

## A New Approach to Sustainable Development: Analysis of the Environmental Phillips Curve Hypothesis

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### Sürdürülebilir Kalkınmaya Yeni Bir Yaklaşım: Çevresel Phillips Eğrisi Hipotezinin Analizi

#### Abstract

This study aims to test the Environmental Phillips Curve hypothesis, which assumes a negative relationship between environmental pollution and unemployment in the Next-11 countries in 1991-2018. In the study in which ecological footprint was used as an indicator of environmental pollution, the long-term relationship was estimated using the LM test, and the coefficient was estimated using the Augmented Mean Group and Dynamic Common Correlated Effects estimators. As a result of the empirical analysis, it was found that the EPC hypothesis is valid in the Next-11 countries; in other words, the increase in unemployment reduces environmental pollution.

**Keywords** : Sustainable Development, Ecological Footprint, Environmental Pollution.

**JEL Classification Codes** : Q01, Q57, Q53.

#### Öz

Bu çalışmanın amacı, Next-11 ülkelerinde 1991-2018 döneminde çevresel kirlilik ve işsizlik arasında negatif bir ilişki olduğunu varsayan Çevresel Phillips Eğrisi hipotezini test etmektir. Çevresel kirlilik göstergesi olarak ekolojik ayak izinin kullanıldığı çalışmada, LM testi ile uzun dönemli ilişki, Genişletilmiş Ortalama Grup ve Dinamik Ortak İlişkili Etkiler tahmincileri ile de katsayı tahmini yapılmıştır. Ampirik analiz sonucunda Next-11 ülkelerinde EPC hipotezinin geçerli olduğu, diğer bir ifade ile işsizlikteki artışın çevresel kirliliği azalttığı bulgusuna ulaşılmıştır.

**Anahtar Sözcükler** : Sürdürülebilir Kalkınma, Ekolojik Ayak İzi, Çevresel Kirlilik.

## 1. Introduction

Environmental pollution and global warming are among the most important problems that today's societies face (Adedoyin et al., 2020). For this reason, researchers and policymakers closely follow the relationship between economic activities with global warming and environmental pollution. Because rapid economic growth, increasing use of fossil (non-renewable) energy, and growing population put the ecosystem and biological diversity in danger, and they may cause irrecoverable environmental problems (Lotfalipour et al., 2010: 5115). Thus, besides aiming to increase their level of welfare, the countries also make an effort to make this development sustainable and minimise the negative effects of global warming and environmental pollution. In summary, nowadays, countries aim to achieve environmental sustainability without compromising on economic activities that will affect the level of welfare.

The relationship between environmental pollution and economic activities is investigated in the literature under different theories and hypotheses. First of them is the Environmental Kuznets Curve (EKC) hypothesis introduced by Grossman & Krueger (1991), claiming that there was an inverted U-shaped relationship between economic growth and environmental pollution (Panayotou, 1993; Grossman & Krueger, 1995). The second one is the Pollution Haven Hypothesis claiming that the heavy and pollutant industry in developed countries is transported to less developed countries, which have more flexible environmental regulations, through direct foreign investments and increases the environmental pollution in those countries (Cole, 2004; Taylor, 2005: 4-6). The third one is the Pollution Halo Hypothesis based on the idea that direct foreign investments popularise the use of environment-friendly production technologies by facilitating their transfer and contributing to the development of a more efficient production process (Birdsall & Wheeler, 1993; Kim & Adilov, 2012: 2598).

Various factors can directly or indirectly influence the environment, including economic growth and direct foreign investments. In this parallel, Kashem & Rahman (2020) drew attention to the relationship between the environment and unemployment (employment) and introduced the Environmental Phillips Curve (EPC) hypothesis. In the EPC hypothesis, it is assumed that, at the current technology level, there is a negative relationship between environmental pollution and unemployment (Kashem & Rahman, 2020: 31153-31154; Ng et al., 2022: 4). Accordingly, besides having a determinant effect on employment, economic growth also increases the pressure on the environment (Bhowmik et al., 2022: 14915). In this case, economic constriction (recession) is expected to increase unemployment and decrease environmental pollution. Hence, an inverse relationship between unemployment increases and environmental pollution is projected (Anser et al., 2021: 48113).

