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An Econometric Analysis of the Environmental Kuznets Curve: The Case of Turkey

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ABSTRACT

Understanding the relationship between the environmental quality and economic growth has increasingly attracted the attention of economists. The literature on this relationship focuses on testing the Environmental Kuznets Curve (EKC) hypothesis. The aim of this study is to examine the relationship between income and the CO2 emission by using time series analysis for Turkey. The validity of the EKC is investigated by the Johansen cointegration test using the data for the time period 1960-2011. The results of our time series analysis suggest a cointegrating relationship between income and the CO2 emission. The results also indicate an N-shaped relationship between these variables, which in turn imply that the EKC hypothesis is not supported by this data set.

Keywords: Environmental Kuznets Curve, Economic Growth, Income, CO_2 emissions, Cointegration

Çevresel Kuznets Eğrisinin Ekonometrik Bir Analizi: Türkiye Örneği

ÖZET

Çevresel kalite ve ekonomik büyüme arasındaki ilişkinin kavranması iktisatçıların artan biçimde ilgisini çekmektedir. Söz konusu ilişki üzerine literatür Çevresel Kuznets Eğrisi (ÇKE) hipotezinin test edilmesine odaklanmaktadır. Bu çalışmanın amacı, gelir ve CO2 emisyonu arasındaki ilişkiyi zaman serisi analizi kullanarak Türkiye için test etmektir. ÇKE'nin geçerliliği 1960-2011 dönemine ait veriler kullanılarak Johansen Eşbütünleşme testi ile araştırılmaktadır. Zaman serisi analizimizin sonuçları gelir ve CO2 emisyonu arasında eşbütünleşik bir ilişkinin olduğunu ortaya koymaktadır. Sonuçlar ayrıca bu değişkenler arasında N-biçiminde bir ilişki olduğunu göstermektedir ki, bu da söz konusu veri setinin ÇKE hipotezini desteklemediğine işaret etmektedir.

Anahtar Kelimeler: Çevresel Kuznets Eğrisi, İktisadi Büyüme, Gelir, CO_2 emisyonları, Eşbütünleşme

1. Introduction

The natural environment plays a significant role in encouraging economic activity in many ways. Natural capital, as defined by the OECD (2001), *"... are natural assets in their role of providing natural resource inputs and environmental services for economic production*". While there is no doubt that natural resources are vital for sustaining economic growth and development, the relationship between economic growth and the environment is still complicated. Although economic growth contributes to improving standards of living and enhancing quality of life, it also causes environmental problems through natural resource depletion and ecosystem degradation. Sustainability of economic growth at the current rates of depletion and degradation of environmental assets has become an important aspect of the debate over economic growth and the environment (Everett, Ishwaran, Ansaloni, & Rubin, 2010: 13).

Starting from the Industrial Revolution, the transformation in production processes gave rise to a dramatic increase in production capacity of the world. Industrialization did not only trigger economic growth but also led a significant increase in world population. Along with the era of transformation, every aspect of human life and lifestyles changed dramatically as well. This was a major turning point in earth's ecology and humans' relationship with their environment (McLamb, 2011). The world's energy demand was growing and fossil fuel coal became the driving force behind the industrialization. However, coal and other fossil fuels imposed massive environmental and economic costs by causing pollution and human health problems.

Many important environmental damages arise from production, conversion and consumption of energy. Pecuniary consequences of these damages raise concerns about environmental issues which are common to energy economics, environmental economics and ecological economics. More recently, the most featured environmental impacts of economic activity are related with the emission of greenhouse gases into the atmosphere, primarily carbon dioxide (CO2), which stem from burning of fossil fuels. Each of the three primary fossil fuels –coal, petroleum and natural gas– includes carbon, which combines with oxygen and produce CO2 during burning. CO2, which is the primary greenhouse gas, accumulates in the atmosphere and possibly results in negative environmental impacts on the earth's climate, including global warming, rises in the ocean levels, increased intensity of tropical storms and losses in biodiversity (Sweeney, 2004: 20).

