THE RENEWABLE ENERGY AND GROWTH: EVIDENCE FOR TURKEY USING ENVIRONMENTAL KUZNETS CURVE MODEL

Gülden Bölük
Department of Economics,
Akdeniz University,
Antalya, Turkey

Mehmet Mert
Department of Econometrics,
Akdeniz University,
Antalya, Turkey

Abstract:

This study examines the potential of renewable energy sources in reducing the impact of the GHG emissions in Turkey. Using Autoregressive Distributed Lag (ARDL) approach, the relationship between CO2 emissions, electricity generated using renewables and GDP in Turkey has been investigated over the period 1961-2010. Moreover, the validity of Environmental Kuznets Curve (EKC) hypothesis has been tested. Model results show that the elasticity of electricity production from renewable sources (hydro power excluded) with respect to CO2 emissions is negative and significant in the long run. Although this effect is positive and statistically significant in the short run, since the ECM term is -0.82, it becomes negative around 1 year. This means that renewable electricity production will contribute to environmental enhancement with one year lag. Our results also suggest an U-shaped (EKC) relationship between per capita GHGs and income. Estimations from a long-run regression shows that, although the peak point has been calculated to be 9,920, this turning point has been outside of the observed sample period. Therefore, GHG emissions start to decrease with an increase in per capita GDP in the following years. Model research implies the potential and the importance of renewable energy sources in controlling of emissions in Turkey.

Keywords: Renewable energy, sustainable development, Environmental Kuznets Curve, Turkey.

1. Introduction

Turkey has an economy challenging by a growing demand for energy while it's self sufficiency ratio is very low. Turkey is heavily dependent on the expensive energy imports which imposes a significant burden on the current account deficit and the price stability. According to the TurkStat (2014a), total energy import was 55,916 million USD and it constituted about 22.2 percent of the total import bill in 2013. As a result of economic development and increased energy consumption, air pollution has caused severe environmental problems in the country. Based on the TurkStat (2011) data, Turkey's GHG emissions (CO2 equivalent) increased 124 percent in the last decade and 72 percent of total emissions approximately emitted from energy sector (TurkStat, 2014b).

Turkey became a party to the Kyoto Protocol in 2009. To comply with Kyoto Protocol, consumption pattern needs to be modified with a further require which is the reduction of the share of coal in the primary consumption. As a candidate country to European Union (EU),Turkey will also have to adopt the bioenergy and biofuel directives of the EU in case of membership. All of the combined macroeconomic data indicate that energy will be one of the most important issues for Turkey's economic development. Turkey, like many countries, tries to foster the renewable energy sources and ensures some incentives such as feed-in tariff, investment incentives etc. The first promotion instrument for renewable energy was the Electricity Market Law in Turkey in 2001. Moreover, legislation activities in renewable energy market have intensified over the past decade. It has been planned that the share of the renewable energy resources in the electricity production would be at least 30 % while the share of the natural gas below 30 % by 2023.

A key policy aim of the international efforts to mitigate negative effects of the global climate change is to alleviate global CO_2 emissions. Since achievement of these efforts depends on commitments of countries to reach global emissions targets, it is important to understand the variables which have impact over the CO_2 emissions (Villanueva, 2012). Thus, whether the economic development causes GHGs or improves the environmental quality was questioned since it would help to the development of emission reduction strategies. The subject of environmental deterioration versus economic development was first emphasized in detail in World Development Report of 1992. Whether economic development causes problems for environmental protection or improves environmental quality has been studied through econometric methods during the three decades. The relationship between economic growth and environment is generally analyzed by the Environmental Kuznets Curve (EKC). The EKC states that the relationship between environment degradation and income per capita takes the form of an inverted U shape. However, although energy is very important factor related to GHG emissions and development, energy aspects have been generally ignored in EKC studies (Marrero, 2010).

The EKC hypothesis for Turkey was examined for the first time in 2004. Gürlük and Karaer (2004) have estimated a regression model for investigating the relationship between GDP per capita and several GHG emissions using the time series data over the 1975-2000 period. They found an inverted U-shaped relationship for Turkey. Başar and Timurlenk (2007) have investigated the validity of EKC hypothesis using time series data over the 1950-2005 period for Turkey. Authors have concluded that a N-shaped relationship is valid between income, fossil fuel consumption and emissions instead of EKC for Turkey. Akbostancı et al.(2009), have investigated the relationship between income and CO2 emissions using time series and panel data models for Turkey. The authors have found that EKC relationship is not valid for Turkey. Halicioglu (2009), has added trade openness and energy consumption variables to explore the relationship between economic growth and CO2 emissions in Turkey. Author has found that income is the most important variable explaining the carbon emissions and there is a causal and long run relationship between carbon emissions, energy consumption and GDP. Acaravci and Orturk (2010), have examined the long run and causal relationship between carbon emissions, economic growth, energy consumption and employment ratio using ARDL model over the 1968-2005 period. They have found no evidence supporting the EKC is true in Turkey. Moreover, since there is only a causal relationship between employment ratio and growth, controlling the emissions will not lower the economic growth of Turkey. Saatçi and Dumrul (2011), have analyzed the relationship between economic growth and environmental pollutants using cointegration analysis over the 1950-2007 period. They have found evidence supporting the EKC hypothesis is true for Turkey. Omay (2013) has examined the relationship between economic growth and carbon dioxide emissions using data over the period 1980-2009. The author has showed that there is a N-shaped relationship instead of U-shaped EKC relationship for Turkey.

Up to the present, there has been no known available study examines the potential of renewable energy in an inverted U-shaped relationship between environmental pollutants and economic growth in determining the level of GHG emissions in Turkey. This study has examined the potential of renewable energy resources in reducing the impact of the GHG emissions in Turkey. Using the EKC hypothesis, this study analyzes the impact of electricity generated from renewables on environment for the period of 1961-2010 conducting an Autoregressive Distributed Lag (hereafter ARDL) bounds approach to cointegration. Since the renewable energy can ensure sustainability of the electricity supply and also can reduce GHG emissions, elasticities of electricity production from renewables sources with respect to GHG emissions in both short and the long run in Turkey will ensure important data for the policies towards to sustainable development.

