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Approaching the Environmental Kuznets Curve: Empirical Evidence from Turkey

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This study investigated the important relationship between environmental factors and economic growth within the context of adaptation to the environment. We generated a Kuznets curve based on the original Kuznets (1995) curve for Turkey's economy for the period 1960–2011, using the carbon dioxide emissions, energy consumption and per capita GDP variables. A time series analysis was applied to test the existence of a long-run relationship between the series and the coefficient definitions of the variables were made. The results obtained were parallel to the Kuznets curve for Turkey's economy and the reverse approach was accepted and the structural break analyzes applied in the study are important in terms of Turkey's economy.

Keywords: environmental Kuznets curve, CO_2 emissions, pollution, energy consumption, cointegration

JEL Classifications: Q43, Q50

1. Introduction

The world has used systems based on fossil fuel since the Industrial Revolution. Carbon fuels such as petroleum, natural gas, and coal still occupy an important place alongside nuclear power. Under these circumstances, the global economy creates substantial greenhouse gas and carbon dioxide emissions (Tutulmaz, 2015: 73). Greenhouse gases gradually affect the global climate, ecosystems, and socioeconomic

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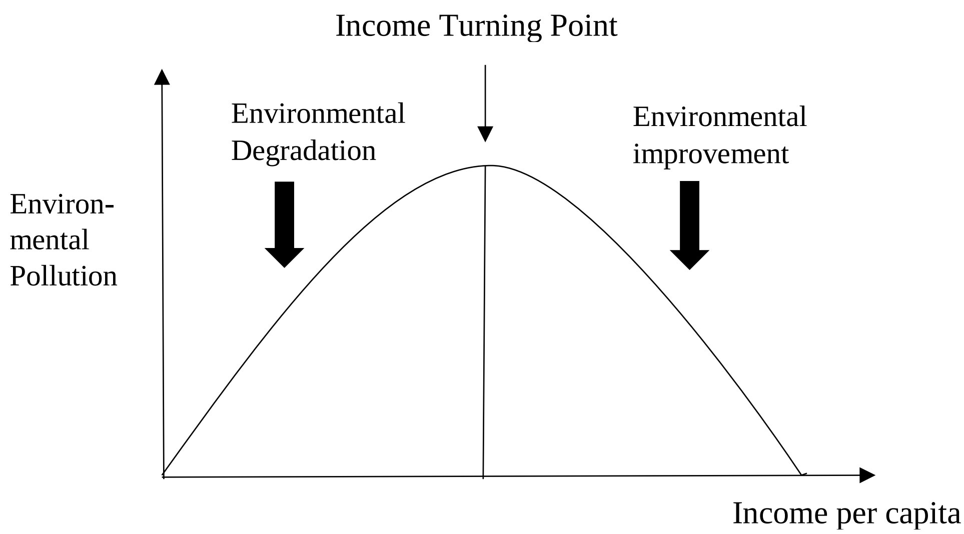
systems. Unless environmental degradation stops, it is estimated that global warming will increase and the rise in sea level will be dramatic (Yin, Zheng, & Chen, 2015: 97). Environmental degradation is currently such a factor that the relationship between economic growth and environmental degradation is significantly associated with increased environmental awareness (Özcan, 2013: 1139). The Environmental Kuznets Curve (EKC) examines the relationship between economic growth and environmental degradation based on the Kuznets curve, which is inverted-U shaped for the relationship between environmental pollution and economic growth.

Figure 1: Environmental Kuznets Curve.



Source: Yandle, Vijayaraghavan, & Bhattarai (2002: 3).

As shown in Figure 1, the EKC hypothesis shows an increase in the first stage of economic growth with income per capita and a decrease of environmental degradation in an inverted-U-shaped relationship with a threshold of income per capita (Apergis & Öztürk, 2015: 16). Typically, the logarithm of the figure is modeled as a quadratic function of the income logarithm (Stern, 2004: 1419). For the inverted-U approximation, reaching the threshold of income per capita is important. After reaching this point, the economy transitions from the beginning regime to a different regime. At the beginning, environmental degradation depends on the economy's growth in developing countries because industrialization is not rudimentary, and it induces poverty and pollution. This corresponds to the first area of increased environmental degradation. At the second stage, industrialization undergoes structural changes, and the effect of economy degradation decreases. The economy shifts from an agricultural structure to a manufacturing one. The final stage is when the chaotic and unproductive industrialization of countries occurs with development and technology. In this stage, the downward tendency appears after environmental degradation reaches a threshold (Robalino-Lopez, 2014: 923). It has been stated that the EKC hypothesis considers environmental pollution; therefore, under it, carbon dioxide (CO_2) is significant, along with sulfur dioxide (SO_2), suspended particulate matter (SPM), and nitrogen dioxide (NO_2) (Onafowora & Owoye, 2014: 47). Therefore, basically the CO_2 emissions of environmental degradation will be used in this study. So it is important in terms of examining the relationship between the economic actors and the environmental factors in peculiar today. The empirical research to be carried out in the study will enable the testing of the EKC hypothesis in terms of the Turkish economy in the resulting breaking structures. A new approach is being followed.