In the relevant literature, environmental pollution is represented by various pollution indicators such as carbon dioxide (CO<sub>2</sub>) emission, nitrogen dioxide (NO<sub>2</sub>) emission, carbon monoxide (CO) emission, methane gas (CH<sub>4</sub>) emission, sulphur dioxide (SO<sub>2</sub>) emission, and

ecological footprint (EFP). However, among these indicators, the environmental effects of CO<sub>2</sub> emission are more commonly investigated since it is the driving force of greenhouse gas and global warming. On the other hand, it is criticised that environmental pollution, a multi-dimensional concept, is represented by a limited indicator such as CO<sub>2</sub> emission, which only measures air pollution (Solarin, 2019: 6167). For this reason, it can be seen that recent studies started employing ecological footprint (EFP), which is an alternative and inclusive indicator, instead of CO<sub>2</sub> emission. Introduced first by Rees (1992) and Wackernagel & Rees (1996), EFP measures the demand of humans on nature and indicates to what extent the current ecological capacity is being used. In addition, the EFP consists of six subcomponents: carbon footprint, forest products footprint, cropland footprint, fishing grounds footprint, built-up land footprint, and grazing land footprint (Global Footprint Network [GFN], 2022).

Next-11 (N-11) refers to 11 developing economies (Bangladesh, Egypt, Indonesia, Iran, South Korea, Mexico, Nigeria, Pakistan, Philippines, Türkiye and Vietnam) having similar economic performance and population structure (Sachs, 2015). The present study focuses on N-11 countries for the following reasons. These countries are expected to be among the significant opponents of developed countries in the near future. Because N-11 countries having high performance constitute approximately 9% of the global gross domestic product (GDP) (World Bank, 2016). Nevertheless, these countries also produce approximately 10% CO<sub>2</sub> emissions (Energy Information Administration [EIA], 2015). Thus, high economic performance, increasing demand for energy, and resulting CO<sub>2</sub> emission increase the concerns regarding environmental pollution in these countries (Aslan et al., 2021: 2; Nathaniel, 2021). From this aspect, it can be stated that despite the disputes about the future of these countries, it is still important to investigate the environmental effects of the factors playing important roles in economic performance, such as technological advancement, energy consumption, population, and employment (Anser et al., 2021: 48113).

The present study aims to investigate the validity of the EPC hypothesis for N-11 countries for the period 1991-2018 within the frame of the STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology) environment model by considering the EFP. This study's novelties and potential contributions to the literature can be listed as follows: i) This is the first study testing the EPC hypothesis specifically on the N-11 countries. ii) Rather than CO<sub>2</sub> emission, the present study used EFP data, which is more inclusive than CO<sub>2</sub> emission because CO<sub>2</sub> emission indicates only the dimension of air pollution, whereas EFP also incorporates the levels of soil and water pollution, in addition to air pollution. iii) Instead of the traditional estimation methods, the present study employed current panel test methods considering the cross-sectional dependence. Since the traditional estimation methods do not consider cross-sectional dependence, the results obtained from empirical analysis need to be more accurate. iv) Unlike most previous studies, the STIRPAT environment model was preferred. Thanks to this model, the economic and socioeconomic variables can be objectively analysed from their environmental effects. v) EPC hypothesis, which is a new environmental pollution curve, was analysed in this study. In this context,

the present study, one of the few studies testing the validity of the EPC hypothesis, aims to bridge the mentioned gaps in the literature.

The remaining part of this study was planned as follows. The second section explains the Environmental Phillips Curve hypothesis. The third section summarises the current literature regarding the research subject, whereas the fourth section introduces the dataset and model used in the analysis. The fifth section, which describes the econometric method, is followed by the sixth section presenting the empirical findings. Then, the final section is the conclusion.

## 2. Environmental Phillips Curve Hypothesis

Countries having environmental consciousness aim to reduce environmental pollution without compromising their economic activities. For this purpose, reducing environmental pollution without decreasing economic activities (i.e., without increasing unemployment) is necessary. Nevertheless, it is now clear that economic activities have increased environmental pollution and further deepened the existing environmental problems. Therefore, the viable options that may overcome the environmental problems and increase the level of welfare are investigated (Kashem & Rahman, 2020: 31153).

