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Araştırma Makalesi / Research Article

Searching for The Existence of EKC Hypothesis in Turkey: An Approach Using Elasticities in The Presence of Multicollinearity

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Abstract

This paper searches for the validity of the Environmental Kuznets Curve (EKC) hypothesis for Turkey in the period of 1990–2015. The multicollinearity problem arising from the inclusion of both the GDP itself and its quadratic form together in the model presented by the Kuznets Curve is taken into account in this research. In order to overcome the multicollinearity problem, the validity of the EKC hypothesis has been decided through the interpretation of the long-and short-term elasticity coefficients of the Autoregressive Distributive Lag (ARDL) model. Economic Complexity Index (ECI) and Environmental Policy Stringency (EPS) index, which are rarely used in the literature, have been added to the EKC model as control variables. The validity of the EKC hypothesis for Turkey is not supported by the results of the empirical analysis since the long–term GDP elasticity is not found negative and also greater than the short–term coefficient. On the other hand, while increasing economic complexity has been found to reduce environmental degradation in the long run, sufficient evidence has not been provided for the importance of the Environmental Policy Stringency (EPS) index in the sample period for Turkey.

Keywords: *EKC Hypothesis, ARDL Model, Economic Growth, Environmental Degradation, Carbon Dioxide Emission, Multicollinearity.*

Türkiye'de EKC Hipotezinin Varlığına Dair Araştırma: Çoklu Doğrusal Bağıntı Durumunda Esneklikleri Kullanan Bir Yaklaşım

Öz

Bu makale, Çevresel Kuznets Eğrisi (EKC) hipotezinin 1990-2015 örneklem dönemi için Türkiye'deki geçerliliğini araştırmaktadır. Bu araştırma yapılırken, Kuznets eğrisinin ortaya koyduğu modelde, GSYİH'nin hem kendisinin hem de ikinci dereceden formunun birlikte yer almasından kaynaklanan çoklu bağlantı sorununu dikkate alınmaktadır. Çoklu bağlantı sorununun üstesinden gelebilmek için Gecikmesi Dağıtılmış Otoregresif (ARDL) model kullanılarak uzun ve kısa dönem elastikiyet katsayılarının yorumlanması ile EKC hipotezinin geçerliliği hakkında karara varılmıştır. Literatürde nadiren kullanılan Ekonomik Kompleksite Endeksi (ECI) ve Çevre Politikası Katılık (EPS) endeksi, EKC modeline kontrol değişkenleri olarak eklenmiştir. EKC hipotezinin Türkiye için geçerliliği, uzun dönem GSYİH esnekliği negatif bulunmadığından ve kısa dönem esneklik katsayısından daha büyük bulunduğundan ampirik analiz sonuçları ile desteklenememiştir. Öte yandan, ekonomik kompleksitenin artmasının uzun vadede çevresel bozulmayı azalttığı bulgulanırken, Türkiye için çevre politikası katılık endeksinin önemine dair incelenen dönem itibariyle yeterli kanıt bulunamamıştır.

Anahtar Kelimeler: *ÇKE Hipotezi, ARDL Modeli, Ekonomik Büyüme, Çevresel Bozulma, Karbondioksit Emisyonu, Çoklu Doğrusal Bağıntı.*

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INTRODUCTION

For developmental economics, it is important to grow or develop by respecting the environment. Hence, questioning the relationship between environmental degradation and economic growth is crucial both for policymakers and researchers alike and it has been analyzed by many scholars since the 1990s. Increasing industrialization has also risen the trade–off between economic growth and environment. This trade–off has sparked the many researchers who study on environmental issues. One of the most popular of them is the in which Environmental Kuznets Curve (EKC).

The EKC hypothesis was derived at the beginning of the 1990s with the leading study of Grossman and Krueger (1993) from the original Kuznets Curve developed by Kuznets in 1955 (Kuznets, 1955). The EKC hypothesis states an inverted U-shaped relationship (see Fig.1.) between environmental degradation and per capita income.

An inverted U–shaped relationship as suggested by the Environmental Kuznets Curve between income and environmental degradation mathematically corresponds to testing a parabolic equation. However, using econometrically both income and square of the income variables together in the model leads to a multicollinearity problem. Many researches contributed to literature around this discussion (Månsson et al., 2018; Taskin and Zaim, 2000; Wagner, 2014). However, the EKC hypothesis has been tested for Turkey many times by ignoring the multicollinearity problem. So, this is as far as we know, the first study taking this problem into consideration for Turkey. Furthermore, we didn’t come across with a study that includes economic complexity and EPS index to investigate the effects of them on environment for Turkey. Thus, with this study, we tried to eliminate the deficiencies we think we had identified in the current literature.