2. Literature Review

Studies related to the EKC have commonly excited academic attention. The EKC appeared in the 1990s with a significant increase in the number of studies related to environmental pollution. First, the entire original curve was reformed by Grossman and Krueger (1991), and Kuznets (1955) changed it to examine the relationship between environmental pollution and economic growth. In these studies, the relationship between the two variables was stated to be inverted-U–shaped.

As a result of the time series being applied to Turkey, Altınay and Karagöl (2004), who examined the relationship between energy consumption and GDP variables, although they did not approach it in the context of the EKC, determined that there is no relationship between energy consumption and GDP variables by applying Granger causality analysis. Kaplan, Öztürk, and Kalyoncu (2011) specified that the two variables are cointegrated, and there is dual causality between them. Soytaş and Sarı (2007) added the manufacturing industry and electrical consumption to the relationship between energy and growth in their study. According to the applied Johansen cointegration test, the authors specified a long-term relationship between variables. Halıcıoğlu (2009) found that a long-term relationship existed between variables by testing the relationship among energy consumption, economic growth, carbon dioxide emission, and foreign trade with ARDL bound testing. According to causality, test income is the most important variable in examining emissions.

Time series tests of the EKC hypothesis have caused division. Başar and Temurlenk (2007); Öztürk and Acaravcı (2010); Dam, Karakaya, and Bulut (2013); and Koçak (2014) specified that the inverted-U–shaped EKC hypothesis did not apply for Turkey's economy. In addition, Başar and Temurlenk (2007) and Dam et al. (2013) specified that the relationship between income per capita and emission was reverse-N–shaped. Saatçi and Dumrul (2011), Shahbaz et al., Ali (2013), Öztürk and Acaravcı (2013), and Çil Yavuz (2014) examined the inverted-U–shaped EKC hypothesis and found long-term relationships between variables in their studies. Bölük and Mert (2015), who added renewable energy usage to the variables, found a U-shaped EKC in their study.

As we examine time series tests applied to different national economies, it can be seen that the ARDL bound test and Granger causality have mainly been applied. As a result, Saboori and Sulaiman (2013) analyzed the relationships among carbon dioxide emission, economic growth, and energy consumption within the context of an EKC for Malaysia between the years of 1980 and 2009 in their study. Considering the total energy consumption, the inverted-U approach was not supported, and a dual relationship between economic growth and energy consumption was determined. Onafowora and Owoye (2014) researched the effects of economic growth, energy consumption, population distribution, and trade gap variables on carbon dioxide emission for Brazil, China, Egypt, Japan, Mexico, Nigeria, South Korea, and South Africa for the period 1970–2010. While the inverted-U approach was confirmed for Japan and South Korea, according to long-term relationships, an N-shaped curve approach was found for the other six countries. In another study, Jebli and Youssef (2015) examined carbon dioxide emission, renewable energy consumption, and international business for Tunisia between the years of 1980 and 2009. According to the results of the long-term estimation, although non-renewable energy sources have a positive effect on carbon dioxide consumption, renewable energy sources had a strong negative effect and, in the long term, the inverted-U approach was not supported.

Al-Mulali, Saboori, and Öztürk (2015) examined the EKC hypothesis for Vietnam for the period 1981–2011 in their studies. Because of short- and long-term relationships between the gross domestic product (GDP) and the pollution rate, they found that the EKC was not effective. Balaguer and Cantavella (2016) tested the EKC hypothesis for Spain for the period 1874–2011 in their study. According to the evidence, the EKC was not supported in this case. Lastly, Javid and Sharif (2016) compared financial development, openness, energy consumption per capita, and income per capita to carbon dioxide emissions for Pakistan for the period 1972–2013 in their study. They found that the EKC approach was valid for Pakistan.