As the deterioration of environmental quality have became a global threat, public concerns about environmental issues have risen and provoked intellectuals' efforts to comprehend more precisely the reasons behind environmental degradation. In recent years, the relationship between economic growth and the environment has increasingly attracted the attention of economists as well. Accordingly, the literature on the debate over economic growth/development and environmental issues has grown to a great extent since 1990s. Most studies refer to the evidence that there is a relationship between environmental quality and economic growth of the kind that environmental quality worsens at early periods of growth and improves at later periods as the economy develops. This points to the fact that environmental degradation is faster than income growth at early periods of development but slows down relative to income growth at higher income levels. This systematic relationship between income change and environmental quality is called the Environmental Kuznets Curve (EKC) in the literature (Dinda, 2004: 431-32).

The rationale behind such a relationship is somehow straightforward. At early stages of industrialization, economic growth remains at the forefront, environmental issues are given less priority, so pollution increases rapidly. However, the rapid growth in income inevitably causes an incremental use of natural resources and emission of pollutants, which in turn put more pressure on environment. At later stages of industrialization, environmental consequences of growth can not be disregarded anymore. As income level rises, people value the environment more, regulatory institutions become more effective and the level of pollution decreases. In this context, compatibility between economic growth and environmental improvement could be ensured by implementing appropriate policies. Therefore, the empirical literature on the EKC particularly focuses on the evidence for the link between economic growth and environmental quality. A precise understanding of the nature of this relationship definitely makes the adoption of effective environmental policies easier.

The purpose of this study is to examine the validity of the EKC for Turkey. Our primary goal is to shed light on the economic growth–environmental degradation relationship in the case of Turkey. In this context, we aim to contribute to the relevant literature by providing empirical evidence and policy implications for the aforementioned relationship. The study begins with a conceptual framework for understanding the relationship between the economic growth and the environment. Then, it proceeds by a review of the recent literature on the subject matter. Afterwards, the empirical model is presented and the empirical findings are sketched based on the econometric analysis. Finally, it evaluates the empirical evidence and concludes.

2. Economic Growth and The Environment: Conceptual Framework

The relationship between economic growth and environmental quality has been subjected to debate for long. In early arguments, researchers asserted that growing economic activity requires larger inputs and energy, which in turn, leads to increased use of natural resources, pollution and degradation of environmental quality. They further argued that emissions- and resource use-related global ecological constraints will eventually put economic activity itself at risk. According to the Limits to Growth view (Meadows, Meadows, Randers & Behrens, 1972) forwarded by the environmental economists of the Club of Rome, these constraints might force an end to economic growth and urged for a steady-state economy. On the other hand, some argued that economic growth paves the way for environmental improvement: higher levels of income lead to increased demand for improved environmental quality and facilitate the adoption of environmental protection measures (Panayotou, 2003: 45).

In contrast to the former views, others hypothesized that the relationship between economic growth and environmental quality, whether positive or negative, is not fixed along an economy's development path. In fact, its sign may change from positive to negative as the economy's income level reaches a point where people demand and afford a cleaner environment. Thus, this hypothesis implies an inverted-U-shaped relationship between environmental degradation and economic growth; the so-called EKC. It is indeed a reinterpretation of the inverted-U-shaped relationship between income and income inequality, originally stated by Kuznets (1955). The Kuznets Curve predicted that income inequality increases initially as per capita income increases but then begins to decrease after a turning point.

In the 1990s, the Kuznets Curve became an instrument for environmental economists to depict the relationship between measured levels of environmental degradation and per capita income. The shape of the EKC reflects a statistical phenomenon that can be summarized as follows: As per capita income rises, so does environmental degradation. However, after reaching a certain point (threshold level), increases in per capita income lead to reductions in environmental degradation (See Figure 1.).

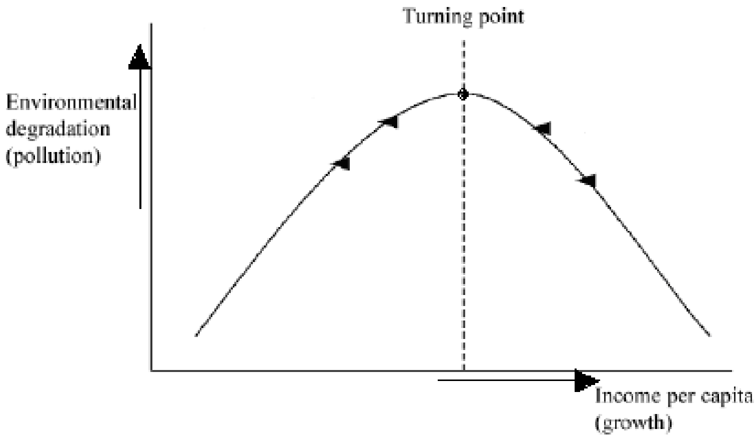

Figure 1. The Environmental Kuznets Curve (EKC)

