JOURNAL OF EMERGING ECONOMIES AND POLICY 2024 9(1) 140-149

JOEEP

e-ISSN: 2651-5318
Journal Homepage: http://dergipark.org.tr/joeep

Araştırma Makalesi ● Research Article

A Study on the Relationship between Economic Growth and the Environment in OECD Countries

OECD Ülkelerinde Ekonomik Büyüme ve Çevre İlişkisi Üzerine Bir Araştırma

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MAKALE BİLGİSİ

Makale Geçmişi:
Başvuru tarihi: 6 Mayıs 2024
Düzeltme tarihi: 28 Mayıs 2024
Kabul tarihi: 2 Haziran 2024

Anahtar Kelimeler:
Ekonomik Büyüme
Çevresel Kuznets Hipotezi
Panel Eşik Model

ÖZ

Ekonomik büyüme ve kalkınma sürecinin önemli bir çıktısı konumundaki çevreye duyarlı büyüme anlayışı ilk olarak "ne pahasına olursa olsun büyüme" anlayışının oluşturduğu çevresel tahribatlar dolayısıyla kendinden söz ettirmeye başlamıştır. Özellikle büyümenin çevresel etkilerini araştıran Kuznets'in 1950'lerdeki çalışması bu alanda birçok çalışmaya referans olmuştur. Bu bağlamda sanayileşmiş veya sanayileşmekte olan ülkelerin yürüttüğü çoğunlukla acımasız şekilde yürütülen ekonomik faaliyetlerin önemli bir kısmının çevreye sunduğu olumsuz dışsallıklar çevrsel Kuznets hipotezinin temel önermesini oluşturmaktadır. Bu çalışmada da, Çevresel Kuznets Hipotezi'nin geçerliliği OECD üyesi ülkeler kapsamında araştırılmaktadır. 1965-2020 dönemini baz alan çalışmada panel eşik modeli kullanılmıştır. Analiz sonuçları Çevresel Kuznets Hipotezi'nin geçerli olduğunu ortaya koymakla birlikte, ekonomik büyümenin belirlenen eşik gelir düzeyine kadar çevresel tahribat üzerinde önemli derecede etkili olduğunu ortaya koymaktadır. Bununla birlikte belirlenen gelir eşik düzeyinin aşılmasından sonra ekonomik büyümenin çevresel tahribat üzerindeki etkisi giderek yavaşlamaktadır. Bu yönüyle ekonomik büyüme ve çevre ilişkilerinin ters-U şeklinde hipotezle uyum içerisinde olduğunu ortaya koymaktadır.

ARTICLE INFO

Article history:
Received: May 6, 2024
Received in revised form: May 28, 2024
Accepted: June 2, 2024

Keywords:
Economic Growth
Environmental Kuznets Hypothesis
Panel Threshold Model

ABSTRACT

The concept of environmentally sensitive growth, which constitutes a significant output of the process of economic growth and development, first emerged due to the environmental degradation caused by the notion of "growth at any cost." Particularly, Kuznets' study in the 1950s, investigating the environmental impacts of growth, has served as a reference for many studies in this field. In this context, the significant negative externalities posed by economic activities, often ruthlessly carried out by industrialized or industrializing countries, form the basic proposition of the environmental Kuznets hypothesis. This study also examines the validity of the Environmental Kuznets Hypothesis within the scope of OECD member countries. Using panel threshold model covering the period 1965-2020, the analysis demonstrates the validity of the Environmental Kuznets Hypothesis, indicating that economic growth significantly influences environmental degradation up to a certain identified income threshold level. However, beyond this threshold level, the impact of economic growth on environmental degradation gradually diminishes. In this regard, the study reveals the concordance of the relationship between economic growth and the environment with the hypothesis in a reverse-U shape.

1. Introduction

The phenomenon of economic growth and advancement desired for all countries from past to present has caused many problems. Especially, many developed countries that have adopted the motto of "growth at any cost" have led to irreversible environmental problems and disasters, first in their own countries and then worldwide. In this process, economic growth and development, particularly propelled by industrialization movements, have brought environmental problems. Whether in developed, developing, or underdeveloped countries, the desire to expand their welfare resulted in the sacrifice of the world. Again, a growth model termed "growth without a future," designated by the United Nations and leading the world that will be inherited by future generations to the brink of destruction by disregarding and polluting the environment, has been implemented by many countries in the pursuit of economic growth and development.