The level of environmental pollution caused by economic activities gradually increases, and ecological limits are being pushed. In other words, it can be seen that economic activities directly or indirectly increase the pressure on the environment and cause environmental pollution (Panayotou, 1993; Ahmad et al., 2020: 1-2). From this aspect, it is assumed that there is a positive relationship between environmental pollution and economic growth. This positive relationship can be expressed in Equation (1) (Kashem & Rahman, 2020: 31154).

$$P = a + bY \quad (1)$$

In equation (1), P refers to environmental pollution and Y to income or economic growth.

Okun (1962) investigated the relationship between the unemployment rate and economic growth in the USA between 1948 and 1960 and concluded that these variables had a negative relationship. This negative relationship between unemployment and income was named Okun's Law. Unemployment decreases when income increases. Accordingly, unemployment is closely related to economic growth or income. This negative relationship between unemployment and income is shown in Equation (2).

$$U = c - dY \quad (2)$$

Examining Equations (1) and (2) together, it can be seen that there was a negative relationship between environmental pollution and unemployment. In Equation (2), U refers

to unemployment and Y to income or economic growth. The negative relationship between environmental pollution and unemployment can be seen in Equation (3).

$$P = g - hU \quad (3)$$

In Equation (3), P denotes environmental pollution, and U denotes unemployment.

Kashem & Rahman (2020) developed a new environmental pollution curve approach to examine the relationship between environmental pollution and unemployment. This approach was defined as the EPC hypothesis based on the assumption that unemployment is a negative function of environmental pollution. According to this hypothesis, there is a negative relationship between environmental pollution and unemployment; in other words, environmental pollution decreases as unemployment increases (Tanveer et al., 2021: 3).

Theoretically, the negative relationship between environmental pollution and unemployment can be explained using two different approaches. These are the approaches to economic growth and preferences. Considering the economic growth approach, unemployment hinders economic growth and reduces energy consumption. This situation is expected to reduce the use of natural sources and environmental pollution. On the other hand, in the preferred dimension, it is stated that unemployment reduces the income of the consumer, which makes it difficult to consume relatively expensive environmentally friendly goods and services (Bhowmik et al., 2020: 14916).

### 3. Literature Review

In literature, the environmental problems, which have reached life-threatening levels, especially since the late 21<sup>st</sup> century, are discussed over various theories and hypotheses. Such studies examine the environmental effects of economic growth, economic complexity index, trade openness, globalisation, foreign direct investments, and renewable and non-renewable energy consumption. Although the environmental effects of these variables have been widely discussed, the environmental effect of unemployment has been ignored until the recent period. Introduced by Kashem & Rahman (2020) as a new environmental pollution curve, the EPC hypothesis drew attention to this gap in the literature. Then, Anser et al. (2021), Tanveer et al. (2021), Bhowmik et al. (2022), Ng et al. (2022), and Tariq et al. (2022) analysed the validity of the EPC hypothesis, which claims a negative relationship between environmental pollution and unemployment.

Kashem & Rahman (2020) tested the validity of the EPC hypothesis in Organization for Economic Co-operation and Development (OECD) countries for the period of 1991-2016. For this purpose, they employed CO<sub>2</sub> emission as the environmental pollution indicator and used a Fixed Effect estimator. The estimations showed that, in most countries, empirical results supported the EPC hypothesis claiming that there was a negative relationship between environmental pollution and unemployment.

Using EFP as the indicator of environmental pollution, Anser et al. (2021) examined the validity of the EPC hypothesis for BRICS-T countries from 1992 to 2016 within the context of the STIRPAT model. The results of ARDL estimation proved the EPC hypothesis stating that there was a negative relationship between environmental pollution and unemployment in BRICS-T countries.

Using the ARDL method, Tanveer et al. (2021) tested the validity of the EPC hypothesis for Pakistan from 1975 to 2014. Unlike the study by Kashem & Rahman (2020), environmental pollution was represented by three different indicators (CO<sub>2</sub>, CH<sub>4</sub> and EFP). Confirming the EPC hypothesis, the results of ARDL analysis proved the negative relationship between unemployment and CO<sub>2</sub>, CH<sub>4</sub>, and EFP. Hence, it was observed that the increased unemployment rate in Pakistan decreased environmental pollution.