There are specific explanations that underlie the shape of the income-environment relationship posited by the ECK hypothesis. One of the factors that shape the EKC is the income elasticity of environmental quality demand (Dinda, 2004: 435). At low income levels, people use their limited income to meet their basic consumption needs. As income grows, they reach a higher standard of living and care more for the environmental quality. Therefore, their willingness to pay for a clean environment rises by a larger extent than income. Changes in the properties of preferences and demand for better environment induce a structural change in the economy in favor of environmental degradation. Other factors that shape the EKC are associated with the effects of economic growth. Economic growth affects environmental quality in three possible ways, namely scale effect, composition effect and technique effect (Grossman & Krueger, 1991: 3-4). An expansion of economic activity requires more inputs and thus greater use of natural resources and energy. Assuming that the nature of that activity remains unchanged, this implies more wastes and emissions which contribute to pollution. Therefore, the scale effect of economic growth has a negative impact on environmental quality. Economic growth might also have both a positive or negative impact on environment through the composition effect. In rural economies, the quantity and the intensity of environmental degradation are specific to the consequences of subsistence economic activity and to limited quantities of biodegradable wastes. However, as economic growth accelerates, the structure of the economy tends to change from agricultural to industrial production. Consequently, both natural resource depletion and waste generation increase as industrialization intensifies. On the other hand, as the economy transfers to higher levels of development, the structure of the economy changes towards information-based industries and services, more efficient technologies and increased demand for a better environment, which all result in a steady decline of environmental degradation (Panayotou, 2003: 45-46). The technique effect of economic growth has a positive impact on environmental quality. As a nation becomes wealthier, it can afford technological progress. Obsolete technologies are replaced by more modern technologies which are cleaner than older ones due to the growing global awareness of the urgency of environmental concerns (Grossman & Krueger, 1991: 5).

This inverted-U-shaped relationship between income per capita and environmental degradation seems to suggest that countries can surpass their environmental problems by simply focusing on economic growth without the need for specific concern about environment itself. In this sense, directing a country's limited resources to achieve rapid economic growth means enjoying the best of both worlds: environmental as well as economic development. However, growing income is not the only factor which causes environmental improvement. The responsiveness of both suppliers and policy makers to the growing demand for environmental quality, the development of environmental legislation and new institutions to protect the environment are all important (Panayotou, 2003: 54).

3. A Brief Literature Review

The onset of the EKC hypothesis and a surge of studies which empirically tested the EKC for several pollutants were first seen in the 1990s. The seminal literature of economic growth and environmental quality relationship can be traced back to the papers of Grossman and Krueger (1991), Shafik and Bandyopadhyay (1992) and Panayotou (1993).

Grossman and Krueger (1991) explored EKCs for 32 countries which are the parts of NAFTA during the period 1977-1988. They used cross-country data to estimate the relationship between per capita GDP and the various measures of air quality, namely SO2, dark matter and suspended particles. They found that both SO2 and dark matter suspended in the air increase with per capita GDP at low levels of national income, but decrease with per capita GDP at higher levels of income. However, for the mass of suspended particles, they found the relationship between pollution and GDP is monotonically decreasing.

Shafik and Bandyopadhyay (1992) explored the relationship between economic growth and environmental quality using data from up to 149 countries for the period 1960-1990. They used eight indicators of environmental quality as dependent variables in panel regressions and found that income has the most consistently significant effect on all indicators of environmental quality. They revealed that most environmental indicators deteriorate initially as incomes rise and many indicators tend to improve as countries approach middle-income levels.

Panayotou (1993) tested empirically the relationship that exists between environmental degradation and economic development for the late 1980s period. His findings, using cross-section data on deforestation and air pollution from a sample of developing and developed countries, supported the hypothesis of an inverted-U-shaped relationship, which he coined the term EKC for the first time.

