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Testing The Environmental Kuznets Curve Hypothesis under Structural Breaks: The Case of Turkey

(Research Article)

Yapısal Kırılmalar Altında Çevresel Kuznets Eğrisi Hipotezinin Sınanması: Türkiye Örneği

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ABSTRACT

In this study, the validity of the Environmental Kuznets Curve (EKC) hypothesis is investigated with annual data for the period 1990-2019 for Turkey. For this, carbon dioxide emission, per capita income, renewable energy use, and energy loss data, and the EKC hypothesis are investigated. For this purpose, unit roots tests, which take into account structural breaks, were used. Then, Gregory-Hansen (1996) cointegration test was applied. The long-short-term relationship between the variables was tested with Fully Modified Least Squares (FMOLS) and Canonical Co-integrated Regression (CCR) estimators. The findings show that the EKC hypothesis is valid for Turkey in the short-long term. In addition, it has been concluded that the increase in energy losses and the use of renewable energy reduces environmental pollution.

1. INTRODUCTION

With the increasing rate of industrialization, developments in information and technology, and population growth, the need for energy is also increasing. It is generally accepted that energy consumption has an important role in the economic growth and development processes of countries and that energy use is one of the important indicators of the level of development. Especially towards the end of the twentieth century, the increasing rate of industrialization has increased the energy demands of countries. Most of the industrializing countries have tried to meet this need with fossil fuels, which are non-renewable energy sources. However, the use of fossil fuels increases carbon dioxide emissions, affects human health negatively, and brings many environmental problems. Therefore, it has become important to accurately determine the relationships between carbon dioxide emissions, non-renewable energy, and renewable energy sources and income. In this context, the rapid increase in environmental problems, especially after the 1990s, has increased the importance of the relationship between economics and the environment (Ari and Zeren, 2011: 38; Kocak, 2014: 62).

The Kuznets Curve approach, put forward by Kuznets (1955), argues that income inequality increases in the period when the first stages of economic growth in an economy occur, but the economic growth that continues to increase will reduce this inequality over time (inverted-U relationship). This relationship was adapted to the environment by Grossman and Krueger (1991). The Kuznets Curve hypothesis is named the Environmental Kuznets Curve (EKC) hypothesis. In other words, in the EKC hypothesis, the environmental pollution variable was preferred instead of the income inequality variable (Dinda, 2004:432). The EKC hypothesis states that as the income level increases, the level of greenhouse gas emissions as an indicator of environmental pollution also increases, but after the income level reaches a certain threshold, the emission level begins to decrease (Apergis and Payne, 2010:650). It is known that environmental pollution occurs at a lower rate in the economies of underdeveloped countries, which have not passed the industrialization stage or where mostly agricultural production is common, compared to developed countries. As the weight of industrialization increases in economies, increasing production and income becomes the main objective. Therefore, in line with this purpose, natural resources can be consumed rapidly, and it is seen that environmental pollution increases with the use of fossil fuels that do not require high technology and are easily available. However, after the income level reaches a certain optimal level, the activities of some institutions and organizations begin to play an active role in the prevention of environmental pollution with the increasing awareness of people. In other words, while increasing economic growth causes environmental pollution in the first stage, economic growth above a certain income level causes environmental pollution to decrease (Yardimcioğlu and Savasan, 2016: 1163-1164; Dumanli, 2020: 100). The EKC hypothesis diagram is shown in Figure 1.

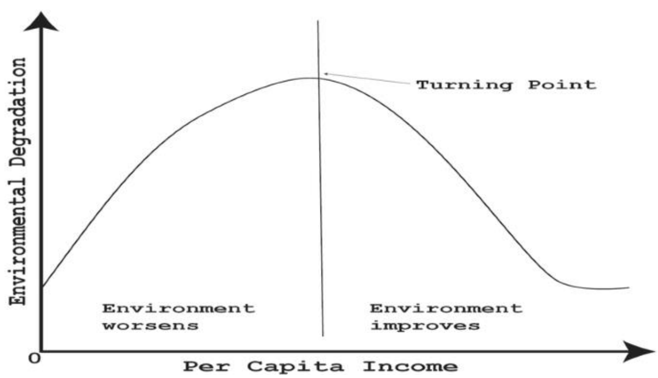

Figure 1. The environmental Kuznets curve (EKC) (Yandle et al., 2004:3; Eratas and Uysal, 2014:6).