While the process of economic growth and development is being pursued so ruthlessly and recklessly, on the other hand, with the increasing awareness of the environment and

Atıf/Cite as: Eroğlu Sevinç, D. (2024). A Study on the Relationship between Economic Growth and the Environment in OECD Countries. *Journal of Emerging Economies and Policy*, 9(1), 140-149.

the idea that "there is no other world," concepts such as environmentally respectful sustainable growth and development, and green growth, have begun to emerge. Thus, the understanding that sustainable growth and development can only be achieved with a sustainable environmental consciousness has begun to prevail, leading all countries to implement economic policies aiming to adopt this understanding. In this context, attempts have been made to bring different perspectives to the energy factor, which is the most important input of the economic growth and development process, and new energy policies have been formulated. The most significant step and policy in this process is the preference for sustainable and renewable energy sources instead of fossil fuels, which are high in carbon emissions. Moreover, a more cautious and sensitive consumption understanding has prevailed regarding using existing carbon-based fossil resources, and efforts have been made to use processes that minimize environmental damage.

A theory called the Environmental Kuznets Hypothesis has been developed in the literature, relating income levels to environmental degradation, and the process of economic growth and development has begun to be reconsidered within the framework of this theory. Thus, this hypothesis, known as the Environmental Kuznets Hypothesis, emphasizes that increasing income levels lead to an increase in carbon emissions, which is the most important indicator of environmental pollution and degradation, but that carbon emissions begin to decrease once a certain threshold level of income is reached. Therefore, in this study, the validity of the Environmental Kuznets Hypothesis will be investigated in 28 OECD member countries using a panel dynamic threshold model for the period 1965-2020. For this purpose, the study will be structured into five sections. Following the introduction, the second section of the study will provide theoretical information and a summary of the literature on the subject, the third section will introduce the data set, methodological background, and econometric model relevant to the application part of the study. After the presentation of the results obtained in the fourth section, the study will be concluded with a general evaluation in the fifth and final section.

2. Theoretical Framework and Literature Summary

The Environmental Kuznets Curve hypothesis has been particularly articulated during a period of global economic growth and development characterized by rampant environmental degradation, particularly in the period of notions of "growth at any cost" and "growth without a future". Fundamentally, this theory, introduced by Kuznets and called the Kuznets Curve, addresses the inverted U-shaped relationship between economic growth, income distribution, and environmental pollution. Similar to the Kuznets Curve, the Environmental Kuznets Curve suggests that increasing income levels exacerbate environmental pollution and degradation; however, pollution and degradation decrease as income levels surpass a certain threshold (Apergis and Payne, 2010:650).

The Environmental Kuznets Hypothesis has primarily been utilized to specify and explain the negative externalities of industrialized or industrializing countries' economic activities on the environment. Moreover, particularly in developing countries, the main point of the hypothesis lies in the pursuit of economic growth at any cost during the initial stages of industrialization, leading to increased environmental degradation and pollution through the adoption of any and all dirty technologies and production processes. Subsequently, as the wealth generated by increasing production deviates from this logic, countries tend to shift towards cleaner production technologies through investments, particularly in research and development activities, and technological advancements aim to reduce environmental pollution. Furthermore, as economic growth progresses and advances the country's development, the emerging environmental consciousness fosters the establishment of environmentally sensitive and sustainable growth principles. Consequently, the dominant industrial sector gradually yields to the service and information-technology sectors, thereby mitigating environmental issues, facilitating economic growth, and ensuring the sustainability of energy resources. Thus, environmental pollution and problems increase as income initially increases; however, after income reaches a certain level, the increasing wealth leads to developmental improvements, fostering the gradual emergence of environmental awareness, consequently reducing environmental degradation and shaping this relationship into a parabolic form (Örnek and Türkmen, 2019: 111-112).