The rest of the paper is organized as follows. The next section presents the literature review of EKC studies which especially includes the energy variables. Section three describes the methodology and the data of the analysis. Section four discusses the empirical results and compares the results of the analysis with the previous studies. Concluding remarks are given in the final section.

2. Literature review

The relationship between pollution and economic growth has gained an increasing research attention in the recent years since it is expected to make contribution to development of emission reduction strategies. Kuznets Curve (KC) was considered as one of the tools for describing the relationship between the measured levels of environmental indicators and income per capita. The inverted U-shaped relationship between economic growth and pollutants has been known as the Environmental Kuznets Curve (EKC) (Halicioglu, 2009).

The EKC hypothesis states that the pollution level increases as a country develops, but begins to decrease when the rising income passes beyond a turning point, in other words the environmental quality gets worse first and then improves with the economic growth (Odhiambo, 2011) (See Figure 1).

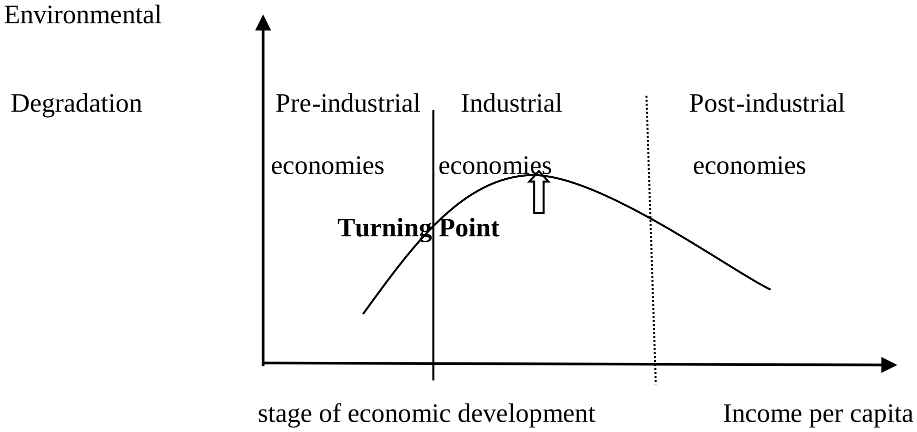

Figure 1: The environmental Kuznets curve: a development-environment relationship
Source: Panayotou, 2003, p.46.

The relationship between economic development and environmental degradation or quality can be decomposed of the three effects, namely scale effect, composition effect and technical effect. Environmental pressure increases as output growth increases (scale effect) but this pressure might be nullified by the other two effects. It is possible that economic development occurs mainly in sectors that pollute less (this is called composition effect) and technological progress can countervail the greater production level (technical effect) (Almeida and Sabadini, 2009).

The EKC hypothesis was first proposed by the paper of Grossman and Krueger (1991). Following this pioneering study, many research studies have mostly focused on the existence of the relationship of EKC. There are mainly three types of research strands in the relevant literature examining the relationship between the economic growth and the environmental quality. The first strand focuses on the economic development and environmental pollutants nexus (Zhang, 2009). This strand simply tests the validity of the so-called EKC hypothesis. EKC studies has gained an increasing research attention over the time since the pioneering works of Grossman and Krueger (1991), Grossman and Krueger (1995), Holtz-Eakin and Selden (1992) and Shafik (1994). It can be said that empirical results for EKC studies are controversial. The EKC hypothesis is being criticized for the lack of feedback from environmental pollutants to economic output as income is assumed to be exogenous variable (See Zhang (2009), Arrow et al.(1995), Stern (2004), Huang and Shaw (2002) etc). Stern (2004), Dinda (2004), Lieb (2003) and Bo (2011), provide review survey of empirical EKC studies.

The second strand focuses on the linkage between economic output and energy consumption since the GHG emissions are mainly caused by fossil fuels. Following the study of Kraft and Kraft (1978), an increasing number of studies have empirically examined the relationship between economic output and energy consumption employing Granger causality and cointegration models (See Akarca and Long (1980), Yu and Choi (1985), Erol and Yu (1987), Yu and Jin (1992), Masih and Masih (1996), Hondroyiannis et al.(2002), Soytas and Sari (2003), Lee and Lee (2010). Payne (2010), provides an extensive review of the studies on the empirical results of energy consumption and economic growth relationship. The recent econometric studies in this group, however, have focused the relationship between economic growth and the renewable energy consumption instead of the aggregate energy consumption (See Chien and Hu 2007, Chien and Hu, 2008, Apergis and Payne, 2010a, 2010b, 2011, 2012, Sadorsky, 2009a, Sadorsky 2009b).

Based on the available EKC literature, it can be noticed that a large part of these studies focuses on the nexus of energy-output or pollution-output. However, recently some studies "combined" approaches of these two strands and investigated the inter-temporal linkage in the energy-environment-income nexus (See Soytas et al. 2007, Soytas and Sari 2009, Halicioglu 2009, Ang 2007, Zhang and Cheng 2009, Apergis and Payne 2009, Marrero 2010, Almeida and Sabadini 2009, Grunewald and Martinez-Zarzoso 2009, Richmond and Kaufman 2006, Zhao 2011, Arouri et al. 2012, Suleiman et al. 2013, Pao and Tsai 2011, etc.).