The EKC hypothesis literature has progressed in two main ways. One of them is searching for the validity of this hypothesis for individual countries and the other one is for a cross–section and/or panel of countries. Although the EKC literature includes many empirical studies it is hard to say that the researches are econometrically powerful. Perman and Stern (2003) searched the relationship between environment and income by using the panel methods for 74 countries. They stated that when they consider the econometric conditions seriously and use appropriate statistical or econometrical techniques, their results sign an invalid EKC hypothesis. In this study, we aim to be on the side that gives importance to econometric tests among studies focusing on a single country in the literature.

The EKC models in general, include the per capita income and square of per capita income variables to explain environmental degradation. After including these required variables many diverse control variables are used. Global warming is thought to be caused by increasing greenhouse gases in the atmosphere. Carbon dioxide (CO_2) is the biggest culprit at this point. Although there are many greenhouse gases (e.g. methane, ozone), the carbon dioxide remains in the atmosphere longer than the other gases emitted as a result of human activities. Carbon dioxide emissions comprise over 80 percent of all total greenhouse gas emissions in Turkey (This share for Turkey, with an upward trend, was 69% in 1990 and 80% in 2018.). Based on these facts, carbon dioxide emission is used as an environmental indicator in this study.

While we are testing the validity of an inverted U–shaped relationship between per capita income and per capita carbon dioxide emission, we also investigated whether the economic complexity indicator might be one of the determinants of mentioned emission. Economic

Complexity Index (ECI), which is first introduced by Hidalgo and Hausmann (2009), is an index that gives information about the production structure of a country depending on the capabilities of its production. The production structure of a country is closely related to the development of that country. In this sense, the ECI has been added to the EKC model in this study.

On the other hand, it is questioned in this study how the environmental policies affect the CO_2 emissions. In accordance with this purpose, we added the Environmental Policy Stringency (EPS) index to the model. We investigated whether the tight regulations on environmental issues are effective in repressing the acceleration of the increase in environmental degradation. However, we also know that this interrelationship takes time after regulations are implemented.

Our results do not support an inverted U–shaped relationship between environment and income as the EKC hypothesis suggested for the investigated period. One can easily say that Turkey is at the very beginning of this curve. It can be judged by Figure 1 that Turkey is in the low–income country areas of the curve. The coefficient of ECI is found significant and negative but very close to zero in the short–run and significant and higher negative in the long–run. On the other side, the coefficient of the EPS index is found insignificant both for the short– and long–run.

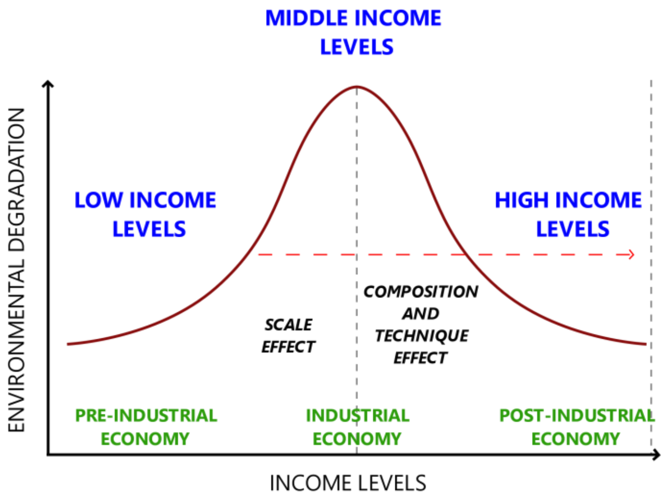
The remainder of this paper is organized as follows: Section one presents the econometric framework of the EKC hypothesis and briefly summarizes the empirical and theoretical literature. Section two outlines our model and introduces the data. Section three presents the empirical results. The last section presents the conclusions and implications of the study.

1. THE FRAMEWORK OF THE EKC HYPOTHESIS AND A SHORT LITERATURE REVIEW

According to the EKC hypothesis visualized in Figure 1, when people start to get more income their consumption behaviors will tend to grow away from carbon–intensive products. Hence, the right–hand side of the curve includes the high–income countries, or so–called developed countries. In other words, it would be appropriate to expect the developing countries to be unable to include this turning point in their past periods, while the developed countries have passed the turning point (Iwata et al., 2010).

