presence of at least one directional Granger causality (Engle RF, Granger CWJ.1987; Oxley L, Greasley D., 2008). Engle and Granger in their study in 1987 stated that in the causality tests while there is a cointegration relation between two nonstationary variables the VAR process performed by taking the differences of the series can produce incorrect results. For this reason, it is suggested to use vector error correction model (VECM) estimated with the adapted VAR model which is made dynamic by delayed error correction term(Narayan and Smyth, 2009; Aytun, 2014). The obtaining process of panel-based VECM is expressed in Equation 3 below. (Pao and Tsai, 2011; Belloumi, 2009). Equation 3 shows the number of countries from i = 1 to N, and the time interval t = 1 to T.Abdalla and Murinde (1997) and Pao and Tsai (2011) were followed to maximize the R^2 and AIC criterion for the appropriate number of delays for each equation in equation 3.

$$\begin{bmatrix} \Delta LREN_{it} \\ \Delta LGDP_{it} \\ \Delta LEDUX_{it} \\ \Delta LIQ_{it} \\ \Delta LHDI^2_{it} \end{bmatrix} = \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \end{bmatrix} + \sum_{p=1}^{r} \begin{bmatrix} \beta_{11p} & \beta_{12p} & \beta_{13p} & \beta_{14p} & \beta_{15p} \\ \beta_{21p} & \beta_{22p} & \beta_{23p} & \beta_{24p} & \beta_{25p} \\ \beta_{31p} & \beta_{32p} & \beta_{33p} & \beta_{34p} & \beta_{35p} \\ \beta_{41p} & \beta_{42p} & \beta_{43p} & \beta_{44p} & \beta_{45p} \\ \beta_{51p} & \beta_{52p} & \beta_{53p} & \beta_{54p} & \beta_{55p} \end{bmatrix} \begin{bmatrix} \Delta LREN_{it-p} \\ \Delta LGDP_{it-p} \\ \Delta LEDUX_{it-p} \\ \Delta LIQ_{it-p} \\ \Delta LHDI^2_{it-p} \end{bmatrix} + \begin{bmatrix} \theta_1 \\ \theta_2 \\ \theta_3 \\ \theta_4 \\ \theta_5 \end{bmatrix} ECT_{it-1} + \begin{bmatrix} \varepsilon_{1it} \\ \varepsilon_{2it} \\ \varepsilon_{3it} \\ \varepsilon_{4it} \\ \varepsilon_{5it} \end{bmatrix} \quad (3)$$

5. FINDINGS

5.1. Panel Unit Root Test Results

In order to question the relationship between variables, firstly root tests were performed. According to test results series have unit root at the level. Also we have found that all of the series are stationary in first differences. The obtained unit root test results are presented in Table 2.

Table 2: Panel Unit Root Test Results

	LLC		PP		IPS		F-ADF	
Variables	**Level**	**First Diff.**	**Level**	**First Diff.**	**Level**	**First Diff.**	**Level**	**First Diff.**
ΔLREN	-1.468	-7.24***	34.71	141.9***	-0.439	-6.83***	31.64	88.77***
ΔLGDP	-1.721	-4.60***	53.64	69.36***	1.517	-2.04***	14.85	35.84***
ΔLEDUX	-3.543	-5.13***	26.18	47.02***	0.932	-2.66***	18.52	43.56***
ΔLINSQ	-4.758	-2.67***	26.13	101.1***	-0.382	-2.65***	34.83	43.82***
ΔLHDI	-0.821	-5.60***	16.30	89.99***	2.661	-3.41***	8.918	50.92***
*** Expresses Statistical significance at the level of 1%. All variables are evaluated as fixed and trendy. The number of delays is automatically determined according to the Schwarz information criterion (SIC).								

5.2. Panel Cointegration Test Results

Findings from unit root test results applied to balanced panel data allow the cointegration test. The long term equilibrium relations of the series at the same level and first degree were questioned by the Pedronicointegration test. According to Pedronicointegration test results,H_0hypothesis, in which there is no cointegration in four of the seven test statistics, was rejected and resulted in cointegration. In this case, it can be said that there is a relation between variables in long term. Pedronicointegration test results are presented in Table 3.