Bhowmik et al. (2022) investigated the validity of the EPC hypothesis for the USA from 1985 to 2018 within the frame of Narayan & Narayan's (2010) EKC hypothesis. In their study employing CO<sub>2</sub> emission as the indicator of environmental pollution, the coefficients were estimated using dynamic ARDL. According to the results obtained from estimations, the EPC hypothesis asserting a negative relationship between environmental pollution and unemployment was valid only in the long term.

Using EFP, Ng et al. (2022) analysed the validity of EKC and EPC hypotheses in 36 OECD countries from 1995 to 2015. While there is evidence that the EPC hypothesis is valid in the findings obtained from the Common Correlated Effect Mean Group (CCE-MG) and Augmented Mean Group (AMG) estimators, the validity of the EKC hypothesis could not be confirmed.

Using EFP data as environmental pollution indicator, Tariq et al. (2022) tested the validity of the EPC hypothesis from 1991 to 2019 in South Asian countries (Pakistan, India, Bangladesh and Sri Lanka) within the frame of the STIRPAT environment model. According to the results of PMG and ARDL estimations, it was found that there was a negative relationship between EFP and unemployment in South Asian countries and that the EPC hypothesis was valid.

Testing different countries and country groups within the context of various models may contribute to establishing sustainable policies. In this context, the present study aims to check the validity of the EPC hypothesis for N-11 countries from 1991 to 2018 within the scope of the STIRPAT model by using EFP. In the literature, it can be observed that there are only a few studies empirically testing the validity of the EPC hypothesis. Thus, it aims to contribute to the literature in which only a few studies exist.

#### **4. Dataset and Model**

Used as the indicator of environmental pollution, the data on EFP per capita were obtained from the Global Footprint Network website (GFN, 2022). The unemployment rate represented unemployment (UNE), whereas economic growth (GDP) was represented by

GDP per capita. Renewable energy consumption (REN) was defined by the share of renewable energy consumption in total final energy and total population data defined population (POP). UNE, GDP, REN, and POP data were provided from the World Development Indicators database (WDI, 2022). Descriptive information of variables is presented in Table 1.

**Table: 1**  
**Descriptive Information of Variables**

Abbreviation	Variable	Measurement	Source
EFP	Ecological footprint	Gha per person	GFN
UNE	Unemployment rate	Percentage of the labour force	WDI
GDP	GDP per capita	Constant 2015 US \$	WDI
REN	Renewable energy consumption	Percentage of total final energy	WDI
POP	Population	Total population	WDI

The STIRPAT environment model developed by Dietz & Rosa (1994) has widely been used in recent studies examining the relationship of socioeconomic variables with the environment. The STIRPAT environment model is based mainly on the IPAT model introduced by Ehrlich & Holdren (1971). IPAT model is expressed as in Equation (4).

$$I = P * A * T \quad (4)$$

In Equation (4), I, P, A, and T represent environmental effects, population, welfare, and technology level or energy, respectively. Although this model has many advantages, the IPAT model also has certain deficiencies. For instance, it was emphasised that the IPAT model ignored the non-linear relationships between the variables and could not be used in empirical analyses because of its mathematical form. Moreover, in this model, it was assumed that they had equal effects on the environment since the relative precedence of P, A, and T factors on the environment could not be distinguished (York et al., 2003; Wang et al., 2017: 3). To overcome these deficiencies, STIRPAT environment model was developed. In this model, the stochastic effects of socioeconomic variables on the environment can be analysed using the regression approach. The standard STIRPAT environment model is shown in Equation (5) (Anser et al., 2021: 48115).

$$EFP_{it} = \sigma P_{it}^{\alpha} A_{it}^{\beta} T_{it}^{\gamma} \varepsilon_{it} \quad (5)$$

After the logarithmic transformation, the STIRPAT environment model is presented in Equation (6).

$$\ln(EFP_{it}) = \sigma + \alpha(\ln P_{it}) + \beta(\ln A_{it}) + \gamma(\ln T_{it}) + \varepsilon_{it} \quad (6)$$

In Equation (6),  $\sigma$  refers to the constant term,  $\varepsilon_{it}$  refers to the error term,  $\alpha$ ,  $\beta$ , and  $\gamma$  refer to the coefficients, i refers to the dimension of cross-section, and t to the dimension of time.