The recent EKC studies within the "combined" third group especially explore the relationship between environmental pollutants, renewable and fossil energy consumption and economic growth using time series analysis and/or panel data analysis. In a research paper by Marrero (2010), panel data analysis has been conducted for 24 EU countries and it has been assumed that the impacts of energy consumption on emissions is dependent on the primary energy mix. Bölük and Mert (2013), have proposed and have estimated a panel model for EU-16 over the time period 1990-2008, which linked greenhouse emissions (CO_2) per capita with real GDP per capita and renewable and non-renewable energy consumption. Authors have indicated that there has been no statistical evidence in favour of the existence of an EKC (inverted-U) and renewable energy consumption significantly has lowered GHG emissions (around 1/2 (half)) than does fossil energy consumption for the EU countries between the period of 1990 and 2008. Suleiman et al (2013), has examined the potential of renewable energy sources in the framework of the EKC hypothesis. Authors have analyzed the impact of electricity generated using renewable energy sources on the environment using ARDL approach over the period 1980-2009 in Malaysia. They have found that the elasticities of electricity production from renewables with respect to CO2 emissions have been negative in both short and long term. Jebli et al.(2013), have investigated the causal relationship between CO2 emissions, renewable and non-renewable energy consumption, income and trade openness for 25 OECD countries over the 1980-2009 period. They have found unidirectional causality from GDP to CO2 emissions and non-renewable energy consumptions. Moreover, renewable energy consumption lowers the CO2 emissions.

The existing EKC literature indicates that validity of EKC hypothesis is still controversial. There is overwhelming evidence linking economic growth and CO_2 emissions. Nevertheless, there is no strong evidence shows economic development itself is not expected to control the GHG emissions. Income- emission relationship, however, seems to be affected by energy consumption quantity and Kyoto Protocol process. Moreover, renewable energy consumption has potential to compete against the global changing and/or warming issue. This means that efforts for reducing the emissions by some mechanisms such as less polluting technologies (renewables) have impact in the shaping of the long run emissions/GDP dynamics as well.

3. Econometric method

3.1. Data, variables and model

Following the recent empirical literature such as Huang et al.(2009), Halicioglu (2009) and Suleiman et al.(2013), it is possible to test whether there is a long-run relationship between CO_2 emissions, economic growth, and electricity production from renewable sources in a quadratic form. To test the validity of EKC hypothesis the following equation has been defined and employed:

$$CO2_t = \beta_0 + \beta_1 GDP_t + \beta_2 GDP2_t + \beta_3 EPR_t + u_t \qquad (1)$$

In Equation (1), CO2 is the carbon dioxide emissions per capita (measured in metric ton per capita) as a proxy for greenhouse gas emissions, GDP is per capita gross domestic product (in constant 2005 US Dollar), GDP2 is the square of GDP, EPR stands for the electricity production from renewable sources per capita, excluding hydroelectric (kWh) and finally u is disturbance term. The Annual time series data was obtained from World Development Indicators (WDI) online data base for Turkey over the time period 1961-2010.

Under the EKC hypothesis, coefficient $\beta_1$is expected positive sign and the coefficient β_2 is expected negative sign. That the coefficient $\beta_1$is positive means that the greater economic growth the greater carbon emissions. At the same time, that the coefficient β_2 is significant and negative means that there is a turning down point on the curve. At this point, increasing economic growth begins to make carbon emissions reduction. In this situation, the peak point of GDP is calculated to be $\beta_1/|2\beta_2|$. However, when the coefficient β_2 is insignificant, carbon emissions increase monotony. As for the expected sign of the other explanatory variable EPR, one expects the coefficient β_3 to be negative since the productions from renewable sources may not lead to emissions whereas the productions from fossil sources and also one may consider that the renewable energy sources are more environmentally friendly.

Table 1 presents some descriptive statistics of the variables over the 1961-2010 period. The summary statistics include the means, median, maximum and minimum of each series.

Table 1: Descriptive statistics of the variables

Variables	Mean	Median	Min.	Max.	St. Deviation
CO2	2.30	2.25	0.62	4.13	1.00
GDP	4669.18	4291.40	2315.94	7833.53	1562.11
EPR	5.23	3.62	0.00	54.29	8.45

Before the beginning analysis, the scatter plot between GDP and CO2 in Figure 1 can give an idea about this relationship partially.

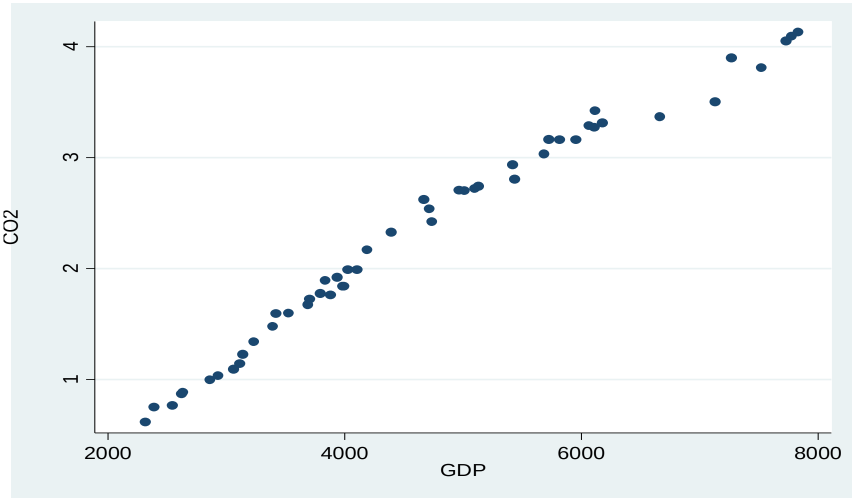

Figure 1: Scatter graph of CO2 and GDP

It can be inferred from the Figure 1, there is no EKC relationship between the economic growth and GHG emissions in Turkey.

3.2. Cointegration method

To reveal the long run relationships among the time series, cointegration techniques can be used. There are several examples using the methodology based on the residuals by Engle and Granger (1987) and based on modified ordinary least square procedures by Phillips and Hansen (1990). Furthermore, multivariate cointegration analysis by Johansen (1988), Johansen and Juselius (1990) and Johansen's (1996) maximum likelihood methods have been used. In all these cointegration techniques, the most important restriction is that all series have same ordered integrations. However, recently found a cointegration approach by Pesaran et al.