In the literature, there are numerous studies investigating the Environmental Kuznets Curve. In this context, seminal examples introduced by Grossman and Krueger (1991, 1995) and implemented by Shafik and Bandyopadhyay (1992), Shafik (1994), Selden and Daging (1995), Stern et al. (1996), Ekins (1997), Panayotou (1997), Roberts and Grimes (1997), Vincent (1997). Moreover, besides these studies, there are more and attention-grabbing studies in the literature, particularly those based on multi-country samples. In this regard, studies carried out by Grossman and Krueger (1991, 1995), Selden and Song (1994), Tucker (1995), Komen et al. (1997), Dijkgraaf and Vollebergh (2001), Heil and Selden (2001), Stern and Common (2001), Perman and Stern (2003), Dinda (2004), Galeotti et al. (2006, 2009), Apergis and Payne (2010), Pao and Tsai (2010), Jaunky (2011), Arouri et al. (2012), Farhani and Rejeb (2012), Cho et al. (2014), Beck and Joshi (2015), Georgiev and Mihaylov (2015), Heidari et al. (2015), Bilgili et al. (2016), Jebli et al. (2016), Acar et al. (2018), Balsalobre-Lorente et al. (2018), Cheng et al. (2019), Danish et al. (2019), Özkan et al. (2019), Sohag et al. (2019), Amin et al. (2020), Nawaz et al. (2021), Aminata et al. (2022), Awan et al. (2022), Htieke (2022), Bao and Lu (2023), Phiri et al. (2023), and Wang et al. (2023) tested the validity of the Environmental Kuznets Curve.

Moreover, there also are studies addressing single-country examples in the literature. Egli (2001), Friedly and Getzner (2003), Jalil and Mahmud (2009), Fosten et al. (2012), Lau et al. (2014), Balaguer and Cantavella (2016), Alshehry and Belloumi (2017), Kharbach and Chfadi (2017), Danish et al. (2018), Dong et al. (2018), Mikayilov et al. (2018), Sinha and Shahbaz (2018), Zambrano-Monserrate et al. (2018), Shabani and Shahnazi (2019), Shahbaz et al. (2020), Chen et al. (2022), and Guo et al. (2022) similarly investigated the validity of the Environmental Kuznets Curve.

Finally, there also are studies based on the panel threshold model, which is the fundamental application model of the study. In this context, in the study carried out by Ouyang et al. (2019) and covering the period 1998-2015 for 30 OECD countries, the EKC hypothesis was tested by using the panel dynamic threshold model. The analysis results indicated the income threshold value to be 1.273 and revealed that income had a positive effect on air pollution up to the threshold value and a negative effect thereafter. These findings indicate that the EKC hypothesis was confirmed in those OECD countries.

In a study carried out by Chen et al. (2022) by utilizing data from the period 1995-2015 for 95 countries from developing, developed, and top-developed country groups, the relationship between renewable energy consumption and income was examined. The analysis results, with a calculated threshold value of 1.475, revealed that, under the short- and long-term assumption, the short-term threshold value is negative and significant (-0.255) in developing countries, whereas it is positive and significant in all other country groups. Considering all the results together, especially for top-developed and developed countries, the increase in renewable energy consumption has a negative and significant effect on carbon emissions. In a study carried out by Akbulut (2022) covering the BRICS countries for the period 1995-2015, no significant relationship was found between income and carbon emissions, leading to the conclusion that the EKC hypothesis is not valid.

In a study carried out by Çatık et al. (2023) covering the period 1990-2019 for 28 OECD countries, the relationships between carbon emissions in the transportation sector and income were investigated in the context of the Environmental Kuznets Curve. The panel dynamic threshold value was found to be 10.062, which indicates that the relationship between variables moves in consistent with the EKC hypothesis. In a study carried out by Uche et al. (2023) examining the validity of the Environmental Kuznets Curve in the Indian economy for the period 1980-2018, it was particularly concluded that income has significant effects on environmental pollution in the long term, and that the EKC hypothesis is valid. Similarly, in a study carried out by Acaroğlu et al. (2023) covering the period 1971-2015 for the Turkish economy, the validity of the EKC hypothesis was proven, with a threshold value found as 11.006 dollars.