There are three main factors in explaining the Environmental Kuznets Curve hypothesis (Grossman ve Krueger, 1991:3-4). These;

- ✓ Scale effect,
- ✓ Composition effect,
- ✓ Technology effect

In the first phase of economic growth, which increases with the scale effect, it is expressed that more resources and energy are used to increase production. In other words, increasing energy and resource use is associated with waste and environmental pollution. The structural transformations in the economic policies of the countries and the transition to agriculture, industry, service, and information society are evaluated within the scope of composition effect. It is known that the use of natural resources and environmental pollution has increased in the economies of countries that have transformed from agricultural society to industrial society. However, in the stages of transformation into service and information economies after the industrial society, the use of natural resources and environmental pollution decrease. The technology effect refers to the improvement in production techniques with increasing income, increasing resource efficiency, and the discovery of new production technologies that are less harmful to the environment (Ang, 2007: 4773). The EKC hypothesis; states that the negative effects of the scale effect that dominates in the first phase of economic growth on the environment will be balanced with the effects of composition and technology, which tend to reduce the effects of environmental degradation. He also argues that the positive effects of these factors will outweigh the economic growth process (Dinda, 2004: 435-436).

In this study, the EKC hypothesis is tested using econometric tests with current data on the Turkish economy. A quadratic model was used in this study. In addition, the relationship between renewable energy and energy loss variables and CO_2 emissions has been tried to be revealed. Therefore, the validity of the EKC hypothesis is tested and the relationship between renewable energy use and energy loss variables and the environment is also examined. Thus, it is thought that it will contribute to the relevant field and policy recommendations are presented. In the sections that follow this study, selected studies that primarily examine the Environmental Kuznets Curve hypothesis are given. Afterward, empirical methods and applications are given and analysis findings are included. Finally, the study ends with the conclusion and evaluation part.

2. LITERATURE REVIEW

The first study examining the relationship between environmental pollution and per capita income in the context of EKC belongs to Grossman and Krueger (1995). The findings of the study revealed that environmental pollution increases up to a certain income level, but decreases after reaching the optimal income level. Therefore, the existence of an inverse-U relationship between the said variables was obtained. Many studies have been carried out following the related study in the world and Turkey. In this section, selected literature on Turkey that tests the Environmental Kuznets Curve approach is presented.

Basar and Temurlenk (2007) investigated the validity of the Environmental Kuznets Curve hypothesis through the Carbon Monoxide, Per Capita Income data for the period 1950-2000 in Turkey. As a result of the test performed through the cubic model with the regression analysis, it was found that the hypothesis in question was invalid. Atici and Kurt (2007) examined the validity of the Environmental Kuznets Curve hypothesis with Regression analysis through the data of carbon monoxide, per capita income, trade openness, agricultural openness for Turkey in 1968-2000 period. As a result of the analysis made through the quadratic model, the validity of the EKC hypothesis was accepted. Saatci and Dumrul (2011) tested the Environmental Kuznets Curve hypothesis with carbon monoxide, per capita income data in Turkey. In the study analyzing the 1950-2007 period, structural break Lee and Strazicich unit root test and Kejriwal cointegration test were used. The findings show that the said hypothesis is valid. In his study, Kocak (2014) investigated the validity of the Environmental Kuznets Curve hypothesis using the ARDL bounds test method with the data of carbon monoxide, per capita income, energy consumption for the period 1960-2010 in Turkey. In the study, in which the cubic model was used, the findings revealed that the hypothesis in question was not valid. Erdogan et al. (2015) tested the validity of the Environmental Kuznets Curve hypothesis for the Turkish economy through carbon monoxide, per capita income data for the period 1975–2010. In the study, in which the Cubic model was used with the ARDL limit test method, it was concluded that the EKC hypothesis was not valid.