As it is seen in the figure 1, the EKC hypothesis suggests a parabolic relationship and the use of GDP and its powers in the same equation as independent variables may cause multicollinearity problems. The presence of multicollinearity may bring about serious statistical problems. In the multicollinearity case, variances of parameters may be overestimated or coefficients on estimators cannot be signed as expected. Generally, this possibility is ignored in a respectable number of researches. As it is expected the Pearson correlations between GDP per capita and square and the third power of GDP per capita are greater than 0.95.

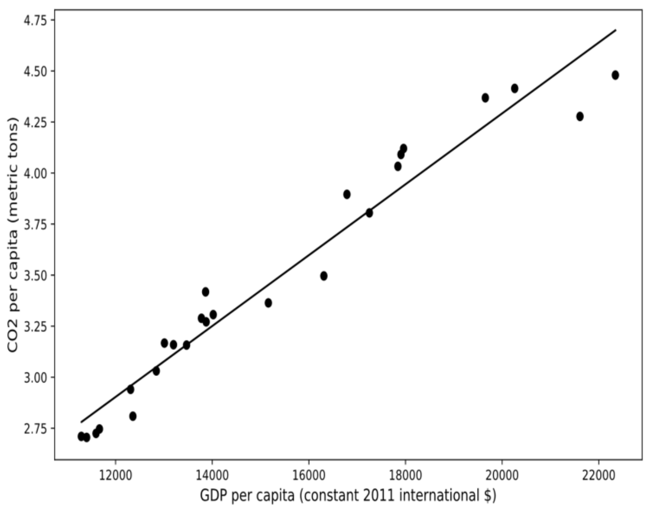
Figure 1. Environmental Kuznets Curve



Source: (Samuel & Strezov, 2019)

Uchiyama (2016) investigated the relationship between national income and environmental degradation for both developed and developing countries by using world data. According to his empirical results, the turning point of this relationship has been found as 30 thousand dollars. After this turning point, the increase in GDP per capita starts to reduce environmental degradation in countries. As can be seen from Figure 2, however, Turkey is quite far from this turning point now as a developing country. In Turkey, both carbon emission and GDP per capita tend to climb simultaneously since the early 1960s. Nevertheless, it is important to take the study one step further and try to find where Turkey is on this path. To do so we interpret the long– and short–term elasticities of this relationship.

Figure 2. The Relationship of Income and Environmental Degradation for Turkey (1990–2015)



The literature of environment–income nexus is well developed and contributions to the field are continuing. To review all the studies in this paper is not our aim. Hence, we prefer to review the researches that are derived from the EKC hypothesis. In this section, we mainly focus on first the studies considering the multicollinearity problem, second the studies that have similar control variables with us and finally the studies which focus on Turkey.

Narayan and Narayan (2010) tested the EKC hypothesis for 43 developing countries over the sample period from 1980 to 2004, considering the multicollinearity problem. They provided evidence to show a negative relationship between economic growth and carbon dioxide emission in Middle Eastern and South Asia. According to the empirical findings of the authors, the short–term elasticities are greater than the long–term elasticities in Latin America, East Asia and Africa. Al-mulali, et al. (2016) tested the EKC hypothesis for Kenya by adopting the approach of Narayan and Narayan (2010) concerning the multicollinearity problem to avoid estimating errors. The short– and long–run results of the ARDL model revealed that the EKC hypothesis is valid for Kenya over the sample period from 1980 to 2012 since the short–term elasticity is greater than the long–term elasticity. They also found that financial development and renewable energy consumption reduce air pollution in Kenya in the long–run. In another study considering the multicollinearity problem, Pablo-Romero and Sanchez-Braza (2017) demonstrated that EKC is valid for 28 EU countries over the sample period from 1990 to 2013. They found the turning point for a per capita income value of around 3.5 in logarithmic terms. As a support for the study of Pablo-Romero and Sanchez-Braza (2017), Baležentis et al. (2019) emphasized that the EKC hypothesis is valid for 27 EU countries over the sample period from 1995 to 2015. However, they presented that the EKC hypothesis is not valid when the renewable energy variable is included in the model.