3. Dataset, Methodology and Econometric Model

In this study, the validity of the Environmental Kuznets Hypothesis (EKH) will be investigated across 28 OECD (Despite being OECD member countries, Czechia, Slovakia, Estonia, Slovenia, Costa Rica, Lithuania, Latvia, Israel, Poland, and Hungary were excluded from the analysis since the data for those countries couldn't be achieved) member countries spanning the period 1965-2020 by using the panel dynamic threshold model. In other words, this study will test whether there is an effect of the growth threshold on the relationship between income or economic growth and the environment, and (if such an effect is observed) the nature of the relationships between the relevant variables will be examined. The primary reason for focusing on this group of countries is their tendency toward rapid increases in income and growth, together with significant levels of environmental degradation. The main reason for considering the specified period, however, originates from the availability of data for analysis. Within the scope of the objectives stated here, logarithmic values of carbon emissions (carbon) were considered to represent environmental impacts, whereas the economic growth (growth) variable was derived by taking the logarithm of per capita income. In addition to these variables, certain control variables that may influence carbon emissions and facilitate the achievement of robust results from the analyses were added to the estimation process. Among these, the logarithmic values of urban population levels (urbanization) were utilized to account for urbanization trends. As a second control variable, energy consumption data were considered, and logarithmic values were used for this set as well. The variables under analysis have been obtained from the official website of the World Bank.

The dynamic threshold model, an extended version of the static model applied to endogenous predictors by Hansen (1999) and further developed by Kremer et al. (2013), was used in this study. The dynamic threshold model was established by building upon the cross-sectional threshold model utilizing Generalized Method of Moments (GMM) type estimators, allowing for the use of endogenous variables, as developed by Caner and Hansen (2004), and is illustrated in Equation (1):

$$y_{it} = \mu_{it} + \beta_1' z_{it} I(q_{it} \leq \gamma) + \beta_2' z_{it} I(q_{it} > \gamma) + \varepsilon_{it} \qquad \textbf{(1)}$$

In the regression model (1), y_{it} refers to dependent variable and constant effect, whereas $\varepsilon_{it} \approx (0, \sigma^2)$ refers to independent and identically developing error term. *I(.)* is included in the model as an indicator function indicating the regime, q_{it} refers to threshold variable and Υ is used as threshold value. Moreover, in the model, z_{it} is the lagged value of dependent variable and used as an explanatory variable vector with *m*-dimensions incorporating other endogenous variables. (Akıncı et al., 2018: 199; Sevinç et al., 2022: 358; Kremer et al., 2013: 4).

The stage following the estimation of the model in Equation (1) is the use of Two-Stage Least Squares (2SLS) method to determine the *growth* turning point. For this purpose, following the study carried out by Caner and Hansen (2004), reduced regression form is estimated for the instrumental variables (z_{2it}), a function of instrumental variables (X_{it}). Then, the estimated values of endogenous variables ($\hat{z}_{2it}$) are used instead of endogenous variables (z_{2it}) in the structural equation. Then, the model in Equation (1) is estimated for a constant threshold point Υ by using the Least Squares (LS) method. This procedure is repeated for the subclusters of q threshold variable. Among the threshold values obtained, the one with the lowest Sum of Squares of Error ($S(\gamma)$) is referred to as the appropriate threshold value. This constrains is expressed as in Equation (2) (Hansen, 2000: 578; Akıncı et al., 2018: 200):

$$\hat{\gamma} = argmin\ S_n(\gamma) \quad \textbf{(2)}$$

Considering the studies carried out by Hansen (1999), Caner and Hansen (2004), Kremer et al. (2013), and Akıncı et al. (2018), critical values for the threshold parameter in the growth variable are calculated at a 95% confidence level. The constraint equation necessary for calculating critical values can be represented as:

$$\Gamma = \{\gamma : LR(\gamma) \leq C(\alpha)\} \quad \textbf{(3)}$$

where LR(γ) represents the asymptotic distribution of the likelihood ratio statistic, and C(α) represents the 95% of this distribution. After determining the appropriate threshold value ($\hat{\gamma}$), the slope coefficients in the dynamic threshold model are estimated via the Generalized Method of Moments (GMM) for previously determined instrumental variables and the estimated threshold value. The impact of growth threshold value on carbon emissions can be examined considering the dynamic threshold model as expressed in equation (4):

$$Carbon_{it} = \mu_{it} + \beta_1 Growth_{it} I(Growth_{it} \leq \gamma) + \delta_1 I(Growth_{it} \leq \gamma) + +\beta_2 Growth_{it} I(Growth_{it} > \gamma) + \psi z_{it} + \varepsilon_{it} \quad \textbf{(4)}$$

In Equation (4), the variable $Growth_{it}$ represents threshold effects for two regimes, whereas z_{it} represents the control variables vector. β_1 and β_2 coefficients refer to regime slope coefficients and δ_1 to the regime constant coefficient.