Albayrak and Gokce (2015) tested validity of the Environmental Kuznets Curve hypothesis by using carbon monoxide, per capita income, energy consumption, and trade openness data for Turkey in 1975-2010 period. Johansen cointegration test and quadratic model were preferred in the study, and the findings showed that relevant hypothesis was valid. Lebe (2016) investigated the validity of the Environmental Kuznets Curve hypothesis through the data of carbon monoxide, per capita income, energy use, financial development, and trade openness for Turkey in the period 1960-2010. As a result of the analysis made by the quadratic model and ARDL bounds test, it was concluded that the hypothesis in question is valid. Kilic and Akalin (2016) investigated the Environmental Kuznets Curve hypothesis by using carbon monoxide, per capita income, and trade openness data for the Turkish economy for the period 1960-2011. In the study, in which both the quadratic and cubic models were established, respectively, with the Autoregressive Distributed Lag (ARDL) boundary test method, the findings showed that the Environmental Kuznets Curve hypothesis was valid according to the first model, while it was invalid according to the second model. Güney (2018) investigated the validity of the Environmental Kuznets Curve hypothesis with the data of carbon monoxide, per capita income, energy consumption, private sector loans, industrial sector contribution share in Turkey for the period 1960-2010, using the quadratic model. As a result of the analysis made with ARDL and error correction model (ECM) methods, the findings show that the hypothesis in question is valid. Durgun and Carefree (2018) tested the validity of the Environmental Kuznets Curve hypothesis for the Turkish economy using annual carbon dioxide emissions, energy consumption, trade openness rate, and per capita income data for the 1968-2015 period. In the study, analyzes were made using the Johansen cointegration and error correction model and it was determined that the Environmental Kuznets Curve hypothesis was not valid. Saygin (2018) analyzed the validity of the Environmental Kuznets Curve hypothesis for Turkey using annual CO_2 emissions, real income per capita, energy consumption, and trade openness data for the period 1960-2014. In the study, in which the ARDL limit test was preferred, the findings revealed that the Environmental Kuznets Curve hypothesis was invalid in Turkey in the mentioned period. Sendoğan (2019) examined the relationship between carbon dioxide emissions, economic growth, and energy demand for Turkey in the context of the Environmental Kuznets Curve hypothesis. In the study covering the period 1970-2013, traditional and break unit roots tests were used and the ARDL bounds test was applied. The findings showed that the Environmental Kuznets hypothesis was not valid in Turkey in the relevant period. Ozaydin and Apaydin (2019) investigated whether the Environmental Kuznets Curve hypothesis is valid in Turkey with carbon monoxide, per capita income data for the 1961-2015 period. In the study, in which the ARDL bounds test approach and the quadratic model were used, the findings demonstrated the validity of the aforementioned hypothesis. Oztürk and Gülen (2019) also tested the validity of the Environmental Kuznets Curve hypothesis in Turkey for the period 1960-2014. As a result of the quadratic model established by the ARDL limit test approach and the Carbon Monoxide, Per Capita Income, Energy Consumption data, it was seen that the hypothesis in question was valid. In the study of Rice (2019), the relationship between carbon emissions, per capita income, and energy consumption for the period 1960-2017 was tested in the context of the Environmental Kuznets Curve hypothesis. As a result of the regression analysis, it was concluded that the Environmental Kuznets Curve is valid in the Turkish economy. On the other hand, as a result of the estimation made with the Threshold Regression model, it was found that the Environmental Kuznets curve hypothesis was invalid. In his study, Güzel (2020) investigated the validity of the Environmental Kuznets Curve hypothesis with the CO2 emission, income, and energy consumption data of the Turkish economy for the period 1960-2015. As a result of the analysis made with the help of the ARDL limit test, the findings revealed that the hypothesis in question is not valid. Ozcan (2020) tested the validity of the Environmental Kuznets Curve hypothesis for the 1983-2018 period using carbon dioxide emissions, per capita income, renewable energy use, oil prices, and coal use. The findings showed the validity of the hypothesis in question.