As a crucial component of economic growth, economic complexity reflecting technological intensity used on the production process and knowledge-based production may play different roles in environmental degradation depending on the economic sizes of countries. In the literature, there are some different findings for different countries and periods about this relationship between environmental degradation and economic complexity. Some of the studies conclude that higher levels of economic complexity are associated with lower carbon dioxide emissions. Lapatinas et al. (2019) investigate mentioned relationship by using 88 developed and developing countries for the period 2002–2012. They showed that increasing product sophistication leads to better environmental degradation. Some other studies, including ours, conclude that a higher economic complexity suppresses environmental degradation in the long–run.

Rahman (2019) is one of the first studies using economic complexity as an indicator for an environmental issue. They investigated the effect of economic complexity on environmental degradation in 55 countries with different income levels. Their main finding revealed that economic complexity has increased the environmental degradation in countries with lower–middle and higher–middle income contrary to high–income ones. Pata (2021) tested the validity of the EKC hypothesis by focusing on economic complexity and globalization for the US. According to his estimation results, the inverted U–shaped EKC hypothesis is valid for the US. Furthermore, non–renewable energy consumption predominantly explains environmental pollution. Doğan et al. (2019) searched for the validity of the EKC hypothesis for 55 countries over the period of 1971–2014 by including the economic complexity with come other control variables such as energy consumption, urbanization, and trade openness. They applied a panel quantile regression found that economic complexity is an important determinant of environmental degradation and economic complexity increase leads to an increase in the environmental degradation in lower– and higher middle–income countries and has controlled carbon dioxide emissions in high–income countries. Yilanci and Pata (2020) investigated the existence of the EKC hypothesis for China and they also tried to understand the role of the economic complexity on the ecological footprint. Their results showed that the complexity index has an increasing impact on ecological footprint and environmental degradation continues to increase in the long run.

The presence of an inverted U–shaped relationship between environmental degradation and national income has been tested for Turkey in the existing empirical literature including Halicioglu (2009), Tutulmaz (2015) and Rahman (2019). As a result of their investigation without considering the multicollinearity problem, the EKC hypothesis is valid for Turkey over the sample periods. The econometrical analysis results of Halicioglu (2009) provide support for the existence EKC hypothesis for Turkey but it is stated in her study that the graphical representation of per capita carbon dioxide emissions and per capita real income does not support the existence of the EKC hypothesis. Rahman (2019) added fiscal development and trade openness degree of countries as explanatory variables of environmental degradation to the EKC model as well as other main explanatory variables. According to the cointegration analysis of Rahman (2019), GDP per capita, electric consumption, fiscal development and trade openness degree have a significant impact on environmental degradation in Turkey. One percent increase in these variables leads an increase in carbon dioxide emission by 0.14%, 0.52%, 0.09% and 0.2%, respectively. Akbostanci et al. (2009) searched for the income–environment nexus. The authors used both time series and panel (including provinces details of Turkey) methods. According to their time series model covers 1968–2003 the EKC hypothesis is not valid in Turkey and the increasing income continues to increase the environmental degradation in the long–run.

2. DATA AND METHODOLOGY

The general model in Equation (1) employed by Grossman and Krueger (1993) (1995), Lucas et al. (1992), Shafik and Bandyopadhyay (1992), Selden and Daqing (1994), Holtz-Eakin and Selden (1995) is used to investigate the possible relationship between environmental degradation and income.

$$E_t = \beta + t_\gamma + \beta_1 y_t + \beta_2 y_t^2 + \beta_4 z_{kt} + \varepsilon_t \tag{1}$$

Here, t is 1,..,T time interval, E is the environmental indicator, y is the income per capita and z_k are the other control variables related to environmental degradation. In some researches, the third power of GDP is used as in Equation (2).

$$E_t = \beta + t_\gamma + \beta_1 y_t + \beta_2 y_t^2 + \beta_3 y_t^3 + \beta_4 z_{kt} + \varepsilon_t \tag{2}$$

Equations (1) and (2) provide an opportunity to test the possible relationship between per capita income and environmental degradation. The possible conclusions are: no relationship ($\beta_1 = \beta_2 = 0$) or the relationship is linear ($\beta_1 > 0,\ \beta_2 = 0$), or the relationship is inverted U–shaped and supports the EKC hypothesis ($\beta_1 > 0,\ \beta_2 < 0$) or the relationship is U–shaped ($\beta_1 > 0, \beta_2 > 0$). Sometimes the Equation (2) is used to test the same relationships and the third power of the y is used in the model and it is tasted that if the relationship is N–shaped ($\beta_1 > 0, \beta_2 < 0, \beta_3 > 0$) or the relationship is inverted N–shaped ($\beta_1 < 0, \beta_2 > 0, \beta_3 < 0$).