The estimation model established following the study of Anser et al. (2021) investigating the EPC hypothesis within the frame of STIRPAT is presented in Equation (7).

$$\ln EFP_{it} = \alpha_0 + \beta_1 \ln UNE_{it} + \beta_2 \ln GDP_{it} + \beta_3 \ln REN_{it} + \beta_4 \ln POP_{it} + u_{it} \quad (7)$$

In Equation (7),  $EFP_{it}$  is the dependent variable and indicates the level of ecological footprint per capita of  $i$  country in time  $t$ , whereas  $UNE_{it}$  refers to the unemployment rate of country  $i$  in time  $t$ .  $GDP_{it}$  refers to the level of income per capita of country  $i$  in time  $t$ ,  $REN_{it}$  refers to the share of renewable energy in total energy consumption in country  $i$  in time  $t$ , and finally  $POP_{it}$  refers to the total population of country  $i$  in time  $t$ .

In Equation (7), a statistically significant and negative  $\beta_1$  coefficient indicates a reverse relationship between EFP and UNE. It suggests that the EPC hypothesis is valid. The  $\beta_2$  coefficient is expected to be positive because economic activities increase the pressure on the environment, whereas the  $\beta_3$  coefficient is expected to be negative since REN increases environmental pollution. Depending on countries' development and environmental consciousness levels, the  $\beta_4$  coefficient might be positive or negative.

## 5. Methodology

In the present study, the empirical method consists of 4 steps. In the first step, cross-sectional dependence was examined using the LM test of Breusch & Pagan (1980) and the  $CD_{LM}$  test of Pesaran (2004). Then the homogeneity/heterogeneity of the panel was tested using Pesaran & Yamagata (2008)'s Delta ( $\tilde{\Delta}$ ) and Delta adjusted ( $\tilde{\Delta}_{adj.}$ ) tests. In cross-sectional dependence (CSD) tests, the null hypothesis was that there was no CSD. In  $\tilde{\Delta}$  and  $\tilde{\Delta}_{adj.}$  tests, the null hypothesis was that there was homogeneity.

In the second step, the stationarity of variables was analysed using Cross-sectionally Augmented Dickey-Fuller (CADF) panel unit root test introduced by Pesaran (2007). CADF, which can be reliably employed in  $T > N$  and  $N > T$  cases, allows for separate testing of the individual stationarity for each cross-section. Moreover, Cross-sectionally Augmented IPS (CIPS) allows for testing the stationarity for the entire panel (Pesaran, 2007: 276-277). In the unit root test, the null hypothesis was that the variables were stationary, whereas the alternative hypothesis was that the variables had unit root (Pesaran, 2007: 298).

In the third step, the long-term cointegration relationship between variables was estimated using the  $LM_N^+$  test introduced by Westerlund & Edgerton (2007). With its bootstrap feature  $LM_N^+$  cointegration test considers the CSD. Furthermore, one of its important features is that it can be reliably used even for small sample panels. In  $LM_N^+$  cointegration test, the null hypothesis ( $H_0 = \sigma_i^2 = 0$ ) was that there was a cointegration relationship for "all units", whereas the alternative hypothesis ( $H_A = \sigma_i^2 > 0$ ) was that there was cointegration relationship for "some units" (Westerlund & Edgerton, 2007: 185-186).  $LM_N^+$  test statistic is shown in Equation (8).

$$LM_N^+ = \frac{1}{NT^2} \sum_{i=1}^N \sum_{t=1}^T \hat{\omega}_i^{-2} S_{it}^2 \quad (8)$$

$S_{it}$  refers to partially total process of completely changed estimation of  $z_{it}$ .  $\hat{\omega}_i^2$ , however, refers to the long-term variance of  $u_{it}$  within the context of  $\Delta x_{it}$ .

In the fourth step, the long-term coefficient estimation was performed using two different estimators, which were the Augmented Mean Group (AMG) estimator introduced by Eberhardt & Teal (2010) and Dynamic Common Correlated Effects (DCCE) estimator developed by Chudik & Pesaran (2015b).