(2001), namely autoregressive-distributed lag (ARDL) and also known as bounds test, withdrew this restriction. ARDL methodology allows that regressors may stationary in levels (I(0)) or the first differenced (I(1)). Because of this convenience, ARDL method has been used in many studies and in the current study, this technique has been used to obtain the long run relationship among the series.

Equation (1) can be rewritten as an ARDL formula as the model with intercept in equation (2) and the model with intercept and trend in equation (3) as follows:

$$\Delta CO2_t = \alpha + \sum_{i=1}^{m} \beta_{1i}\Delta CO2_{t-i} + \sum_{i=0}^{m} \beta_{2i}\Delta GDP_{t-i} + \sum_{i=0}^{m} \beta_{3i}\Delta GDP2_{t-i} + \sum_{i=0}^{m} \beta_{4i}\Delta EPR_{t-i} + \beta_5 CO2_{t-1} + \beta_6 GDP_{t-1} + \beta_7 GDP2_{t-1} + \beta_8 EPR_{t-1} + v_t \tag{2}$$

$$\Delta CO2_t = \alpha_0 + \alpha_1 t + \sum_{i=1}^{m} \beta_{1i}\Delta CO2_{t-i} + \sum_{i=0}^{m} \beta_{2i}\Delta GDP_{t-i} + \sum_{i=0}^{m} \beta_{3i}\Delta GDP2_{t-i} + \sum_{i=0}^{m} \beta_{4i}\Delta EPR_{t-i} + \beta_5 CO2_{t-1} + \beta_6 GDP_{t-1} + \beta_7 GDP2_{t-1} + \beta_8 EPR_{t-1} + v_t \tag{3}$$

Existence of a long-run relationship among the variables is researched by Bounds test. According to test, null hypothesis which implies no cointegration is $H_0\colon \beta_5 = \beta_6 = \beta_7 = \beta_8 = 0$. If the calculated F statistic is higher than the upper bound critical value I(1) for the number of explanatory variables (k) by Pesaran et al. (2001), null hypothesis will be rejected. If the F statistic is lower than the lower bound critical value I(0), null hypothesis cannot be rejected. That the F statistic is between the I(0) and I(1) means indecision about cointegration. Narayan (2005) suggested alternative critical values I(0) and I(1) which are more appropriate than that of Pesaran et al. (2001) for small sample sizes. Optimal lag value m in equation (2) and (3) is chosen based on the model selection criteria such as Akaike (AIC) or Schwarz (SIC) information criteria. The minimum AIC or SIC of the model implies optimal m. Besides, there must be no serial correlation in residuals for the model. If there is a cointegration, next step of ARDL process holds the long-run ARDL equation as follows:

$$CO2_t = \beta_0 + \sum_{i=0}^{p} \beta_{1i} CO2_{t-i} + \sum_{i=1}^{q} \beta_{2i} GDP_{t-i} + \sum_{i=0}^{r} \beta_{3i} GDP2_{t-i} + \sum_{i=0}^{s} \beta_{4i} EPR_{t-i} + \varepsilon_t \tag{4}$$

To select the lag values p, q, r and s in equation (4), model selection criteria such as AIC, SIC, Hannan-Quin information criteria, Adjusted R-squared are used. The best estimated model is the model which has the minimum information criteria or the maximum R-squared value. Finally, short-run estimation of ARDL model also known as error-correction model is estimated in the equation below:

$$CO2_t = \delta_0 + \sum_{i=0}^{p} \delta_{1i}\Delta CO2_{t-i} + \sum_{i=1}^{q} \delta_{2i}\Delta GDP_{t-i} + \sum_{i=0}^{r} \delta_{3i}\Delta GDP2_{t-i} + \sum_{i=0}^{s} \delta_{4i}\Delta EPR_{t-i} + \lambda ECM_{t-1} + \tau_t \tag{5}$$

The coefficient of the error-correction term (ECM_{t-1}) λ in equation (5) is the speed of adjustment parameter which shows how quickly the series come long-run equilibrium. The expected sign of this coefficient is negative and it is also expected significant.

The diagnostic tests such as serial correlation, normality, functional form, heteroscedasticity tests are conducted to ensure the acceptability of the model. Besides, stability test such as cumulative sum (CUSUM) and cumulative sum of squares (CUSUMQ) by Brown et al. (1975) are done to see the stability of the coefficients on the graphical representations.

4. Empirical results

4.1. Integration process

In order to test the presence of stochastic stationary in our data, we first investigated the integration of our times series. For this purpose, we run Augmented Dickey-Fuller test (ADF) by Dickey and Fuller (1981) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test by Kwiatkowski, et al. (1992). In Both tests, we used the models with intercept. For the test ADF, we decided lag length by using Schwarz information criteria. We used Bartlett Kernel estimation method with Newey-west bandwidth in the test of KPSS. In Table 2, the results of the unit root tests on the level of the variables can be seen.

Table 2: Unit root tests at the levels of the variables

	ADF (Null: Variable has a unit root)		KPSS (Null: Variable is stationary)	
Variables	Test Statistic	Critical value at .05 level	Test Statistic	Critical value at .05 level
CO2	-0.16	-2.92*	0.94	0.46**
GDP	0.50		0.92	
GDP2	1.20		0.87	
EPR	1.11		0.38	

*: MacKinnon (1991).

**: Kwiatkowski et al. (1992, Table 1).

According to ADF and KPSS tests, the series CO2, GDP and GDP2 have unit root at levels. For the series EPR, ADF and KPSS tests give different results. KPSS test implies that the EPR is stationary unlike ADF test. To make a decision, we draw Correlogram of the EPR and we saw that after one lag, both autocorrelations and partial autocorrelations are between the .95 confidents bounds which implies stationary process. The results of correlogram for EPR have not beendisplayed here to conserve space. Finally, we concluded that the series EPR is I(0). Unit root tests for the first differences of the variables CO2, GDP and GDP2 are given in Table 3.