In order to overcome the multicollinearity problem, Narayan and Narayan (2010) suggested a linear model for testing the validity of the EKC hypothesis instead of the quadratic model. In their linear model, the validity of the EKC hypothesis depends on the long– and short–term income elasticities. According to their study, the EKC hypothesis is valid provided that long–term coefficient is negatively signed while short–term coefficient is positively signed. In this case, an increase in GDP leads to reduce carbon emission and an inverted U–shaped relationship suggested by the EKC hypothesis exists. While most of the studies which consider multicollinearity support the Narayan and Narayan (2010) approach it is also criticized that if the long–term coefficient is still positive that means the turning point was not covered yet. However, according to us, it may be assumed that a smaller long–term coefficient than short–term coefficient is a point near to peak despite on the left side of the turning point which signals a forthcoming negative coefficient, especially for developing countries.

In this paper, following Narayan and Narayan (2010) we employed linear ARDL methodology and we did not use the powers of GDP. According to the results of the model, if the short–term GDP elasticity of environmental degradation is greater than the long–term GDP elasticity of environmental degradation, it is concluded that when income increases it will help to decrease the carbon emissions in the long–term. We used annual data. The carbon emission as metric tons per–capita for the proxy of environmental degradation and as explanatory variables the gross domestic product (GDP) per capita (y), economic complexity index (ECI) and environmental policy stringency index (EPS). We investigated over the sample period from 1990 to 2015. We should highlight that when we look at the periods investigated in the literature in this field, it is seen there is 4 or 5 years lag in relation to the publication date. In our research, 2015 is the recent year for the ESP index. However, alternatively, we removed the EPS index and reran the model for the period 1990–2018. The results are nearly robust. We evaluate that the effects of EPS on the environment will be more important in the near future. Hence, we prefer to present the results of the model which is including the EPS even if it is significant or not. We also present briefly the results of the alternative model but the details can be provided upon request.

We use the following Equation (3) in our analysis.

$$\ln(CO_2)_t = \beta_0 + \beta_1 \ln(y)_t + \beta_3 \ln(ECI)_t + \beta_4 \ln(EPS)_t + \varepsilon_t \quad (3)$$

In Equation (3), $\ln(CO_2)$ is the natural logarithm of carbon dioxide emissions per capita, $\ln(y)$ is the natural logarithm of real GDP per capita and $\ln(ECI)$ is the natural logarithm of the Economic Complexity Index, and $\ln(EPS)$ is the natural logarithm of the Environmental Policy Stringency Index.

Whereas data of CO2 per capita, GDP per capita and EPS are obtained from OECD (2021), the source of ECI data is the Observatory of Economic Complexity (OEC) (2021) and Our World in Data (2021) that calculated by the Massachusetts Institute of Technology (MIT). The fact that the observation numbers of explanatory variables are not as much as the observation number of the dependent variable restricts sample size for Turkey. Thus, the annual data set used for estimation in this study covers the period 1990 – 2015. Table 1 and Table 2 display the unit root tests results and descriptive statistics of our data set, respectively.

All variables have a unit root in level. The first differences of these non–stationary variables have no unit root. Thus, the variables with integration degree I(1) do not pose a statistical problem in terms of the ARDL models. Moreover, this situation is suitable for the cointegration test we conducted. On the other hand, as can be seen in Table 2, even though our sample data traces back to 1960, 26 observations can be used due to the unavailability of the ESP index. This is why we prefer the ARDL model for cointegration analysis. ARDL approach provides more reliable results for small samples.

Table 1. ADF, PP and KPSS Unit Root Test Results

	In Level			In First Difference			Results
Variables	ADF	PP	KPSS	ADF	PP	KPSS	(α=0.05)
ln CO2_pc	-0.219	-0.023	0.675	-5.845	-6.032	0.077	I (1)
ln GDP_pc	0.410	1.342	0.676	-5.381	-5.380	0.193	I (1)
ln ECI	-1.867	3.732	0.234	-10.985	-11.46	0.106	I (1)
ln EPS	-0.845	-0.450	0.720	-10.969	-10.969	0.204	I (1)
Critic.Val. (1%)	-3,58		0,739	-3,58		0,739	
Critic.Val. (5%)	-3,00		0,463	-3,00		0,463	