3. Data Set and Model Description

In this study, metric tons per capita, carbon dioxide emission, equivalent kiloton petroleum energy consumption per capita, and per capita GDP variables from the dollar-denominated 2005 base year were used, including the years 1960–2011, for Turkey's economy. The data were obtained from the World Bank database. The models stated in the study were identified as the result of the scanning carried on the academic field. In considering the relationship between variables, we followed the models obtained by Ang (2008), Apergis and Payne (2009, 2010), Lean and Smyth (2010), and Acaravci and Öztürk (2010). The reason for selecting these models is that the variables followed in the studies that are performed are compatible with our hypothesis.

$$C_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 Y_t^2 + \alpha_3 E_t + \varepsilon_t$$

The t = 1960, . . . , 2011 time period is shown here.C_t is represent Carbon dioxide emission and it is a constant parameter, Y_t is represent GDP per capita, Y_t^2 is represent squared GDP per capita, E_t is represent energy consumption and error term. These are added to the model by taking the variables' logarithms. The EKC hypothesis suggests that a_1>0 as an increase in emissions coupled with an increase in income level so it states that a_2<0 as hypothesis requirement and a_3>0 as an energy consumption results in increase in carbon dioxide emissions The model has an inverted-U shape and increases to a certain threshold level based on income growth. After reaching this threshold, it is expected that the parameter sign will be negative or positive to support the EKC hypothesis, which is assumed to be decreasing. As it is thought that energy consumption increases emissions, the parameter's coefficient is expected to be positive.

4. Methodology and Empirical Results

In this study, a time series analysis is performed. First, we determined the intercept level by doing a unit root test with the variable. In the case of [I(I)], we looked at the relationship between variables by applying the Gregory-Hansen cointegration test. When there was cointegration, we created the EKC figure by estimating the FMOLS, DOLS, and CCR parameters.

4.1. Traditional Unit Root Test

Because of the importance of series stability, the unit root test is needed. The variables are analyzed by the extended non-structural break unit root test, which was developed by Dickey-Fuller (ADF; 1981) and Phillip-Perron (PP; 1988). Results are shown in Table 1.

Table 1: ADF and PP Test Results

	Variables	ADF	PP
Level			
	CO_2	–2.6813(0)	–3.3763(7)
	ENC	–1.0006(0)	–1.0223(3)
	GDP	–0.3333(0)	–0.3007(3)
Intercept	GDP^2	–0.1192(0)	–0.0041(4)
	CO_2	–2.6190(0)	–2.6677(6)
	ENC	–2.3922(0)	–2.3922(0)
	GDP	–2.9317(0)	–2.9317(0)
Intercept + Trend	GDP^2	–2.8804(0)	–2.8804(0)
First Differences			
	CO_2	–7.0409(0)*	–7.0422(1)*
	ENC	–6.8915(0)*	–6.8900(2)*
	GDP	–7.1164(0)*	–7.1214(3)*
Intercept	GDP^2	–7.0981(0)*	–7.1037(3)*
	CO_2	–7.7662(0)*	–7.7339(2)*
	ENC	–6.9225(0)*	–6.9276(3)*
	GDP	–7.0466(0)*	–7.0494(3)*
Intercept + Trend	GDP^2	–7.0234(0)*	–7.0256(3)*

Notes: * values show the intercept level of the variables. For the ADF test, parenthetical values show delay lengths selected by SIC criteria and DF tests when delay lengths are 0. MacKinnon (1996) critical values are –2.855 at 5% confidence interval for the intercept model and –3.447 for the intercept and trend model. Parenthetical values for the PP test show bandwidths selected by Newey-West using Bartlett kernel criteria. The critical values are equal to the ADF test.

In this study, the unit root test used augmented ADF and PP tests non-structural breaks. The predicted statistical value's absolute value must be greater than the MacKinnon (1996) critical value. According to the unit root test applied to variables when the levels include the unit root, they are intercept on first differences [I (1)].

4.2. Unit Root Test with Structural Break

Unlike non-structural break unit root tests, the unit root test with a structural break has become a subject of central importance because of structural changes and major interventions in economic systems (Lanne, Lütkepohl, & Saikkonen, 2002: 668). In this study, a unit root test that considers one endogenously structural fracture, which was developed by Zivot and Andrews (1992), is applied.

4.2.1. Zivot–Andrews Unit Root Test Considering One Endogenously Structural Break

Research has found that the break date actualizes on the determined date by using Perron's (1989) ADF test strategy, developing the presence of the external break, and differentiating to the test (Zivot & Andrews, 1992: 251). According to the developed model, Model A, which allows for one-time change in the level of the series, Model B, which permits a one-time changes in the slope and trend, Model C, which combines one-time changes in the intercept and trend.