Yurtkuran (2021) analyzed the relationship between logistics, economic growth, and CO2 emissions in the Turkish economy from the period of 1995-2016. Fourier autoregressive distributed lag (ADL) cointegration test, fully modified least squares (FMOLS), canonical cointegration regression (CCR) long-term estimators, and Toda-Yamamoto (TY) and Fourier TY causality methods were used as empirical methods. Empirical findings revealed that the EKC hypothesis was valid in the relevant period in Turkey.

Khan and Ozturk (2021) investigated the validity of the EKC hypothesis in the economies of 88 developing countries. In the study examining the relationship between various financial development data and environmental pollution for the 2000-2014 period, the validity of the EKC hypothesis was reached.

Okumus and Bozkurt (2020) investigated the validity of the EKC hypothesis through the 1980-2013 period data belonging to the economies of countries with different levels of development. In the empirical model, energy consumption, real gross domestic product per capita, square of real GDP per capita, trade liberalization, CO2 emissions, and urbanization variables are included. In the study using Westerlund's (2007) panel cointegration test, the findings show the validity of the hypothesis in high-middle-income and low-middle-income country groups; It has been revealed that the EKC hypothesis is not valid in developed and underdeveloped country groups.

Ornek and Turkmen (2019) investigated the validity of the environmental Kuznets curve hypothesis in emerging and developed economies. The dynamic panel data analysis findings made in the 1975-2016 sampling period showed that the EKC is valid in developed market economies; showed that the relevant hypothesis is invalid in emerging market economies.

In their study, Destek and Sarkodie (2019) investigated the validity of the EKC in the economies of 11 newly industrialized countries in the 1977-2013 sample period. Both the increased mean group (AMG) estimator and the heterogeneous panel causality method were used as empirical methods. The findings revealed that there is an inverted-U-shaped relationship between economic growth and ecological footprint. The causality results showed the existence of bidirectional causality between economic growth and ecological footprint.

Ozturk and Acaravci (2013) investigated the validity of the EKC hypothesis in Turkey from the period 1960-2007. In the study, in which CO2 emission was used as the dependent variable, income per capita, the square of per capita income, energy consumption, trade liberalization, and financial development were included in the model as independent variables. In the study, in which ARDL and VECM Granger causality analysis were used as the empirical model, the findings demonstrated the validity of the EKC hypothesis.

Acaravci and Oztürk (2010) investigated the validity of EKC in Denmark, Germany, Greece, Iceland, Italy, Portugal, and Switzerland using the Autoregressive Distributed Lag (ARDL) approach in the 1960-2005 sampling period. Empirical findings have demonstrated the existence of EKC in Denmark and Italy in the long term.When empirical studies on EKC are examined, there are various variables used and different models created. While the results of the study show that the EKC is valid to a large extent, there are also studies reporting that the EKC is not valid. As a result, it is seen that there is no consensus in the literature on EKC.

Therefore, when the literature is examined for the EKC hypothesis, it is seen that different results are obtained from the different method(s) used for different country(s).

3. DATA and METHODOLOGY

In this section, the relationship between CO2 emission, which is known as an environmental quality indicator for Turkey, and per capita income, renewable energy consumption, and losses in energy are empirically discussed.

In this study, in which the Environmental Kuznets Curve hypothesis for Turkey was tested for the period 1990-2019, the logarithms of the variables were used. The explanation, source, and periods of the variables used in the study are shown in Table 1.