As stated by Roodman (2009), using all lagged values of the dependent variable as instrumental variables in regime regression analysis leads to unbiased and consistent coefficient estimates. Therefore, following the research of Arellano and Bover (1995), all lagged values of the dependent variable have been utilized as instrumental variables in the model.

4. Results

Determining whether the variables used in models are stationary, and if they are, at what level of stationarity they are, is very important. When a panel data set is used to test the presence of a unit root, testing for cross-sectional dependence is also important. Generally speaking, in tests for cross-sectional dependence, when the time dimension is greater than the cross-sectional dimension (T>N), the Berusch-Pagan (1980) CD LM1 test is employed; when the time dimension is equal to the cross-sectional dimension (T=N), the Pesaran (2004) CD LM2 test is applied; and when the time dimension is smaller than the cross-sectional dimension (T<N), the Pesaran (2004) CD LM test is utilized (Göçer, 2013: 5092). In this study, with 28 countries (N=28) and 56 years (T=56), thus (T>N), the Bresuch-Pagan CD LM1 test was utilized to identify cross-sectional dependence. The Breusch-Pagan CD LM1 test is calculated by using the formula below:

$$LM = \sum_{i=1}^{N-1}\sum_{j=i+1}^{N} T_{ij}\hat{\rho}_{ij}^2 \rightarrow \chi^2 \frac{N(N-1)}{2} \quad \textbf{(5)}$$

In this equation, $\hat{\rho}_{ij}$ refers to the correlation coefficients obtained from model residuals. Asymptotic χ^2 distributions are obtained in a constant N range for each i and j for $T_{ij} \rightarrow \infty$ and constructed by assuming that errors have a normal distribution. In this context, the null hypothesis indicates that there is no correlation relationship between cross-sectional units (no cross-sectional dependence), whereas the alternative hypothesis suggests that there is a valid correlation relationship between cross-sectional units (cross-sectional dependence exists). If cross-sectional dependence is rejected in the panel data set, it is more appropriate to use first-generation unit root tests; otherwise, if cross-sectional dependence is found to be valid, the use of second-generation unit root tests allows for more consistent results (Çınar, 2010). Table 1 shows the results of the Bresuch-Pagan CD LM1 test used to measure cross-sectional dependence. The test results shown in Table 1 indicate that there is a correlation relationship between cross-sectional units. Accordingly, it can be said that cross-sectional dependence manifests itself, and it would be more appropriate to use second-generation unit root tests to detect the presence of a unit root.

Table 1: Breusch-Pagan CD-LM1 **Cross-Sectional Dependence Analysis Results**

Variable	Test Statistics	Probability
*Ln*Carbon	10534.11***	0.000
LnIncome (Growth)	20360.09***	0.000
LnUrbanization	18452.91***	0.000
*Ln*Energy Consumption	13489.33***	0.000
Entire Equation	4519.614***	0.000

Note: *** indicates that the coefficient associated with the respective variable is statistically significant at the 1% level, thereby demonstrating the validity of cross-sectional dependence.

The presence of correlation relationships between the cross-sectional units of variables highlights the potential utility of second-generation unit root tests in determining the stationarity degrees of variables. In this context, Table 2 presented herein showcases the results of CADF and CIPS unit root tests for panel data variables. While in the CADF test, a unit root test is conducted for each cross-sectional unit comprising the panel, the CIPS test operates a common unit root test for all cross-sectional units constituting the panel. In the CADF test, applicable when T>N and N>T, the null hypothesis stating the series' non-stationarity is rejected if the calculated CADF test statistic exceeds the CADF critical values in absolute terms, thus accepting the alternative hypothesis that underscores the stationarity of the series (Pesaran, 2007: 265-312). The CADF test statistic is calculated using the equations below (Pesaran, 2007; 268):

$$y_{it} = (1-\varphi_i)\mu_i + \varphi_i y_{i,t-1} + u_{it} \quad ,i = 1,\ldots,N; t = 1,\ldots,T \qquad \textbf{(6)}$$

$$u_{it} = \gamma_i f_t + \varepsilon_{it} \qquad \textbf{(7)}$$

In these equations, f_t refers to the unobserved common effects and ε_{it} to individual-specific error term. Combining Equations (6) and (7),