Table 3: Unit root tests at the first differences of the variables

	ADF (Null: Variable has a unit root)		KPSS (Null: Variable is stationary)	
Variables	Test Statistic	Critical value at .05 level	Test Statistic	Critical value at .05 level
CO2	-7.50	-2.92	0.06	0.46
GDP	-7.03		0.14	
GDP2	-6.53		0.34	

*: MacKinnon (1991).

**: Kwiatkowski et al. (1992, Table 1).

In Table 3, both tests gave same results and we concluded that the series CO2, GDP and GDP2 are I(1). We concluded that the series CO2, GDP and GDP2 are I(1). As mentioned before, the ARDL approach allows estimation of cointegrating vector with both I(1) and I(0). That our regressors are I(0) or (1) confirmed the employing of ARDL bounds testing to estimate the long-run relationship.

4.2. Cointegration process

The Bounds testing approach was employed to determine the presence of cointegration among the series. The Bounds testing procedure is based on the joint F-statistics. We selected the maximum lag value m=7 in equation (2) and equation (3). In table 4, AIC, SIC values and F statistics for the $H_0 : \beta_5 = \beta_6 = \beta_7 = \beta_8 = 0$ are given. The optimum lag is selected relying on the minimizing the Akaike Information Criterion and Shwarz Criteria (SIC). For both models, the minimum AIC and SIC values in the model were obtained when the lag value m was equal to m=6. For the residuals of this model, we performed Breusch-Godfrey serial correlation LM test and detected no serial correlation. F statistic for this model is higher than the upper critical values by Pesaran et al. (2001) and Narayan (2005) in all cases and we conclude that there is a cointegration which means a long-run relationship among the series.

Table 4: ARDL bounds test results for Cointegration

	Intercept			Intercept and Trend		
Lag	AIC	SIC	F	AIC	SIC	F
1	-2.1529	-1.6851	4.943	-2.1125	-1.6057	4.623
2	-2.0201	-1.3908	3.376	-1.9926	-1.3234	2.871
3	-2.1055	-1.3104	4.059	-2.0621	-1.2272	2.866
4	-2.0928	-1.1293	2.656	-2.0602	-1.0565	2.108
5	-2.1984	-1.0630	3.525	-2.1693	-0.9934	3.363
6	**-3.0263**	**-1.7157**	**5.656****	**-3.0670**	**-1.7183**	**5.692******
7	-2.9813	-1.4919	0.987	-2.9475	-1.4167	0.761

*: This statistic is higher than the upper critical value I(1)=4.35 at .05 level for k=3 from the table CI(iii) case III by Pesaran et al. (2001) and also higher than the upper critical value I(1)=4.70 at .05 level for k=3 and n=50 from the table Case III by Narayan (2005).
**: This statistic is higher than the upper critical value I(1)=5.07 at .05 level for k=3 from the table CI(V) case V by Pesaran et al. (2001) and also higher than the upper critical value I(1)=5.545 at .05 level for k=3 and n=50 from the table Case V by Narayan (2005).

According to AIC, SIC and Hannan-Quinn information criteria, the best model for equation (4) is ARDL(1,0,0,1) model which means p=1, q=r=0 and s=1, selecting the maximum lag value p=q=r=s=4. The estimating ARDL(1,0,0,1) model results are given in Table 5. In this model, all coefficients are significant and diagnostics are well. For serial correlation, lagrange multiplier test, for functional form, Ramsey's RESET test are performed besides normality tests and the test for heteroscedasticity.

Table 5: ARDL(1,0,0,1) model results

Dependent variable: CO2	Coefficient	St. Error	T-Ratio	Prob
$CO2_{t-1}$	0.1779*	0.088	2.02	0.050
GDP	0.0011**	0.14E-3	7.40	0.000
GDP2	-0.53E-7**	0.95E-8	-5.52	0.000
EPR	0.0173**	0.006	2.88	0.006
EPR_{t-1}	-0.0261*	0.010	-2.54	0.015
Intercept	-1.7070**	0.273	-6.24	0.000
$\bar{R}^2$=0.99, F(5,40)=1362.4 (Prob=0.000), DW=1.92, Durbin's h=0.35 (Prob=0.723)				

Diagnostic Tests:

Serial Correlation: $\chi^2_{(1)}$=0.06 (Prob=0.806)
Functional Form: $\chi^2_{(1)}$=0.10 (Prob=0.754)
Normality: $\chi^2_{(2)}$=0.06 (Prob=0.971)
Heteroscedasticity: $\chi^2_{(1)}$=2.10 (Prob=0.148)

*: significant at .05 level, **: significant at .01 level

The long-run estimation results are given in Table 6. All coefficients are significant and they all have the expected signs.

Table 6: Long-run estimation

Dependent variable: CO2	Coefficient	St. Error	T-Ratio	Prob
GDP	0.0013**	0.79E-4	16.05	0.000
GDP2	-0.65E-7**	0.79E-8	-8.15	0.000
EPR	-0.0104*	0.006	-1.76	0.085
Intercept	-2.0764**	0.197	-10.55	0.000

*: significant at .10 level, **: significant at .01 level

That the coefficient of the variable GDP is positive and the coefficient of the variable GDP2 is negative means that the EKC hypothesis is valid for Turkey even if the relationship between CO2 and GDP from Figure 1 does not support the existence of the EKC hypothesis. This result is in line with the former studies about EKC hypothesis for Turkey such as Halicioglu (2009), Gürlük and Karaer (2004), Lise and Montfort (2007) and Saatci and Dumrul (2011). From the estimated long-run regression equation, we calculated peak point as $\beta_1/|2\beta_2| \cong 9{,}920$. This value is higher than the highest value of GDP in our sample which can be seen in Table 1 (the maximum value of the variable GDP is 7,833.53 in the sample). This result may explain the relationship which was depicted in Figure . Moreover this result is consistent with the study for China by Jalil and Mahmud (2009) which has found EKC's turning point outside of the sample period and another study for Malaysia by Sulaiman et al. (2013) which has found EKC's turning point outside of the observed sample period as well.