Table 3.Pedronicointegration test results

	Fixed			**Fixed and trendy**	
	Within-dimension			**Within-dimension**	
Tests	**Test Statistics**	**Prob.**		**Test Statistics**	**Prob.**
Panel v-Statistic	-2,652	0,996		-4.151873	1.0000
Panel rho-Statistic	2,968	0.998		4.078259	1.0000
Panel PP-Statistic	-7.28***	0.000		-10.66508	0.0000
Panel ADF-Statistic	-5.02***	0.000		-4.107223	0.0000
	Between-dimension			**Between-dimension**	
Tests	**Test Statistics**	**Prob.**		**Test Statistics**	**Prob.**
Group rho-Statistic	4,292	1.000		4.750691	1.0000
Group PP-Statistic	-9.32***	0.000		-14.04127	0.0000
Group ADF-Statistic	-4.10***	0.000		-3.231691	0.0006
Notes: The 1%, 5%, and 10% critical values are respectively 1.28, 1.645, and 2.33 for the panel-v statistics and 1.28, -1.645, and -2.33 for the other statistics. The maximum delay was identified as 1 with SIC.					

5.3. Panel FMOLS Estimation Results

It has come to the forefront of the estimation process of cointegrated series after the series have been revealed to be in the cointegration. According to FMOLS estimation results presented in Table 4, it is seen that there is a positive relation between inflation, renewable energy use, education expenditures and institutional quality. There is no statistically significant relationship between the human development index and the use of renewable energy. According to the findings, the use of renewable energy and per capita income has been falling. This situation can be explained by the Kuznets curve. The increase in income level increases the environmental degradation in the early period and after a certain level, the environmental degradation decreases. This situation is explained by scale effect. The increase in production increases the need for energy and as a result, the consumption of cheap fossil fuels is increasing. Due to the lack of physical capital accumulation of countries with low and middle income levels, the capital required for the use of renewable energy can not be provided in these countries and fossil fuel is preferred as energy source in production. The fact that the institutional structure in the country is not developed sufficiently can not prevent the production methods and energy usage which are harmful to the environment.

Looking at the panel FMOLS results, it is expected that the 1% increase in per capita income will reduce the use of renewable energy by 0.54% in the fixed model and 0.55% in the fixed and trending model. This situation also overlaps with the Pollution Heaven Hypothesis. High-income countries transform less developed countries into a pollution heaven by transferring polluting production

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technologies to them. Less-developed countries are producing with technologies that generate pollution and work with more primary energy sources until income levels reach a certain level. A statistically significant coefficient estimate between education expenditure, institutional quality, human development index and renewable energy use could not be estimated.

Table 4. Panel FMOLS Estimate Results

FMOLS							
	Fixed Model			**Fixed and Trendy Model**			
Variables	**Coefficent**	**t-statistics**	**Prob.**		**Coefficent**	**t-statistics**	**Prob.**
LGDP	-0,5401	-1,7668	0,0797		-0,5567	-1,8186	0,0713
LEDUX	0,0957	1,2218	0,2240		0,1002	1,2774	0,2038
LINSQ	1,8107	0,8050	0,4223		1,7962	0,7974	0,4267
LHDI	-1,3792	-1,3267	0,1870		-1,3922	-1,3373	0,1835
R-squared			0,9811		R-squared		0,9811
Adjusted R-squared			0,9789		Adjusted R-squared		0,9789
S.E. of regression			0,1334		S.E. of regression		0,1333
Mean dependent var			3,2589		Mean dependent var		3,2589
S.D. dependent var			0,9183		S.D. dependent var		0,9183
Sum squared resid			2,2771		Sum squared resid		2,2745
Long-run variance			0,0265		Long-run variance		0,0266
Note: *** p<0.01, ** p<0.05, * p<0.1							

5.4. Panel VECM Causality Analysis Results

When short-run and long-run causality between variables are examined, it is seen that there is a two-way causality relationship between the human development index and the use of renewable energy. (Table 5) While the use of renewable energy increases the level of human development of the country, the increased level of development and prosperity also increases the demand for renewable energy use. The increase in income indirectly affects the use of renewable energy. Increased income affects institutional quality and human development, which indirectly affects the use of renewable energy. Similarly educational expenditures also affect the level of institutional quality and income in the country. In addition, Figure 1 and Figure 2 summarize short and long cyclical causality relationships.