Model A;

$$x_t = \alpha_0 + \alpha_1 DU_t + \beta_t + \rho x_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta x_{t-i} + e_t$$

Model B;

$$x_t = \alpha_0 + \gamma DT_t + \beta_t + \rho x_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta x_{t-i} + e_t$$

Model C;

$$x_t = \alpha_0 + \alpha_1 DU_t + \gamma DT_t + \beta_t + \rho x_{t-1} + \sum_{i=1}^{p} \varphi_i \Delta x_{t-i} + e_t$$

In this model, where the intercept dummy DU_t represents a change in the level; $DU_t = 1$ if $t > TB$ and "0" otherwise the slope dummy DT_t represents a change in slope of the trend function; $DT = t - T_B$ if $t > TB$ and "0" otherwise. TB shows the break date.

Table 2: The Results of the Unit Root Test with One Endogenously Structural Break

	Variables	t Statistic	Break Date
Level			
Intercept (Model A)	CO_2	–4.037	1968
	ENC	–3.846	1970
	GDP	–4.095	1977
	GDP^2	–4.365	1980
Intercept + Trend (Model C)	CO_2	–4.081	1976
	ENC	–4.094	1977
	GDP	–5.353**	1977
	GDP^2	–5.292**	1976
First Differences			
Intercept (Model A)	CO_2	–8.488*	1975
	ENC	–7.317*	1975
	GDP	–7.236*	1974
	GDP^2	–7.218*	2000
Intercept + Trend (Model C)	CO_2	–8.337*	1975
	ENC	–7.286*	1975
	GDP	–7.190*	1979
	GDP^2	–7.204*	2005

Notes: * values show the intercept level of variables. *, **, *** values indicate significance levels of 1%, 5%, and 10%, respectively.

According to Zivot-Andrews, the results of the unit root test considering structural break show that variables are parallel with the results of the traditional unit root tests. When the level values contain the unit root, it can be seen that they are constant on first differences [I(1)]. The constant value at the level value in Model C is ignored due to the long memory of GDP and other variables. It can be seen that the break dates generally happened between 1974 and 1979. It can also be seen that the oil shock that occurred in these years triggered the break dates. The break dates that occurred at emission, energy consumption, and real GDP reflect the crisis period in the Turkish economy. According to the result of the unit root test considering structural breaking, cointegration tests considering structural breaks will be applied to the [I(I)] series in further study.

4.3. Gregory-Hansen Cointegration Test with Structural Breaks

A test with the structural break allows changing the Gregory-Hansen (1996) cointegration vector during a representative period at an unknown time and is related to the more general possibility of cointegration (Gregory & Hansen, 1996: 100). The regression model is the only equation developed to allow structural changes at cointegration. Gregory and Hansen (1996) stated that structural changes can be differently developed and proposed three types of tests.
Model C shows a break when it is intercept, Model C/T is a model with the trend and breaking intercept, and Model C/S shows breaking at the regime.

Using dummy variables for modeling structural changes,

$$\varphi_{t\tau} = \begin{cases} 0 & t \leq [n\tau], \\ 1 & t > [n\tau], \end{cases}$$

where n is the observation number, $\tau \in (0,1)$ is the breaking point, and the statement in [] is an integer.

Model C:
$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \alpha^T y_{2t} + e_t \qquad t = 1, \dots, n$$

Model C/T:
$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \beta t + \alpha^T y_{2t} + e_t \qquad t = 1, \dots, n$$

Model C/S:
$$y_{1t} = \mu_1 + \mu_2\varphi_{t\tau} + \alpha_1^T y_{2t} + \alpha_2^T y_{2t}\varphi_{t\tau} + e_t \qquad t = 1, \dots, n$$

μ_1 indicates a intercept parameter before breaking, and μ_2 means changing at intercept during break time. α_1 is the slope coefficient before changing the regime, and α_2 is the change of the slope coefficient. Gregory and Hansen (1996) used ADF^*, Z_t^*, Z_a^* statics to test Model C, Model C/T, and Model C/S.