Table 7: Short-run estimation

Dependent variable: ΔCO2	Coefficient	St. Error	T-Ratio	Prob
ΔGDP	0.001*	0.14E-3	7.39	0.000
ΔGDP2	-0.53E-7*	0.95E-8	-5.52	0.000
ΔEPR	0.017*	0.006	2.88	0.006
Constant	-1.707*	0.273	-6.24	0.000
ECM_{t-1}	-0.82*	0.088	-9.35	0.000
$\bar{R}^2$=0.99, F(4,41)=24.31 (Prob=0.000), DW=1.92				

*: significant at .01 level

The short-run estimation results are given in Table 7. The coefficient of the error correction term is negative and significant as expected. When per capita CO_2 emissions far away from its equilibrium level, it adjusts by almost 82% within the first period (year). The full convergence to equilibrium level takes about 1.2 period (years). In the case of any shock to the emissions, the speed of reaching equilibrium level is fast and significant.

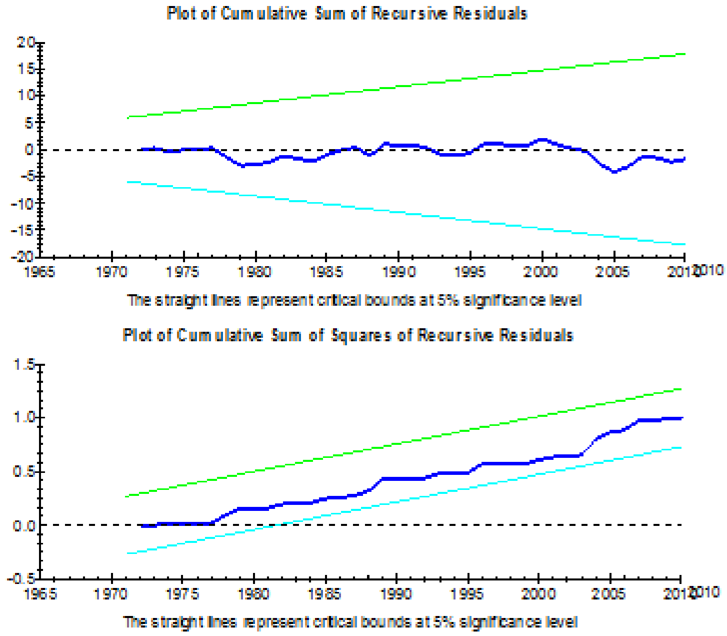

Figure 2: Graph of CUSUM and CUSUMSQ

Finally, we tested the stability of the parameters. In this purposes we got the CUSUM and CUSUMSQ graphs in Figure 2. From this figure, statistics are between the critical bounds which implies the stability of the coefficients.

5. Conclusions

This paper attempted to examine empirically the short-run and long-run relationship between CO2 emissions, income and the potential of electricity production from renewable resources in Turkey for the period of 1961-2010. The Autoregressive Distributed Lag (ARDL) approach proposed by Pesaran et al. (2001) was chosen to analyze the relationship between the income per capita, GHGs per capita and renewable electricity production per capita. The significant positive and negative coefficients of GDP and GDP2 respectively, suggest an inverted U-shaped relationship between per capita GHG emissions and per capita real income supporting the so-called EKC hypothesis in both long and short run. This confirms that GHG emissions increase with income increase then starts to decline with higher level of income. Estimations from a long-run regression equation, the peak point has been calculated to be $\beta_1/|2\beta_2| \cong 9{,}920$. This turning point, however has been outside of the observed sample period. This implies that GHG emissions might start to decrease with the increase in per capita GDP in coming years in Turkey .

The coefficient of CO2 emissions per capita with respect to electricity production from hydro excluded renewable resources is negative and statistically significant in the long run. Although this effect is positive and statistically significant in the short run, since the ECM term is 0.82, it becomes negative around 1 year because -0.82. In other words, renewable electricity production will contribute to environmental enhancement with one year lag. Moreover, when the electricity production from renewable energy including the hydro power was analysed in the this model, statistically significant relationship between CO2 emissions could not be obtained. This also has very important policy implications for energy and environmental aspects of the country. Hydro energy utilization for electricity production does not seem an effective energy alternative in controlling the CO2 emissions in Turkey. Possible deterioration effects of hydro powers on forest might be considered as an explanation for this result.

Our results imply the importance of renewable energies such as biogas, solar and wind in controlling the CO2 emissions in Turkey. A shift in the energy mix towards less polluting energies (renewable energy technologies) would be very important in order to achieve environmental targets as well as the sustainable development of the country. Our findings also highlight that regulations to support renewable sources would yield reduction in per capita emissions. By increasing the utilization of electricity produced from renewable sources will help to mitigate energy dependency and ensure the energy security issue. Therefore, it is envisaged and concluded that these results and the findings of our research ensure highly important information for policy makers in Turkey.

Brief Biographies of Authors:

Gülden Bölük is an assistant professor at University of Akdeniz, Faculty of Economics and Administrative Science, department of Economics, Antalya, Turkey. She held a Ph.D. in Economics (2010: University of Akdeniz, Institute of Social Sciences). Her main topics are microeconomics, industrial organization, energy economics and policy, regulation and environment, Contact: guldenboluk@akdeniz.edu.tr.

Mehmet Mert is an assistant professor at University of Akdeniz, faculty of Economics and Administrative Science, department of Econometrics, Antalya, Turkey. He holds a PhD in Statistics (2006: University of Hacettepe, Ankara, Turkey). His main topics are applied statistics, applied econometrics, panel models and time series analysis. Contact: mmert@akdeniz.edu.tr.