Table 5.Panel VECM Causality Results

	Short-term causality [Chi-sq]					**Long-term causality**
Series	**ΔLREN**	**ΔLGDP**	**ΔLEDUX**	**ΔLINSQ**	**ΔLHDI**	**ECT (ϕ)**
ΔLREN	-	3.737	0.203	1.370	11.89**	-1.13***
ΔLGDP	2.361	-	9.39**	2.399	6.993	0.127*
ΔLEDUX	0.725	6.189	-	6.158	9.482*	0.381
ΔLINSQ	3.549	8.66*	8.93*	-	1.545	0.008
ΔLHDI	9.18**	8.242*	0.830	12.28**	-	0.025
Notes: H0: There is no causality relationship among the series. Δ: indicates that the first difference of the series is taken. ***p<0.01, ** p<0.05, * p<0.1						

Looking at long-term causality (Table 5 and Figure 2), it is seen that the error correction coefficient ΔLREN is negative and meaning while it is the dependent variable. This case reveals that the indicators of economic growth (ΔLGDP), education expenditure (ΔLEDUX), institutional quality (ΔLINSQ) and human development level (ΔLHDI) are, as a whole, long-term explanatory of the renewable energy use variable (ΔLREN).

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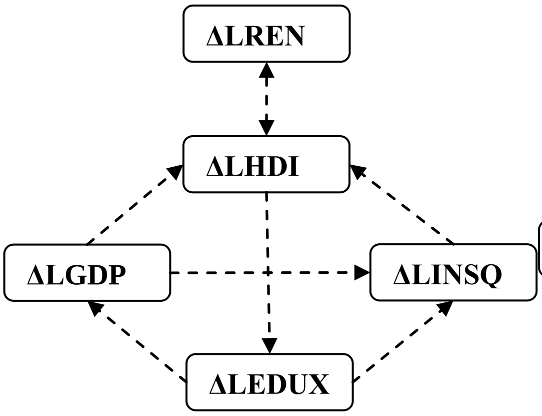

Figure 1.Short-term Causality Relations

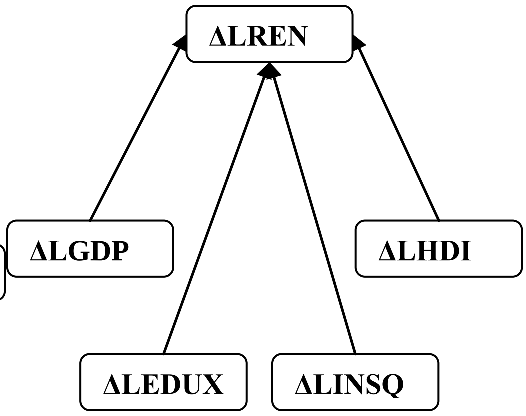

Figure 2. Long-term Causality Relations

6. CONCLUSIONS

At the center of macroeconomic policies, the goal of production increase is taking place, which causes the development phenomenon to be neglected. Development has begun to be measured together with qualitative factors in the early 1990s. Especially environmental quality has become one of the important elements of development. While the energy demand in the production process appears to be the primary cause of environmental degradation, increasing the use of renewable energy to reduce this degradation has become the main policy applied by governments. In this study, to identify determinants of the use of renewable energy sources, the use of renewable energy, per capita national income, education expenditure were included in the analysis and apart from the other studies, institutional quality and human development indexes were included in the analysis. According to panel FMOLS results, there is no statistically significant coefficient for the interaction between education expenditure and change in institutional quality, human development index and renewable energy use.On the other hand, it is expected that the 1% increase in per capita income will reduce the use of renewable energy by 0.54% in the with constant model and 0.55% in the with constant and trend model. This situation also overlaps with the Pollution Heaven Hypothesis.

Investments made in countries with low institutional quality increase production while energy demand increases. In order to be able to meet the renewable energy resources needed, these resources need to be created with investments. These resources require high capital investment, and undeveloped countries that do not have such capital tend to primary energy resources, which are important in environmental degradation. In this case, environmental quality is regarded as luxury goods, corporate regulations are made with increasing income and environmental degradation is reduced. Within the context of the analysis, only the human development index and the use of renewable energy in the short term are related within the human context, while the other three variants are the reasons of the use of renewable energy source in long term. In this case, it is understood that environmental degradation can be avoided by making institutional arrangements in particular. The active role of the government in this process will improve environmental degradation more quickly.

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