Table 2. Descriptive Statistics of Variables

	Ln CO2_pc	Ln GDP_pc	Ln ECI	Ln EPS
Mean	0.767956	7.660601	-1.843373	-0.168128
Median	0.910028	7.625761	-1.738829	-0.374693
Maximum	1.499623	9.435034	-0.797988	0.792238
Minimum	-0.494296	5.648375	-5.596454	-1.568616
Std. Dev.	0.552635	1.147144	0.915793	0.655625
Skewness	-0.623992	-0.030585	-1.855742	0.006556
Kurtosis	2.433272	1.898881	8.698641	1.902188
Jarque-Bera	4.383509	2.939162	71.30151	1.305809
Probability	0.111721	0.230022	0.000000	0.520532
Sum	43.00553	444.3149	-68.20481	-4.371339
Sum Sq. Dev.	16.79731	75.00851	30.19236	10.74611
Observations	26	26	26	26

ARDL model introduced by Pesenran et al. (2001) among the cointegration methods of Engle and Granger (1987), Johansen and Juselius (1990) and Hansen and Phillips (1990) allows testing cointegration for variables in different level stationarity (I(0)) or in the first differenced

(I(I)) –but not in the second differenced (I(2)). The short– and long–run relationships will be estimated with the general form of the ARDL model in Equation (4).

$$\begin{aligned}\Delta \ln CO_{2t} = \beta_0 &+ \sum_{i=1}^{n} \beta_{1i} \Delta \ln CO_{2t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta \ln Y_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta \ln ECI_{t-i} \\ &+ \sum_{i=1}^{n} \beta_{4i} \Delta \ln EPS_{t-i} \\ &+ \delta_1 lnCO_{2t-1} + \delta_2 \ln Y_{t-1} + \delta_3 \ln ECI_{t-1} + \delta_4 \ln EPS_{t-1} + \varepsilon_t \end{aligned} \quad (4)$$

The existence of the cointegration between variables is investigated with the bounds test approach. Equation (4) is the conditional ARDL model to apply the bound test. The null hypothesis ($H_0\colon \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$) implies there is no long–term relationship (cointegration) and the alternative hypothesis ($H_A\colon \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$) refers to a cointegration. The calculated F–statistic should be higher than the upper bound I(1) to reject the null hypothesis. However, if it is lower than the lower bound I(0) the null hypothesis cannot be rejected. In the case of the F–statistic is between the upper and lower bounds that means indecision about the cointegration. The optimal lag–length is determined through Akaike information criteria (AIC) for $ARDL(p, q_1, q_2, q_3)$.

Considering the model with optimal lag–length the long–term parameters can be estimated. The short–term relationship between variables can be estimated by employing the error correction model based on the ARDL approach. If there is no cointegration, the $ARDL(p, q_1, q_2, q_3)$ model is specified only with short–term coefficients as in Equation (5)

$$\begin{aligned}\Delta \ln CO_{2t} = \alpha_0 &+ \sum_{i=1}^{p} \alpha_{1i} \Delta \ln CO_{2t-i} + \sum_{i=1}^{q_1} \alpha_{2i} \Delta \ln Y_{t-i} + \sum_{i=1}^{q_2} \alpha_{3i} \Delta \ln ECI_{t-i} \\ &+ \sum_{i=1}^{q_3} \alpha_{4i} \Delta \ln EPS_{t-i} + \varepsilon_t \end{aligned} \quad (5)$$

Otherwise, if there is cointegration, the error correction model representation is specified as;

$$\begin{aligned}\Delta \ln CO_{2t} = \beta_0 &+ \sum_{i=1}^{p} \beta_{1i} \Delta \ln CO_{2t-i} + \sum_{i=1}^{q_1} \beta_{2i} \Delta \ln Y_{t-i} + \sum_{i=1}^{q_2} \beta_{3i} \Delta \ln ECI_{t-i} \\ &+ \sum_{i=1}^{q_3} \beta_{4i} \Delta \ln EPS_{t-i} + \varphi ECT_{t-1} + \varepsilon_t \end{aligned} \quad (6)$$

In Equation (6), $\varphi = (\iota - \sum_{i=1}^{n} \beta_{1i})$ is the speed of the adjustment parameter with a negative sign. $ECT = \left(lnCO_{2,t-i} - \theta X_t\right)$ is the error correction term and θ in the calculation is the coefficient of long–term relationship. β_{1i}, β_{2i}, β_{3i}, and β_{4i} are the short–term coefficients of the model.