Table 1. Definition and Sources of Variables

Variable	Definition	Source	Period
CO_2	Log(CO_2 emissions (metric tons per capita))	IEA	1990-2019
GDP	Log(GDP per capita (constant 2010 US$))	WDI	1990-2019
GDP^2	Log((GDP per capita (constant 2010 US$))2)	WDI	1990-2019
REN	Log(Renewable Energy use (kg of oil equivalent per capita))	WDI, IEA	1990-2019
LOS	Log(losses during the generation, transport and distribution of energy (kg of oil equivalent per capita))	WDI, IEA	1990-2019

The closed function representation of the model used in the study is

$CO_2 = f(GDP\ , GDP^2$, REN, LOS)   (1)

Its representation as an econometric model is

$(CO_2)_t=\beta_0+ \beta_1 GDP_t+ \beta_2 GDP_t^2+ \beta_3 REN_t+ \beta_4 LOS_t$ (2)

In the context of the EKC hypothesis, since the increase in per capita income (GDP) is expected to increase CO_2 emissions (CO_2), the coefficient of the GDP variable is expected to be positive ($\beta_1>0$). In addition, it is expected that the GDP^2 variable, which expresses the square of real income per capita, will reduce carbon emissions (CO_2) after a certain income level. Therefore, the coefficient of the GDP^2 variable is expected to be negative ($\beta_2<0$). In line with the general literature, since renewable energy consumption (REN) will reduce carbon dioxide emissions (CO_2), the coefficient of the REN variable is negative ($\beta_3<0$). At the same time, the coefficient of the LOS variable is expected to be positive ($\beta_4>0$), since the increases in energy losses (LOS) do not turn into any output and will increase the carbon emission (CO_2) as it leads to inefficient/ineffective use of energy.

4. AMPIRICAL RESULTS

In this part of the study, stationarity will be tested with the traditional Extended Dickey-Fuller (ADF) unit root test, which allows for structural break, and Perron (1989) and Zivot and Andrews (1992) unit roots tests.

4.1. ADF Unit Roots Test

A shock or crisis in an economy is not taken into account in the ADF unit root test. Therefore, a stationary series with structural change may not be stationary, the stationarity degree of the series may be miscalculated, or the results may not be reliable. Therefore, stationarity has been investigated with unit roots tests that take into account the structural change or not, and it has also been tried to reveal whether the stationarity is affected by the structural changes.

The results of the ADF unit roots test, in which the structural break is not taken into account, are shown in Table 2.

Tablo 2. ADF unit roots test results

Variable	Statistic	Porbability
CO_2	-0.325	0.907
GDP	-1.114	0.697
GDP^2	-1.095	0.704
REN	3.089	0.999
LOS	-4.255	0.002

When Table 2 is examined, it is seen that all variables except energy losses (LOS) contain unit roots in their level values. However, these results came out this way because they did not take into account the structural break. Considering the current economic structure in the said period, it is expected to give more accurate results by taking into account the structural break tests. Perron (1989) and Zivot and Andrews (1992) argued that this break could be included in the model by taking into account the structural change and obtaining the date of the structural break, and they developed their own unit roots tests.

4.2. Perron (1989) Unit Roots Test

In the unit root test developed by Perron, she stated that the shocks caused by the Great Depression and Oil Crises in 1929 and 1973 would cause structural change, and she discussed three models under the Ho hypothesis (Perron, 1989:1364)

$$y_t = \mu + \alpha y_{t-1} + \delta_1 D(TB)_t + e_t \quad \text{(Model A)}$$

$$y_t = \mu + \alpha y_{t-1} + \delta_2 DU_t + e_t \quad \text{(Model B)}$$

$$y_t = \mu + \alpha y_{t-1} + \delta_1 D(TB)_t + \delta_2 DU_t + e_t \quad \text{(Model C)}$$

While Model A expresses the unit root process in which the alternating structural break occurs at the level, Model B at the slope, Model C expresses the process in which the structural break occurs at both the level and the slope. In addition, the basic hypothesis for Model A is that it has a unit root with a change in the level, while for Model B it has a unit root in the slope, and for Model C due to a shock that occurs in both the slope and the level. Where $D(TB)_t$ and DU_t are dummy variables that take into account structural breaks in level and slope, respectively.

Perron unit roots test results with the structural break of the units are shown in Table 3.