AMG, which follows a common dynamic process, can be safely used under parameter heterogeneity, endogeneity, and CSD presence conditions. AMG estimator consists of two steps, as can be seen in Equation (9) and Equation (10) (Eberhardt & Bond, 2009: 2-3; Eberhardt & Teal, 2010).

$$\text{Step-1: } \Delta y_{it} = b' \Delta x_{it} + \sum_{t=2}^T c_t \Delta D_t + e_{it} \Rightarrow \hat{c}_t = \hat{\mu}_t^* \quad (9)$$

$$\text{Step-2: } \hat{b}_{AMG} = \frac{1}{N} \sum_i \hat{b}_i \quad (10)$$

In Equation (9),  $\Delta D_t$  denotes the difference of series, T-1 denotes time dummies, and  $\hat{\mu}_t^*$  denotes estimation coefficients. In Equation (10),  $\hat{b}_i$  denotes the average of individual coefficient estimations and  $\hat{b}_{AMG}$  denotes to panel AMG estimator.

Introduced by Chudik & Pesaran (2015b) as a new estimator, DCCE was developed based on Pesaran et al. (1999)'s Pooled Mean Group (PMG), Pesaran & Smith (1995)'s Mean Group (MG), Pesaran (2006)'s Common Correlated Effects (CCE), and Chudik & Pesaran (2015a)'s estimators. However, since PMG and MG estimators ignore CSD, it causes misleading estimations when used in the presence of CSD. Besides that, the CCE estimator does not consider the lag value of endogenous variables as independent variables. Given such deficiencies, the main advantages that DCCE estimator offers are as follows: i) It allows for panel heterogeneity and CSD and dynamic common relevant effects. ii) It does not lose its estimation power in the presence of structural breaks. iii) It shows a good performance for both balanced and non-balanced panels. iv) It yields robust results in small sample panels. v) It remarkably eliminates the endogeneity problem and can be safely used even under the weak exogeneity problem (Chudik & Pesaran, 2015b; Ditzen, 2018). The DCCE model is defined in Equation (11).

$$EFP_{it} = \alpha_i EFP_{it-1} + \beta_i X_{it} + \sum_{p=0}^{pT} \gamma_{xip} \bar{X}_{t-p} + \sum_{p=0}^{pT} \gamma_{yip} \bar{Y}_{t-p} + \mu_{it} \quad (11)$$

In Equation (11), EFP, the dependent variable, refers to ecological footprint, whereas  $EFP_{it-1}$  as the independent variable refers to the lag value of EFP.  $X_{it}$  refers to independent variable cluster (UNE, GDP, REN, and POP), whereas  $pT$  refers to the number of lags included in cross-sectional averages and  $\mu_{it}$  refers to the error term.

## 6. Empirical Results

CSD was determined using LM and  $CD_{LM}$  tests, whereas homogeneities of slope coefficients were tested using  $\tilde{\Delta}$  and  $\tilde{\Delta}_{adj}$  tests. Table 2 represents the test results.

**Table: 2**  
**Cross-sectional Dependence and Slope Homogeneity Test Results**

Variables	LM test	$CD_{LM}$ test
EFP	519.754***	44.312***
UNE	72.303*	1.650**
GDP	97.241***	4.028***
REN	90.178***	3.354***
POP	186.809***	12.567***
$EFP=f(UNE, GDP, REN, POP)$	70.605*	1.488*
Slope homogeneity test	$\tilde{\Delta}$ Test	$\tilde{\Delta}_{adj}$ Test
$EFP=f(UNE, GDP, REN, POP)$	14.813***	16.634***

Note: \*, \*\*, and \*\*\* represent the significance level at 10%, 5%, and 1%, respectively.

Given the results of CSD tests presented in Table 2, the null hypothesis assuming the absence of CSD for all variables and models, was rejected. Thus, it was determined that there was CSD for variables and models. The existence of CSD suggests that a shock on any countries constituting the panel will also be effective on the other countries. On the other hand, given the results of  $\tilde{\Delta}$  and  $\tilde{\Delta}_{adj}$  tests, the null hypothesis assuming that the model was homogeneous was rejected at the statistical significance level of 1% and found that the panel was heterogeneous. After determining the presence of CSD and the heterogeneity of the panel, the stationarity of variables was examined using the CIPS panel unit root test. Table 3 presents the results of the CIPS unit root test.