3. EMPIRICAL RESULTS

Table 3 presents the estimation results[1] of our model. According to the Bounds test, the null hypothesis of "there is no cointegration" is rejected. Best $ARDL\ (p, q_1, q_2, q_3)$ model is selected by using the combinations until 3 lag length and using the AIC and SIC indicators. The best–estimated model which has the minimum information criteria is $ARDL\ (3,2,2,3)$ which means p and q_3 are equal to 3 and q_1, q_2 are equal to 2. Hence, we can investigate the long–term relationship. On the other hand, we can search for the short–term relationship by using the Error Correction Model.

In the long–term model, the coefficients of GDP_pc and ECI are significant and the diagnostics tests are well. We applied the Breusch–Godfrey serial correlation test, calculated Jarque–Bera test statistic for the normality test of residuals and to check heteroscedasticity we performed the Breusch–Pagan–Godfrey test. We presented that income has a positive and statistically significant short–term effect on carbon dioxide emissions in Turkey.

The long–term GDP elasticity refers that a 1 percent increase in GDP per capita leads to around 0.4 percent increase on carbon dioxide emissions. In the short–term, a 1 percent increase in GDP leads to around 0.2 percent carbon dioxide emission increase. The Error Correction Term is found negative, near one and significant at level 1%. Hence the full convergence to equilibrium takes approximately 1 year. We test the stability of the parameters by drawing CUMSUM and CUSUMSQ graphs in Figure 3 (Brown et al, 1975). The coefficients seem stable and there is no structural break for the investigated period.

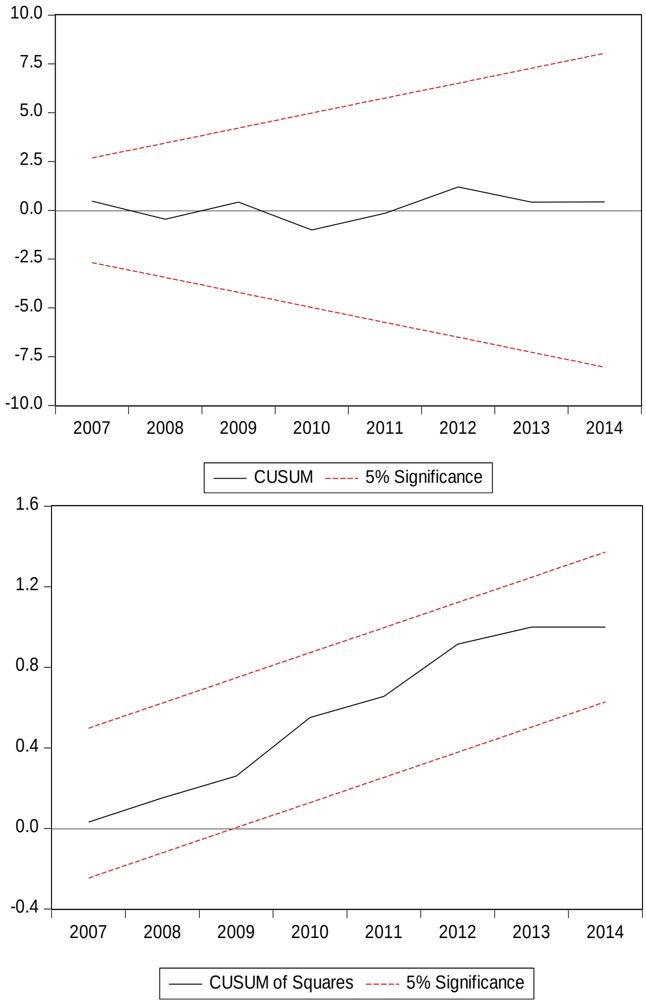
According to coefficients, since the long–term GDP elasticity of carbon dioxide emissions is higher than the short–term elasticity, the EKC hypothesis is not valid in Turkey in the investigated period. Similar to the findings of Özcan et al. (2018) and Akbostancı et al. (2009). As a developing country, Turkey is probably at the beginning of this curve. There is a monotonically increasing relationship between carbon dioxide emission and income. The coefficient of ECI in the short–term is significant and negative but near zero (-0,038). The long–term coefficient of ECI is significant and a higher negative (-0,10). The ECI indicator, which is rarely included in environmental studies, contributes to suppressing environmental degradation, especially in the long term. Investment in sophisticated goods helps to reduce environmental degradation mostly in the long–term.