More recently, existing literature on the relationship between economic growth and environmental quality usually focuses on testing the EKC using time series analyses. There exists a wide range of literature consisting of both developed and developing country studies. For our purpose here, we review the studies which concentrate on the case of Turkey.

Başar and Temurlenk (2007) investigated the validity of the EKC for Turkey, using time series data for the period 1950-2000. They found no significant relation between income level and CO2 emissions from fuel oil and solid fuels, yet they found inverted-N shaped relations between income and CO2 emission per capita and emissions from fossil fuels.

Halıcıoğlu (2008) examined the relationships between carbon emissions, energy consumption, income and foreign trade in the case of Turkey using the time series data for the period 1960-2005. The empirical results of his study suggest that income is the most significant variable in explaining the carbon emissions in Turkey which is followed by energy consumption and foreign trade. He also concludes that the EKC does not hold for Turkey.

Akbostancı, Aşık and Tunç (2009) investigated the relationship between income and environmental quality for Turkey by using both a time series model and panel data model for the time periods 1968-2003 and 1992-2001. The results of their time series and panel data analyses, including observations from 58 provinces, did not support the EKC hypothesis. Their results also implied that the relationship between CO2 emissions and income in Turkey follows an N-shaped pattern.

Saatçi and Dumrul (2011) analyzed the relationship between economic growth and environmental pollution in Turkey for the time period 1950-2007. The findings of the study indicated that there exists a long run relationship between environmental pollution and economic growth in Turkey. Moreover, their results supported the existence of an inverted U-shaped relationship between economic growth and environmental pollution in Turkey.

Erol, Erataş and Nur (2013) examined the relationship between income and environmental pollution for 10 country, including Turkey. By using panel data analysis and cointegration tests for the time period 1995-2011, they found that the EKC hypothesis holds for the suggested countries.

Erataş and Uysal (2014), by using panel data analysis, examined the relationship between income level and environmental pollution within "BRICT" countries (namely, Brazil, Russia, India, China and Turkey) for the period 1992-2010. Their findings indicated that the EKC is valid for the countries in question.

Martino and Nguyen-Van (2016) investigated the EKC hypothesis for 106 countries (including Turkey) over the period 1970-2010. Based on the panel data analysis, they found no evidence supporting the EKC hypothesis, even for the OECD countries.

4. Model and Data

Basically, the EKC focuses on the relationship between income and environmental factors. In general form, the EKC hypothesis is formulated as follows (Akbostancı et al., 2009: 863):

$$E = f\left(Y, Y^2, Y^3, Z\right) \tag{1}$$

In this formulation, E denotes the environmental indicator, Y denotes income and Z denotes an explanatory variable which is supposed to cause environmental degradation.

Studies that estimate the EKC in the literature utilize polynomial regression techniques. Polynomial regression is a specific form of general linear model in regression analysis. Grossman and Krueger (1991), Shafik and Bandopadhyay (1992), Selden and Song (1994), Shafik (1994), Grossman and Krueger (1995), Cole, Rayner and Bates (1997) and Panayotou (1997) use polynomial regression to estimate the model in their studies. In order to create a regression function in curvilinear form, the values of the independent variables are raised to integer powers such as quadratic or higher degrees. In this respect, the relationship between the variables in the EKC analysis is tested by using the polynomial regression (Kutner, Nachtsheim, Neter & Li, 2004: 219). Three basic models, namely linear, quadratic and cubic are tested with a view to establishing the relationship between income and environmental indicators (Shafik & Bandyopadhyay, 1992: 5):

$$E_t = \beta_1 + \beta_2 \log Y + \beta_3 time \tag{2}$$

$$E_t = \beta_1 + \beta_2 \log Y + \beta_3 \log Y^2 + \beta_4 time \tag{3}$$

$$E_t = \beta_1 + \beta_2 \log Y + \beta_3 \log Y^2 + \beta_4 \log Y^3 + \beta_5 time \tag{4}$$

In these models, the E variable stands for environmental pollution, the Y variable stands for per capita income and the time variable stands for the time trend. The validation of the ECK is usually tested by using quadratic or cubic models in the literature. In the case of estimating a quadratic model, the coefficients β_2 and β_3; in the case of estimating a cubic model, the coefficients β_2, β_3 and β_4 are subjected to analysis.