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \gamma_i f_t + \varepsilon_{it} \qquad \textbf{(8)}$$

In Equation (8) $\alpha_i = (1-\varphi_i)\mu_i$, $\beta_i = -(1-\varphi_i)$ and $\Delta y_{it} = y_{it} - y_{i,t-1}$ olarak ifade edilmektedir. Therefore, the null and alternative hypotheses for CADF analysis,

$H_0: \beta_i = 0$ for all is(Series is not stationary)

$H_1: \beta_i < 0$, $i = 1,2,\ldots,N_1$, $\beta_i = 0$, $i = N_1+1, N_1+2,\ldots,N$ (Series is stationary) **(9)**

The CIPS test, on the other hand, is calculated by taking the average of the stationary statistics calculated for each cross-sectional unit and presents the stationary information for the panel as a whole. Similar to the CADF test, in the CIPS test, if the absolute value of the calculated CIPS test statistic is higher than the critical CIPS values, the null hypothesis stating that the series is non-stationary is rejected, and the alternative hypothesis, which emphasizes that the series is stationary, is accepted. In general, the CIPS test statistic can be expressed as,

$$CIPS = N^{-1}\sum_{i=1}^{N} CADF_i \qquad \textbf{(10)}$$

Table 2: CADF and CIPS Unit Root Test Results

CADF Unit Root Results								
Countries	***LnCarbon***		***LnIncome (Growth)***		***LnUrbanization***		***LnEnergy Consumption***	
	p	**t-statistic**	**p**	**t-statistic**	**p**	**t-statistic**	**p**	**t-statistic**
Austria	0	-2.938	0	-2.350	4	0.344	0	-3.442*
Australia	0	-4.438**	0	-2.222	0	0.334	0	-4.706***
Belgium	0	-2.780	0	-2.707	1	-2.183	1	-3.193
Canada	0	-2.737	0	-2.189	7	-1.834	0	-2.597
Chile	1	-3.587*	0	-1.924	2	-0.800	1	-3.300
Columbia	0	-2.703	0	-1.593	2	-1.780	0	-1.900
Denmark	0	-3.541*	1	-3.455*	5	-2.625	0	-4.038**
France	0	-0.595	0	-4.733***	4	-3.042	0	-4.181**
Finland	0	-4.379**	1	-3.607*	6	-2.164	0	-2.410
Germany	2	-4.152**	0	-2.645	1	-2.119	5	-5.932***
Greece	0	-2.793	0	-1.162	2	-1.745	2	-5.637***
Iceland	0	-3.510*	1	-4.358**	3	-3.906**	0	-1.176
Ireland	5	-2.637	0	-2.454	2	-2.603	5	-2.166
Italy	0	-3.302	0	-1.674	1	-1.736	0	-3.037
Japan	0	-3.532*	0	-0.978	1	-3.273	0	-2.536
South Korea	0	-0.896	0	-2.564	5	-3.996**	0	-0.304
Luxemburg	0	-1.474	0	-3.357	3	-2.706	0	-1.550
Mexico	0	-2.443	0	-4.098**	1	-1.400	0	-2.158
Holland	7	-4.435**	0	-2.472	3	-2.400	0	-1.639
New Zealand	0	-3.777*	0	-3.696*	1	-1.865	0	-3.502
Norway	1	-4.173**	0	-1.300	6	-3.658*	0	-3.857**
Portugal	0	-2.156	0	-1.588	3	-3.757*	0	-3.045
Spain	0	-3.541*	0	-3.098	1	-4.798***	0	-2.571
Sweden	0	-2.015	0	-3.269	6	-1.341	0	-2.058
Switzerland	0	-4.470**	0	-3.806**	2	-2.149	0	-4.344**
Türkiye	0	-2.540	0	-2.262	2	-2.672	0	-2.554
England	0	-2.581	1	-2.832	1	-2.755	0	-4.538***
USA	0	-4.309**	0	-1.765	1	-2.700	0	-2.926
Critical Values	%1	-4.49	%1	-4.49	%1	-4.49	%1	-4.49
	%5	-3.79	%5	-3.79	%5	-3.79	%5	-3.79
	%10	-3.44	%10	-3.44	%10	-3.44	%10	-3.44