Tablo 3. Perron unit roots test statistic results

	Model A			**Model C**		
Variable	**Statistic**	**Lag Lenght**	**Break Date**	**Statistic**	**Lag Lenght**	**Break Date**
CO_2	-4.224	1	2000	-4.152	1	2000
GDP	-2.897	0	2003	-3.128	0	2004
GDP^2	-2.811	0	2003	-2.970	0	2004
REN	0.013	0	1998	-1.522	0	2013
LOS	-2.791	0	2014	-3.482	0	1995
Critic Values	%1=-5.82, %5=-5.23, %10=-4.92			%1=-6.32, %5=-5.59, %10=-5.29		

Note: Critical Values were obtained from Perron (1989).

When Table 3 is examined, besides Model A, which includes the change in level, the unit root test results calculated for Model C, which includes the change in both level and slope, are included. Since the statistical values of all variables for both Model A and Model C are less than the absolute critical values, all series have unit roots at the level.

4.3. Zivot and Andrews (1992) Unit Roots Test

In structural break unit roots tests, determining the break date externally, in other words assuming independent, may not be consistent for the tests to be followed. For this reason, Perron (1989) was criticized for determining the break date externally in his model and therefore led to the development of internally determined unit roots tests.

Zivot and Andrews (1992) determined the structural break date internally in the unit root test they developed and investigated

$$y_t = \mu + \beta t + \alpha y_{t-1} + \theta_1 DT(\varphi) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \qquad \text{(Model A)}$$

$$y_t = \mu + \beta t + \alpha y_{t-1} + \theta_2 DU(\varphi) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \qquad \text{(Model B)}$$

$$y_t = \mu + \beta t + \alpha y_{t-1} + \theta_1 DU(\varphi) + \theta_2 DU(\varphi) + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \qquad \text{(Model C)}$$

Model A is the constant, Model B is the trend, and Model C is the process in which there is a structural break in both the constant and the trend.In addition, the basic hypothesis for Model A is that it has a unit roots with a change in the constant, while in Model B it has a unit roots in the trend, and in Model C, it has a unit root due to a shock that occurs in both the constant and the trend. Where, DT and DU are constant term and trend are dummy variables in which structural break is taken into account, respectively. Δy_{t-i} was created and added to the model in order to eliminate the autocorrelation that may occur in the error terms.

Zivot and Andrews (1992) unit roots test results of units with structural break are shown in Table 4.

Tablo 4. Zivot and Andrews Unit Roots Test Results

	Model A			Model C		
Variable	**Statistic**	**Lag Lenght**	**Break Date**	**Statistic**	**Lag Lenght**	**Break Date**
CO_2	-4.204	0	2006	-4.132	0	2001
GDP	-2.997	0	2004	-2.994**	0	2004
GDP^2	-2.942	0	2004	-2.855	0	2013
REN	0.021	0	1999	-1.442	0	2014
LOS	-3.600	0	2013	-3.817	0	1998
Kritik Değerler	%1=-5.34, %5=-4.93, %10=-4.58			%1=-5.57, %5=-5.08, %10=-4.82		

Note: Critical Values were obtained from Zivot ve Andrews (1992).

When Table 4 is examined, besides Model A, which includes the change in the constant, the unit root test results calculated for Model C, which includes both the constant and the change in the trend, are given. Since the statistical values of all variables for both Model A and Model C are less than the absolute critical values, all series have unit roots at the level.