Table 3. ARDL (3,2,2,3) Model Estimates

Bound Test Results / Null hypothesis: No long–run relationship.		
F–Statistics: 6.540748	I (0)	I (I)
10% Significance	2.72	3.77
5% Significance	3.23	4.35
2.5% Significance	3.69	4.89
1% Significance	4.29	5.61
Long–Run Model		
Dependent Variable: Ln_CO2		
Regressor	Coefficient	t–values
Ln_GDP_pc	0.390323	4.411912†
Ln_ECI	-0.108465	-4.092743†
Ln_EPS	0.049960	0.743057
†, ††, and ††† indicate the significance at level %1, %5, and %10, respectively.		
Diagnostic test statistics		
	Test Statistics	p–values
Serial correlation	3.192829	0.1218
Normality	0.435874	0.808270
Heteroskedasticity	0.293979	0.9757
†, †† and ††† indicate the significance level at 1%, 5%, and 10%, respectively		
Short–Run		
Regressor	Coefficient	t–values
Ln_GDP_pc	0.245853	8.427598†
Ln_ECI	-0.038770	-6.006153†
Ln_EPS	0.054061	1.747933
†, ††, and ††† indicate the significance of the level 1%, 5%, and 10%, respectively.		

On the other hand, the evidence suggests that the coefficient of environmental policy stringency indicator is positive but not significant both in the short–and long–term. It is expected to be a significant variable for mostly in developed countries that can manage the emission by policies. However, we also guess that the occurrence of the relationship between the EPS index and environmental degradation will take time after policy implementations.

Fig. 3. Graphs of CUSUM and CUSUM of Squares



4. CONCLUSION AND POLICY IMPLICATION

This paper has attempted to investigate the empirical relationship between economic growth and environmental degradation. The EKC hypothesis has been widely tested in order to figure out the relationship between environmental degradation and income. However, a sizable part of the empirical studies in the literature ignores the multicollinearity problem caused by the quadratic form of per capita income in the model as required by the mathematical definition of the Kuznets Curve.

In this paper, we followed Narayan and Narayan (2010) and employed the well–known Autoregressive Distributed Lag (ARDL) methodology. Instead of solving much more complicated non-linear models, we preferred a linear model which gives opportunities to interpret short-and long-run elasticities to decide the validity of the EKC hypothesis. If the long-run income elasticity is smaller than the short–run income elasticity, then it is evident that a country has reduced its emissions with income growth.

We investigated the existence of the EKC hypothesis in Turkey during the period 1990–2015. Our results suggest that long–term income elasticity of the environmental degradation has a positive sign. Moreover, the short–term income elasticity is smaller than the long–term income elasticity coefficient meaning that the EKC hypothesis is not valid in Turkey. This is so because Turkey is probably at the beginning of the Kuznets Curve. According to EKC hypothesis environmental pollutants increase with a higher per capita income, but it declines after the turning point. Turkey seems not very close to its own turning point. However, we should highlight an important conclusion that we do not have much time to wait for enough per capita income to rise. There are some other expediter indicators that we must focus on. Not only the increasing per capita income but also trade openness, foreign direct investments, urbanization rates, economic complexity, economic policy stringency are some other determinants of environmental degradation. In this study, we included the economic complexity and the environmental policy stringency indicators in the analysis as independent control variables alternative to frequently used variables of the literature.

In the investigation period, it seems that the environmental policy stringency is not significant for environmental degradation. However, it is accepted generally by the literature that more stringency policies lead to environmental degradation reduces. As stated in the study of Halicioglu (2009), Turkey still needs to design new environmental policies. It is probable that after an adoption period, the data analysis regarding the EPS could sign a significant and positive impact on environmental degradation. On the other side economic complexity mitigates carbon dioxide emissions especially in the long–run. If Turkey ventures the cost of investment on producing more sophisticated production goods it would have a suppressor effect on the carbon emissions in the long–run. Increasing economic complexity tends to encourage environmentally friendly technologies in the long–run. Maybe, the relationship between economic complexity index and per capita income could be behaving like another Kuznets Curve. According to Rahman (2019), economic complexity has increased the environmental degradation in countries with lower–middle and higher–middle income contrary to high–income ones.

NOTES

[1] According to the results of the alternative model which is excluding EPS index the short-run coefficients of GDP and ECI are 0.19 and -0.01, respectively. The long-run coefficients of GDP and ECI are 0.33 and -0.01, respectively.

AUTHOR STATEMENT

Statement of Research and Publication Ethics

This study has been prepared in accordance with scientific research and publication ethics.

Author Contributions

The authors contributed equally to the study.

Conflict of Interest

There is no conflict of interest for the authors or third parties arising from the study.

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