CIPS Unit Root Test								
Panel	0	-3.087***	0	-2.648*	0	-2.631*	0	-3.066***
Critical Values	%1	-2.79	%1	-2.79	%1	-2.79	%1	-2.79
	%5	-2.66	%5	-2.66	%5	-2.66	%5	-2.66
	%10	-2.59	%10	-2.59	%10	-2.59	%10	-2.59

Not: p indicates the optimum lag lengths. A Monte Carlo simulation with 10,000 iterations was used to calculate the p-value. Schwarz Information Criterion was used for the selection of optimum lag lengths, and analyses were conducted over a maximum of 8 lag lengths. Both stationary and trended structures were employed in the analyses, and factor selection was based on the method proposed by Bai and Ng. The Schwert structure was utilized for determining the maximum number of factors. *, **, and *** denote the stationary significance of the respective coefficients at the 10%, 5%, and 1% levels.

The results of the CADF unit root tests presented in Table 2 indicate that the Carbon variable was stationary at level [*I(0)*] for Australia, Chile, Denmark, Finland, Germany, Iceland, Japan, the Netherlands, New Zealand, Norway, Spain, Switzerland, and the USA. Moreover, the Growth variable was found to be stationary at level [*I(0)*] for Denmark, France, Finland, Iceland, Mexico, New Zealand, and Switzerland. The Urbanization variable exhibits level stationarity [*I(0)*] for Iceland, South Korea, Norway, Portugal, and Spain, whereas Energy Consumption variable was stationary at level [*I(0)*] for Austria, Australia, Denmark, France, Germany, Greece, Norway, Switzerland, and the United Kingdom. On the other hand, the CIPS test results, which indicate the stationarity information for the entire panel, revealed that all variables considered within the model are stationary at level [*I(0)*]. Overall, it can be stated that the variables used in the analysis are integrated at level.

The stationarity of variables at the level within the panel implies that coefficients pertaining to the relationships among these variables can be directly estimated. Accordingly, Table 3 presents the results of the dynamic panel threshold model analysis reflecting the impact of income threshold values on the relationships between environment and growth.

Table 3: Dynamic Panel Threshold Model Results

Dependent Variable: *LnCarbon*	
***LnIncome (Growth)* Threshold Value and Confidence Intervals**	
Threshold Value (γ)	3.204%**
95% Confidence Intervals	[2.070, 4.999]
Regime-Dependent Regressors: Effect of *LnIncome (Growth)* Variable	
Low Regime (β_1)	1.497** (0.048)
High Regime (β_2)	-1.959* (0.075)
Regime-Independent Regressors: Effect of Control Variables	
Constant (δ)	18.601*** (0.000)
LnUrbanization	1.173* (0.057)
LnEnergy Consumption	1.862** (0.041)
LnEnergy Consumption LnUrbanization*	3.248*** (0.000)
Statistics of Models	
R^2	0.765
F (Probability)	22.259*** (0.000)
DW	1.823
Unit Effect:	Yes
Time Effect:	Yes
Numbers of Observations	1568
Instrumental Variables	
$LnCarbon_{t-1}$, $LnCarbon_{t-2}$, $LnCarbon_{t-3}$	

Note: *, **, and *** denote that the respective coefficients are statistically significant at the 10%, 5%, and 1% levels, respectively. Ln represents the natural logarithm of the relevant variable. The values in parentheses indicate the probability values associated with the respective coefficient. In the selection of instrumental variables, all possible lag values of the dependent variable were determined considering a maximum of 10 lag lengths based on the SIC criterion.