References

Acaravci A, Ozturk I. (2010). On the relationship between energy consumption, CO2 emissions and economic growth in Europe. Energy; 35:5412-5420.

Akarca AT, Long TV. (1980). On Relationship Between Energy Consumption and GNP: A Re-Examination., Journal of Energy and Development; 5: 326-331.

Akbostancı E, Turut -Asık S, Tunc GI. (2009). The Relationship Between Income And Environment in Turkey: Is There An Environmental Kuznets Curve?, Energy Policy ; 37(3): 861-867.

Almeida E. and Sabadini T., (2009). The Global Environmental Kuznets Curve and the Kyoto Protocol. Department of Economics and Finance, Federal University of Juiz de Fora. Discussion Paper No:36036-330.

Lee C, Lee J. (2010). A panel data analysis of the demand for total energy and electricity in OECD countries. Energy Journal ; 31(1); 1–23.

Ang, J B. (2007). CO2 Emissions, Energy Consumption, and Output in France. Energy Policy; 35:4772-4778.

Apergis N. and Payne J. (2012). Renewable and non-renewable energy consumption-growth nexus:Evidence from a panel error correction model, Energy Economics, 34, 733-738.

Apergis, N, Payne J.(2009). CO_2 Emissions, Energy Usage, and Output in Central America**.** Energy Policy; 37: 3282-3286.

Apergis, N, Payne J. (2010a). The Emissions, Energy Consumption and Growth Nexus: Evidence from the Commonwealth of Independent States. Energy Policy; 38**:** 650-655.

Apergis, N, Payne J. (2010b). Renewable Energy Consumption and Economic Growth: Evidence from a Panel of OECD Countries. Energy Policy; 38: 656-660.

Apergis, N, Payne J. (2011). Renewable Energy Consumption, Growth, and Economic Development: An Exploratory Panel Analysis. Advances in Energy Research; 9: 359-372.

Arouri M.E.H., Youssef ,A.B., M'henni, H.Rault, C. (2012). Energy Consumption, economic growth and CO2 emissions in the Middle East and North African countries, Energy Policy; 45, 342-349.

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C. S., Jansson, B-O., Levin, S., Mäler, K-G., Perrings, C., and D. Pimentel, (1995). Economic growth, carrying capacity, and the environment. Science; 268: 520-521.

Başar, S., Temurlenk, M.S. (2007). Environmental Kuznets Curve: An Empirical Analysis for Turkey,Journal of Economics and Administrative Sciences, 21(1), 1-12. (in Turkish).

Bo S. (2011). A Literature Survey on Environmental Kuznets Curve. Energy Procedia ; 5: 1322-1325.

Bölük G. and Mert M. (2013). Fossil&Renewable Energy Consumption, GHGs and Economic Growth:Evidence from a Panel of European Union (EU) Countries, International Conference on Energy&Environment (ICEE), University of Porto, May 9-10, 2013, Porto,Portugal.

Brown, R.L., Durbin, J., Evans, J.M. (1975). Techniques for testing the constancy of regression relations over time. Journal of the Royal Statistical Society, Series B 37, 149–163.

Chien T, Hu JL. (2007). Renewable Energy and Macroeconomic Efficiency of OECD and non-OECD Economies. Energy Policy ; 35: 3606–3615.

ChienT, . Hu JL. (2008). Renewable Energy: An Efficient Mechanism to Improve GDP. Energy Policy; 36: 3045– 3052.

Dickey, D.A., Fuller, W.A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. Econometrica 49, 1057–1072.

Dinda S. (2004). Environmental Kuznets Curve Hypothesis:A Survey, Ecological Economics; 49, 431-455.

Engle, R., Granger, C. (1987). Cointegration and error correction representation: estimation and testing. Econometrica ; 55, 251–276.

Erol U, Yu ESH.(1987). Time series analysis of the causal relationships between US energy and employment. Resources and Energy; 9: 75–89.

Grossman GM, Krueger AB. (1995). Economic Growth and the Environment. The Quarterly Journal of Economics; 110: 353-377.

Grossman GM. Krueger AB. (1991). Environmental Impacts of a North American Free Trade Agreement. NBER Working Paper no. 3914, http://www.nber.org/papers/w3914.pdf, (retrieved 10/10/2012).

Grunewald N. and Martinez-Zarzaso I. (2009). Driving Factors of Carbon Dioxide Emissions and the Impact from Kyoto Protocol, Ibero America Institute for Econ Research (IAI) Discussion Papers 190, Ibero-America Institute for Economic Research, http://www.cesifo-group.de/portal/page/portal/DocBase_Content/WP/WP-CESifo_Working_Papers/wp-cesifo-2009/wp-cesifo-2009-08/cesifo1_wp2758.pdf (retrieved 10/02/2014).

Gürlük, S., Karaer, F. (2004). On the examination of the relation between economic growth and environmental pollution, Turkish Journal of Agricultural Economics; 10(2), 43-54. (in Turkish).

Halicioglu, F.,(2009). An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. Energy Policy; 37: 1156-1164.

Holtz-Eakin D, Selden TM. (1995). Stoking the fires? CO2 Emissions and Economic Growth. Journal of Public Economics;57:85-101.

Hondroyiannis G, Lolos S, Papapetrou E. (2002). Energy consumption and economic growth: assessing the evidence from Greece. Energy Economics; 24: 319–336.

Hung, MF.. and D. Shaw (2002). Economic Growth and the Environmental Kuznets Curve In Taiwan: a Simultaneity Model Analysis, Mimeo, http://www.engr.mun.ca/~bingchen /EN9629 /Supplements /Supplement4_EKC%20case%20study.pdf, (retrieved 05/01/2014).

Jalil, A. and S.F. Mahmud (2009). Environment Kuznets curve for CO2 emissions: A cointegration analysis for China. Energy Policy, 37: 5167-5172.

Johansen, S., (1988). Statistical analysis of cointegrating vectors. Journal of Economic Dynamics and Control 12, 231–254.