In our study, the validation of the EKC hypothesis for Turkey is tested by using a cubic model. The EKC relationship is examined by the help of cointegration technique. The model used in the context of the time series analysis is formulated as follows:

$$\log\left(E_t\right) = \beta_0 + \beta_1 \log\left(Y_t\right) + \beta_2 \log\left(Y_t\right)^2 + \beta_3 \log\left(Y_t\right)^3 + \varepsilon_t \tag{5}$$

In this model, CO2 emission per capita is used as the environmental indicator. As for the income variable, the GDP per capita in constant U.S. dollars is used.

In the case of estimating the model in Equation (5), the coefficients of the income variable (β_1, β_2, β_3) take different values, which indicate that they have different functional forms. Thus, the estimation of the model implies that there exist various forms of relationships between the income per capita and CO2 emission per capita (Akbostancı et al., 2009: 863; Dinda, 2004: 440-441):

- (i) $\beta_1 = \beta_2 = \beta_3 = 0$ There is no relationship between Y and E.

- (ii) $\beta_1 > 0$ and $\beta_2 = \beta_3 = 0$ There is a linear relationship between Y and E.
- (iii) $\beta_1 < 0$ and $\beta_2 = \beta_3 = 0$ There is an inverse relationship between Y and E.
- (iv) $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 = 0$ There is an inverted-U-shaped relationship between Y and E. The EKC is valid.
- (v) $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 = 0$ There is a U-shaped relationship between Y and E.
- (vi) $\beta_1 > 0$, $\beta_2 < 0$ and $\beta_3 > 0$ There is an N-shaped relationship between Y and E.
- (vii) $\beta_1 < 0$, $\beta_2 > 0$ and $\beta_3 < 0$ There is an inverted-N-shaped relationship between Y and E.

In our study, the data for the variables CO2 per capita and the GDP per capita in constant U.S. dollars (base year is 2000:100) is obtained from the World Bank World Development Indicators (WDI) and it covers the period 1960-2011. Estimations of various studies in the literature are based on the level, logarithmic or semi-logarithmic values of variables. In this study, we use logarithmic series for our estimation. Since the GDP per capita increases exponentially, we aim to stabilize the change of the variable via linearization.

5. Estimation Results

Time series analysis involves estimating Eq. (5). The initial step in time series analysis is testing for stationarity. Generally, "*a stochastic process is said to be stationary if its mean and variance are constant over time and the value of the covariance between the two time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which the covariance is computed… In short, if a time series is stationary, its mean, variance, and autocovariance (at various lags) remain the same no matter at what point we measure them; that is, they are time invariant*" (Gujarati, 2004: 797-798). Thus, initially stationarity of the variables in the model is examined by the ADF and PP unit root tests. According to these unit root tests, the null hypothesis indicates the existence of a unit root while the alternative hypothesis implies a stationary time series. In this context, accepting the null hypothesis means that the time series has a unit root, so the stationarity analysis proceeds with taking the differences of the variables. The results in the Table 1 display that all the variables in the model become stationary (at the level of significance of 95%) after taking their first differences.

Variables	Level		First Difference		Level		First Difference	
	ADF		ADF		PP		PP	
	t-Statistic	Test critical values	t-Statistic	Test critical values	t-Statistic	Test critical values	t-Statistic	Test critical values
LCO_2	-2.608435	-3.500495	-4.961085	-1.947520	-2.656330	-3.500495	-5.067826	-1.94752
LY_t	-2.943121	-3.500495	-5.168187	-1.947520	-2.943121	-3.500495	-5.371383	-1.94752
LY_t^2	-2.900903	-3.500495	-5.201159	-1.947520	-2.900903	-3.500495	-5.396507	-1.94752
LY_t^3	-2.791478	-3.500495	-5.227126	-1.947520	-2.791478	-3.500495	-5.367178	-1.94752

Table 1. Results of unit root tests

According to the results of the ADF and PP unit root tests, all the series in the model are integrated of order one; i.e., I(1). In this regard, we investigate for evidence of cointegration among these variables, which may also rule out the possibility of spurious regression. Cointegration analysis investigates the existence of a long-run relationship between the variables that are integrated of the same order. Although there are several methods for testing for cointegration, we use the Johansen cointegration test.