4.4. Gregory-Hansen (1996) Cointegration Test

In the cointegration test developed by Gregory and Hansen (1996), structural break is allowed and the break is determined internally. As in structural break unit roots tests, three different models in the form of

$$y_{1t} = \mu_1 + \mu_2\varphi_{tr} + a^T y_{2t} + \varepsilon_t \qquad \text{(Model A)}$$

$$y_{1t} = \mu_1 + \mu_2\varphi_{tr} + \beta t + a^T y_{2t} + \varepsilon_t \qquad \text{(Model B)}$$

$$y_{1t} = \mu_1 + \mu_2\varphi_{tr} + a_1^T y_{2t} + a_2^T y_{2t}\varphi_{tr} + \varepsilon_t \qquad \text{(Model C)}$$

were used in the Gregory-Hansen (1996) cointegration test to investigate the long-term relationship between the series. Here, μ_1 and $\mu_2$are the constant breakage, a_1 is the slope coefficient before the breakage occurs, and a_2 is the change in the slope parameter after the breakage occurs. The Philips test statistical equations used for Gregory-Hansen (1996) cointegration test are

$$Z_a^* = inf_{\tau eT} Z_a(\tau)$$

$$Z_t^* = inf_{\tau eT} Z_t(\tau)$$

$$ADF^* = inf_{\tau eT} ADF(\tau)$$

The Z_a^*, Z_t^* and ADF^*test statistics obtained in these tests are compared with the critical values found in the study of Gregory-Hansen (1996), and the basic hypothesis that there is no cointegration relationship is tested (Tirasoğlu and Yildirim, 2012:115).

The cointegration relationship in the model was tested with the Gregory-Hansen (1996) cointegration test and is shown in Table 5.

Table 5. Gregory-Hansen (1996) Cointegration Test Results

Tests	Test Statistic	Lag	Break Date	Critic Values
ADF	-6.363*	0	2003	1%=-6.92, %5=-6.41, %10=-6.17
Zt	-6.485**	-	2003	
Za	-35.725	-	2003	1%=-90.35, %5=-78.52, %10=-72.56

Note: ** and * indicate the statistical significance at 5%, and 10% levels, respectively.

When Table 5 is examined, the ADF and Zt test statistics are greater than the critical values at the 10% significance level. therefore, there is a long-term relationship between CO_2 emissions and GDP, GDP^2, renewable energy and energy losses in the relevant period in Turkey.

4.5. Estimation of Cointegration Coefficients

Gregory-Hansen (1996) shows that there is a long-term relationship between the variables as a result of the cointegration test, and long-term coefficient estimation can be made. For this, Fully Modified Ordinary Least Squares (FMOLS) developed by Philips and Hansen (1990), which allows structural changes to be included in the model as dummy variables, and Canonical Cointegrating Regressions (CCR) developed by Park (1992) estimators will be used to estimate the long-short term coefficients. The FMOLS estimator is an important estimator for the relationship between the explanatory variables and the residuals and for eliminating the deviations that may occur due to the internality problem (Nazlioğlu, 2010:99). In the CCR estimator, on the other hand, it asymptotically eliminates the internality problem arising from the correlation that may occur in the long run (Mehmood et al. 2014:9).

A cointegration relationship was found in the model and FMOLS and CCR estimation results for long-short term coefficient estimation are shown in Table 6.

Table 6. FMOLS and CCR Long-Term Coefficient Estimation Results

	FMOLS				**CCR**			
Dependent Variable	GDP	GDP^2	REN	LOS	GDP	GDP^2	REN	LOS
CO_2	3.177**	-0.432**	0.037	0.177***	3.938	-0.539	0.042	0.169***
	1.143	0.162	0.026	0.015	2.670	0.381	0.029	0.018

Note: ** and *** indicate the statistical significance at 5% and 1% levels, respectively.

According to FMOLS results in Table 6, the coefficient of the GDP variable was found to be positive and significant in the long run, and the coefficient of the GDP^2 variable was negative and significant. Therefore, it is seen that the Environmental Kuznets Curve, which expresses the inverted-U (Concave/concave) relationship between economic development and environmental degradation due to the sign of GDP^2, is valid for Turkey in the relevant period. In addition, a 1% increase in energy losses according to the long-term coefficients increases CO_2 emissions by approximately 0.18%.