Johansen, S. (1996). Likelihood-Based Inference in Cointegrated Vector Auto- Regressive Models, second ed. Oxford University Press, Oxford.

Johansen, S., Juselius, K. (1990). Maximum likelihood estimation and inference on cointegration with application to the demand for money. Oxford Bulletin of Economics and Statistics 52, 169–210.

Kraft, J., Kraft, A. (1978). On the relationship between energy and GNP. Journal of Energy and Development, 3, 401-403.

Kwiatkowski, D., P.C.B. Phillips, P. Schmidt, Y. Shin (1992): Testing the Null Hypothesis of Stationary against the Alternative of a Unit Root, Journal of Econometrics, 54, pp. 159-178, North-Holland.

Lieb CM. (2003). The Environmental Kuznets Curve –A Survey of the Empirical Evidence and of Possible Causes, University of Heidelberg, Department of Economics, Discussion Paper Series, No:391, http://www.uni-heidelberg.de/md/awi/forschung/dp391.pdf, (retrieved 6/10/2013).

Lise, W., Montfort, K. (2007). Energy consumption and GDP in Turkey: is there a cointegration relationship? Energy Economics; 29, 1166–1178.

Mackinnon, J.G. (1991). Critical value for cointegration tests. In: Engel, R.F., Granger, C.W. (Eds.), Long Run Relationships: Readings in Cointegration. Oxford University Press, Oxford, 267–287.

Marrero G.A. (2010). Greenhouse gases emissions, growth and the energy mix in Europe. Energy Economics; 32: 1356-1363.

Masih, A, Masih R. (1996). Energy consumption, real income and temporal causality: Results from a multicountry study based on cointegration and error-correction modelling techniques. Energy Economics; 18: 165–183.

Narayan, P.K. (2005). The Saving and investment nexus for China: evidence from cointegration tests. Applied Economics 37, 1979–1990.

Odhiambo N.M. (2011), Economic Growth and Carbon Emissions in South Africa: An Emprical Investigation, International Business&Economics Research Journal, 10 (7), 75-84.

Omay R.E. (2013). The Relationship between Environment and Income:Regression Spline Approach, Internatinal Journal of Energy Economics and Policy, Vol.3, Special Issue, 52-61.

Panayotou T. (2003). Chapter 2: Economic Growth and the Environment. Economic Survey of Europe, No:2, 2003; http://www.unece.org/fileadmin/DAM/ead/pub/032/032_c2.pdf, (retrieved 15/06/2013).

Pao HT, Tsai CM. (2011). Modelling and forecasting the CO2 emissions, energy consumption, and economic growth in Brazil. Energy; 36: 2450-2458.

Payne JE. (2010). A survey of the electricity consumption-growth literature. Applied energy ; 87:723-731.

Pesaran, M.H., Shin, Y., Smith, R.J. (2001). Bounds testing approaches to the analysis of level relationships. Journal of Applied Econometrics 16, 289–326.

Phillips, P., Hansen, B. (1990). Statistical inference in instrumental variables regression with I(1) process. Review of Economic Studies 57, 99–125.

Richmond AK, Kaufmann RK. (2006). Is there a Turning Point in the Relationship between Income and Energy Use and/or Carbon Emissions?, Ecological Economics; 56: 176-189.

Saatci M, Dumrul Y. (2011). The Relationship Between Economic Growth and Environmental Pollution: The Estimation of Environmental Kuznets Curve With A Cointegration Analysis of Structural Breaks for Turkish Economy (in Turkish). Erciyes Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi; 66 (37): 65-86.

Sadorsky P. (2009a). Renewable energy consumption and income in emerging economies. Energy Policy; 37 (10): 4021–4028. / Sadorsky P. (2009b). Renewable energy consumption, CO_2 emissions and oil prices in G7 countries. Energy Economics; 31(3): 456-462.

Shafik N. (1994). Economic development and environmental quality: An econometric analysis. Oxford Economic Papers; 46:757-773.

Soytas U Sari U, Ewing BT. (2007). Energy consumption, income and carbon emissions in the United States. Ecological Economics; 62: 482-489. / Soytas U, Sari R. (2003). Energy consumption and GDP: causality relationship in G-7 countries and emerging markets. Energy Economics; 25: 33–37.

Stern D I. (2004). The Rise and Fall of the Environmental Kuznets Curve. World Development; 32(8): 1419-1439.

Sulaiman, J., Azman, A. And Saboori, B. (2013). The potential of renewable energy: using the environmental Kuznets curve model. American Journal of Environmental Science, 9 (2): 103-112.

TurkStat (2014a), Foreign Trade Statistics, www.tukstat.gov.tr. / TurkStat, 2014b, Environment Statistics, www.tukstat.gov.tr.

Villanueva I.A., (2012), Introducing Institutional Variables in the Environmental Kuznets Curve (EKC): A Latin American Study, Annals of the Constantin Brâncuşi" University of Târgu Jiu, Economy Series, Issue 1/2012, http://www.utgjiu.ro/revista/ec/pdf/2012-01/9_ITALO_ARBULU_VILLANUEVA.pdf, (retrieved 07/01/2014).

Yu ESH, Choi JY. (1985). The causal relationship between energy and GNP: an international comparison, Journal of Energy and Development; 10: 249–272.

Yu ESH, Jin JC. (1992). Cointegration tests of energy consumption, income, and employment. Resources and Energy; 14: 259–266.

Zhang XP, Cheng X.M. (2009).Energy consumption, carbon emissions, and economic growth in China. Ecological Economics; 68(10): 2706–2712.

Zhao X. (2011). The Impact of CO2 Emission Cuts on Income, Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting, July 24-26, 2011. Pittsburgh, Pennsylvania, USA, 2011; http://ageconsearch.umn.edu/bitstream/103412/2/Zhao-1-the%20impact %20of% 20The%20cost %20of %20CO2%20emission%20cuts%20on%20income.pdf, (retrieved 05/12/2012).