The results of the dynamic panel threshold model shown in Table 3 indicate that the estimated growth threshold value is 3.204%, which falls within the 95% confidence interval. The analysis findings reveal that a 1% increase in economic growth leads to a 1.497% increase in carbon emissions until reaching the growth threshold of 3.204%, highlighting the exacerbation of environmental degradation with growth until this threshold is reached. However, after surpassing the 3.204% growth threshold, a 1% increase in growth leads to a 1.959% reduction in carbon emissions, indicating a decrease in environmental degradation with growth rates exceeding the threshold. In this context, it can be stated that the growth-environment relationships among OECD countries are consistent with the predictions of the Environmental Kuznets Curve hypothesis, exhibiting parabolic patterns between these variables and valid inverse-U relationships. Moreover, the results indicating the direct effect of urban population growth on the environment show that a 1% increase in urban population results in a 1.173% increase in carbon emissions, accelerating environmental degradation due to urbanization. Analysis findings reflecting similar outcomes for energy consumption reveal that a 1% increase in energy consumption leads to a 1.862% increase in carbon emissions, thus accelerating environmental degradation. On the other hand, it is observed that the combination of accelerated urbanization and increased energy consumption significantly increases carbon emissions, with a 1% increase in energy consumption accompanying urbanization leading to a 3.248% increase in environmental degradation.

Finally, it should be noted that the relatively high explanatory power of the analyses, the meaningfulness of the model as a whole, and the absence of autocorrelation problems indicate the reliability of the obtained results.

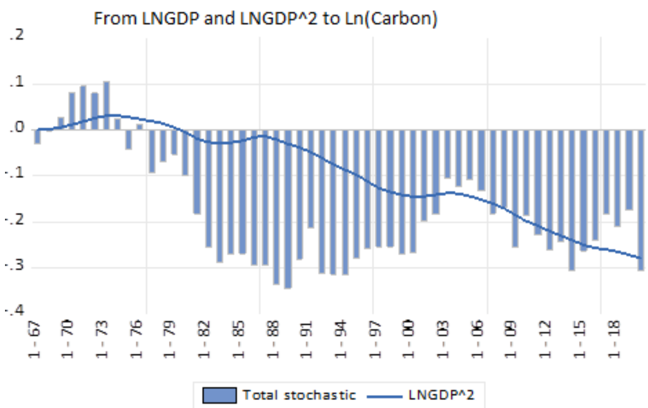

Figure 1: Relationships between Growth and Environment

5. Conclusion

In this study, the validity of the Environmental Kuznets Curve (EKC) hypothesis in 28 OECD member countries was investigated by using panel dynamic threshold model for the period of 1965-2020. In other words, this study questions whether the growth threshold value has an effect on the relationship between income or economic growth and the environment, and if so, it explores the nature of the relationships between the relevant variables.

For this purpose, the cross-sectional dependencies of the variables were examined first, and then the Breusch-Pagan CD LM1 analysis was employed. The analysis results indicated the presence of cross-sectional dependence both within variables and across the entire panel, suggesting the need for second-generation unit root tests to determine the stationarity of the variables. Accordingly, CADF and CIPS unit root tests were applied, revealing that all variables considered in the model were stationary at the level [*I(0)*]. Following the acquisition of stationarity information of the variables, a dynamic panel threshold model analysis was utilized to estimate the effect of income threshold value on the relationship between environment and growth. The analysis results demonstrated that economic growth increased carbon emissions until reaching a growth threshold value of 3.204%; however, after surpassing the growth threshold value, increases in the growth rate reduced environmental degradation. This result revealed the validity of the Environmental Kuznets Curve hypothesis and underscored the significant effect of income threshold value on the growth-environment relationship. In addition, the results emphasize that urban population growth accelerates environmental degradation, and increased energy consumption yields similar results.

Considering the analysis results as a whole, it can be stated that sustainable and future-oriented growth conditions need to be established in economic systems, thereby essential to preventing unsustainable growth processes. On the other hand, reducing energy consumption and limiting urban population growth can be of paramount importance in ensuring good, sustainable, and green growth conditions. Policy implementations supporting renewable energy production and usage, embracing the concept of sustainable economy, providing investment incentives to economic agents endorsing environmental activism movements and encouraging participation in them, educating society on environmental ethics and regulations to expedite the recycling process, and policies shifting the economic growth process from a quantitative to a qualitative level can lay the groundwork for fostering growth supportive of the future.

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