In the context of the Johansen testing procedure, two different test statistics are formulated as follows:

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{g}\ln\left(1-\hat{\lambda}_i\right) \tag{6}$$

$$\lambda_{\max}(r, r+1) = -T\ln\left(1-\hat{\lambda}_{r+1}\right) \tag{7}$$

In Equations (6) and (7), r symbolizes the number of cointegrating vectors while $\hat{\lambda}_i$ is the estimated value for the ith order eigenvalue of the matrix and λ_{trace} is the trace statistics. Under the trace test, the null hypothesis is that the number of cointegrating vectors is less than or equal to r against the alternative hypothesis that it is more than r. $\lambda_{\max}$ is the maximum eigenvalue and the null hypothesis for the maximum eigenvalue test is that the number of cointegrating vectors is r against the alternative hypothesis of r+1 (Brooks, 2002: 404-405). There exists a cointegrating relationship if these test statistics are greater than the critical values provided by Johansen and Juselius (1990).

In the circumstances, the underlying cointegrating equation in our study is described as follows:

$$LCO_{2t} = \beta_1 L(Y_t) + \beta_2 L(Y_t)^2 + \beta_3 L(Y_t)^3 \tag{8}$$

To use the Johansen cointegration test, initially the lag length is estimated. According to the test results, the lag length is determined as three (3) by Schwarz information criteria. Then, the Johansen cointegration test is applied. Table 2 displays the trace and the max-eigen statistics obtained from the cointegration analysis. The results suggest that there are three cointegrating vectors at the level of significance of 95%. In other words, the results indicate that the income and the CO2 emission variables are cointegrated and that there exists a long run relationship between them.

Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistics**	**0,05 Critical Value**	**Maximum Eigen Statistics**	**0,05 Critical Value**
0	0.637914	97.12325	54.07904	48.76195	28.58808
1	0.383465	48.36129	35.19275	23.21476	22.29962
2	0.285193	25.14654	20.26184	16.11566	15.89210
3	0.171504	9.030871	9.164546	9.030871	9.164546

Table 2. The results of the Johansen cointegration test

The estimated long run relationship between the income and the CO2 emission can be described as follows:

$$\begin{aligned} LCO_{2t} &= 275,9376L(Y_t) - 67,013L(Y_t)^2 + 5,42L(Y_t)^3 \\ &\quad (76.9115) \qquad (20.3061) \qquad (1.78792) \end{aligned} \tag{9}$$

The coefficients of the long run cointegrating relationship and of the standard errors are statistically significant. Based on these results, it is observed that β1 > 0, β2< 0 and β3>0. According to this, it can be concluded that there is an N-shaped relationship between the income and the CO2 emission, so that the EKC is not valid for Turkey.

6. Conclusions

The natural environment is crucial in promoting economic activity and growth. On the other hand, rapid economic growth inevitably results in greater use of natural resources and emission of pollutants, which in turn puts more pressure on the environment. Therefore, the relationship between environmental quality and economic growth is far from simple. Common evidence of the so-called relationship refers to the fact that environmental quality worsens at early periods of growth and improves at later periods as the economy develops. The existing literature on this relationship between income change and environmental quality usually focuses on testing the Environmental Kuznets Curve hypothesis using time series analyses.

In our study, the relationship between income and the CO2 emission is examined by using time series analysis for Turkey. The validity of the EKC is investigated by the Johansen cointegration test using the annual data for the time period 1960-2011. The results of our empirical analysis suggest that there exists a cointegrating relationship between income and the CO2 emission. The results also imply that the relationship between these variables follows an N-shaped pattern. In this context, our findings indicate that the EKC hypothesis is not supported by this data set. The existence of the EKC suggests that environmental problems will be resolved automatically with economic growth without any need to take policy actions. However, a similar result can not be achieved with an N-shaped relationship between income and the CO2 emission.

The main policy implication of our analysis is that taking no action and staying only in expectation of rising consciousness about environmental issues are not reasonable in the case of Turkey. Based on our findings, we can conclude that environmental pollution in Turkey will not go away by itself with economic growth. This also points to the fact that economic growth alone can not be the solution to all environmental problems. In this context, the EKC analysis suggests that there is a need for Turkey to adopt effective environmental policies to struggle against pollution regardless of its economic growth.

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