Turkey is a country that realizes its growth with the energy it imports from time to time and still has a high dependence on fossil fuels among its energy resources. In addition, it could not provide sufficient energy efficiency / effectiveness in the energy losses caused by energy use. Therefore, the increase in GDP increases energy consumption, and similarly, energy losses increase energy consumption since they do not turn into any output. These situations lead to a negative impact on environmental quality with more CO_2 emission increases as a result of more energy consumption for developing countries such as Turkey, which has a high share of fossil fuels among energy sources.In addition, the increase in renewable energy increases reduced CO_2 emissions, but the model was also found to be meaningless.

According to the CCR model results, the size and signs of the coefficients gave similar results as in the FMOLS model, but other variables were insignificant except for the energy losses.

Short-term coefficient estimation was made in the model, followed by FMOLS and CCR error correction model, and the results are shown in Table 7.

Table 7. FMOLS and CCR Short-Term Coefficient Estimation Results

	FMOLS					**CCR**				
Dependent Variable	ECT_{t-1}	ΔGDP	ΔGDP^2	ΔREN	ΔLOS	ECT_{t-1}	ΔGDP	ΔGDP^2	ΔREN	ΔLOS

ΔCO_2	-0.277***	0.500	-0.050	-0.007	0.036	-0.299***	0.840	-0.093	-0.044	0.008
	0.078	0.513	0.070	0.018	0.063	0.092	0.865	0.118	0.048	0.72

Note: *** indicate the statistical significance at 1% levels.

Error correction coefficient (ECT), which expresses the long-term relationship between errors, is negative and statistically significant in accordance with the theoretical expectation. Therefore, this confirms that there is a long-run relationship between CO_2 emissions and explanatory variables. The error correction term (ECT) indicates the correction rate and shows how quickly the variables return to equilibrium in the long run. Thus, the coefficient of the ECT term indicates that according to the FMOLS (-0.277) and CCR (-0.299) models, approximately 0.28% and 0.30% of a variance in the t-1 period will be corrected in the t period (within a period or year), respectively.

5. CONCLUSION AND POLICY IMPLICATIONS

The Kuznets Curve approach put forward by Kuznets (1955) states that unequal income distribution will increase in the early stages of growth in national economies, but this situation will move in the opposite direction as income growth continues. The adaptation of the said approach to the environment is expressed by the Environmental Kuznets Curve approach.

In this study, the validity of Environmental Kuznets Curve hypothesis was tested with annual data for period 1990-2019.In the study, unit roots tests, which take into account both traditional and structural breaks, were applied and it was determined whether the variables included in the analysis were stationary. Afterwards, the quadratic model and Gregory-Hansen cointegration test were used to test validity of the EKC hypothesis. The long-short term relationship between the variables was tested with the Fully Modified Ordinary Least Squares (FMOLS) and the Canonical Cointegrating Regressions (CCR) estimators developed by Park (1992). The findings show that the EKC hypothesis is valid, that is, environmental deteriorations occur in the first stage of economic growth in Turkey, and then these deteriorations disappear.

This result is consistent with the studies of Acavraci and Ozturk (2010), Acavraci ve Ozturk (2013), Sendoğan (2019), Ozaydin and Apaydin (2019), Oztürk and Gülen (2019), Ozcan (2020), Khan and Ozturk (2021), and Yurtkuran (2021). The relationship between the renewable energy and energy loss variables used in the study and the carbon dioxide emission variable also reveals important results. The findings show that increased use of renewable energy and reduced energy loss reduce environmental pollution. Therefore, Turkey, which is among the emerging market economies with the current potential for the developing country group, needs to increase its economic growth and development process. In addition, it is considered important to turn to policies that increase-encourage renewable energy production and to increase energy efficiency/effectiveness. Thus, it will be possible to transfer a sustainable clean environment to new generations by both reducing energy dependence, which is the main cause of the high current account deficit, and reducing environmental pollution.

In studies following this study, this hypothesis can be tested for country groups using panel data methods. Policy recommendations can be made by making comparative analyzes in terms of developed and developing country groups. According to the results to be obtained, environmental degradation can be prevented and the chance to leave a cleaner future for future generations can increase by presenting more inclusive policy recommendations across the world.

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