Table 3: Gregory-Hansen Cointegration Test Considering Structural Break Results

		Breaking at Intercept				
	Test	**Statistic**	**Break Date**	**1%**	**5%**	**10%**
GH-1996	**ADF**	–6.052*	1992	–5.77	–5.28	–5.02
	Zt	–6.109*	1992	–5.77	–5.28	–5.02
	Za	–38.09	1973	–63.64	–53.58	–48.65
		Model with Trend, Breaking at Intercept				
	Test	**Statistic**	**Break Date**	**1%**	**5%**	**10%**
GH-1996	**ADF**	–6.048*	1992	–6.05	–5.57	–5.33
	Zt	–6.104*	1992	–6.05	–5.57	–5.33
	Za	–38.34	1973	–70.27	–59.76	–54.94
		Breaking at Regime				
	Test	**Statistic**	**Break Date**	**1%**	**5%**	**10%**
GH-1996	**ADF**	–7.572*	1983	–6.51	–6.00	–5.75
	Zt	–7.656*	1983	–6.51	–6.00	–5.75
	Za	–52.60	1982	–80.15	–68.94	–63.42

Note: * values show the value of variables' cointegration. The 1%, 5%, and 10% critical values are obtained from Gregory and Hansen (1996).

When the obtained statistical value exceeds the stated value by the Gregory-Hansen absolute value, the empty hypothesis, which tests cointegration relationships, is ignored. In this study, according to data obtained from the ADF and Zt tests, it is determined that the variables have a cointegration relationship through the cointegration test. The study by Gregory and Hansen (1996) stated that the Zt test statistic has the highest power value. According to the results, the Zt test statistic is significant in breaking at intercept, the model with trend that is broken at intercept, and breaking at regime. Cointegration parameters will be used in further studies to test stated values according to model specifications between long-term relationship variables by predicting coefficient values.

4.4. Prediction of Cointegration Parameters with FMOLS, DOLS, CCR

The methods of fully modified ordinary least squares (FMOLS) by Philips and Hansen (1990), dynamic ordinary least squares (DOLS) by Stock and

Watson (1993), and canonical cointegrating regression (CCR) by Park (1992) are used to predict the long-term cointegration coefficient.

Table 4: Predicted Results of Coefficients with FMOLS, DOLS, and CCR

	Breaking at İntercept		
	FMOLS	**DOLS**	**CCR**
ENC	0.7524* (0.000)	0.8389* (0.000)	0.7533* (0.000)
GDP	9.3875* (0.000)	8.7700* (0.000)	9.2170* (0.000)
GDP^2	–0.5181* (0.000)	–0.4870* (0.000)	–0.5077* (0.000)
DUM	–0.0375** (0.014)	–0.0368* (0.001)	–0.0405** (0.013)

Notes: Parenthetical values are prop values. *, **, ***, indicate 1%, 5%, 10% significance level, respectively.

According to the results, the coefficient of the energy consumption variable is positive for each of the three tests, and the energy consumption increases as expected. Although the real GSYH's sign is positive, the square of the GSYH's real sign in the EKC hypothesis is negative. All variables' signs are actualized in the hypothesis, as we supposed. This is the indicator that the inverted-U approach is valid for Turkey's economy.

5. Conclusion

The existence of the relationship between environmental problems and economic growth has begun to be investigated in particular in the last few years. In this study we used the EKC hypothesis to test this problem in practice. The EKC hypothesis, which examines the relationship between environmental degradation and economic growth, was tested with time series analysis for Turkey's economy for the period 1960–2011. Traditional unit root test was applied to evaluate the stability level of variables. Although the level values of series have a unit root, it was determined that they are constant at first differences [I(1)]. In the next phase, the Zivot-Andrews (1992) unit root test, which includes one endogenously structural break, was applied. It was similarly seen that the variables are constant. The long-term cointegration relationship between variables, thanks to the applied Gregory-Hansen (1996) cointegration test, considering a structural break. The coefficient prediction of variables was performed with the FMOLS, DOLS, and CCR predictors. The first structural break year, 1992, was found, added as a dummy variable, and used for coefficient prediction. Each variable obtained significant results. According to the results, the coefficients supported the EKC hypothesis. Results showed that the inverted-U hypothesis of the EKC was valid for Turkey's economy. According to these results per capita income increases in parallel with environmental degradation to some extent, after that point which the per capita income decrease environmental degradation. An active energy policy to be applied in such a case, it can be seen that the environmental degradation from the threshold value for the Turkish Economy can be decrease and that this is a positive situation. Hence, an effective environmental policy should be set for this. For instance, in developing countries such as Turkey, we should reduce dependence on fossil fuels such as oil by using renewable energy sources to reduce high emission rates. In particular, given the strong negative effect between renewable energy consumption and carbon dioxide emission, dismissal of the inverted-U approach used by Jebli and Youssef (2015) and Bölük and Mert (2015) in their studies is significant to give direction to further studies. In addition, after an active energy policy that enables efficient production and use of energy, the situation of the Turkish economy needs to be evaluated.

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