**Table: 3**  
**CIPS Unit Root Test Results**

Variables	At level	1 <sup>st</sup> difference
	Test statistics	Test statistics
EFP	-1.741	-3.411***
UNE	-1.992	-3.185***
GDP	-1.560	-2.302**
REN	-1.115	-3.204***
POP	-1.375	-2.175*

Notes: \*, \*\*, and \*\*\* indicate the significance level at 10%, 5%, and 1%, respectively. In the study of Pesaran (2007), critical values for  $T=28$  and  $N=11$  are -2.51 (1%), -2.25 (5%) and -2.12 (10%).

Given CIPS panel unit root test results shown in Table 3, the null hypothesis assuming that the panel had unit root could not be rejected for any variable at the level. Taking the first differences of variables, it was observed that the null hypothesis was rejected for all the variables. Hence, it was concluded that all the variables were stationary at the first difference. Then, the long-term cointegration relationships of variables were tested using the  $LM_N^+$  test. Table 4 shows the results of the  $LM_N^+$  cointegration test.

**Table: 4**  
**LM Cointegration Test Results**

$LM_{\alpha}^*$ test EFP=f(UNE, GDP, REN, POP)	Test statistic	Bootstrap p-value	Asymptotic p-value
	2.511	1.000	0.006

In Table 4, the asymptotic p-value applies to panels without CSD and the bootstrap p-value to panels with CSD. Since it was found that there was CSD, the long-term cointegration relationship was tested using the bootstrap p-value. Using the bootstrap-p value, the null hypothesis indicating the cointegration relationship could not be rejected. It was determined that EFP and UNE, GDP, REN, and POP variables moved together in the long term and were consequently cointegrated. Finally, the long-term coefficient estimations were performed using DCCE and AMG estimators. The results of DCCE and AMG estimations are provided in Table 5.

**Table: 5**  
**Results of DCCE and AMG Estimations**

Variables	EFP=f(UNE, GDP, REN, POP)		
	Coefficient	Std. error	p-value
DCCE estimation			
EFP (-1)	-0.990***	0.083	0.000
UNE	-0.065*	0.039	0.090
GDP	0.485***	0.134	0.000
REN	-0.142	0.096	0.142
POP	0.316	4.434	0.943
AMG estimation			
Cons.	15.908**	3.091	0.011
UNE	-0.081**	0.314	0.028
GDP	0.525***	0.140	0.000
REN	-0.307***	0.041	0.010
POP	-1.070***	0.264	0.008

Note: \*, \*\*, and \*\*\* denote the significance level at 10%, 5%, and 1%, respectively.

Given the results of DCCE estimations in Table 5, it can be seen that the UNE coefficient was statistically significant and negative. Accordingly, the validity of the EPC hypothesis, assuming a negative relationship between UNE and EFP, could be confirmed. On the other hand, the GDP coefficient was statistically significant and positive. In other words, the positive relationship between GDP and EFP suggests that economic activities increased the pressure on the environment. Finally, it was observed that the coefficients of REN and POP were statistically non-significant.

As seen in Table 5, the results of AMG estimation showed that the UNE coefficient was statistically significant and negative. It proves the validity of the EPC hypothesis, assuming a negative relationship between UNE and EFP. The results of the present study are in parallel with those reported by Kashem & Rahman (2020), Anser et al. (2021), Tanveer et al. (2021), Bhowmik et al. (2022), Ng et al. (2022), and Tariq et al. (2022). GDP coefficient was found to be statistically significant and positive. Thus, it can be seen that the advancements in economic activities increased environmental pollution. The REN coefficient was found to be statistically significant and negative. Given this finding, it can be stated that, as expected, renewable energy consumption decreased environmental

pollution. Finally, the POP coefficient was found to be statistically significant and negative. It suggests that environmental consciousness reduces environmental pollution.

## 7. Conclusion

Nowadays, countries' developmental priorities have been preserving the environment, economic growth and employment. Within this context, as a new perspective on sustainable development, the validity of the EPC hypothesis, assuming a negative relationship between environmental pollution and unemployment in N-11 countries, was tested in the present study. Given the cointegration test results, environmental pollution was found to have a statistically significant long-term relationship with unemployment, economic growth, renewable energy consumption, and population. In other words, it was observed that the variables moved together (i.e., were cointegrated) in the long term. Examining the long-term estimation results of DCCE and AMG, unemployment coefficients were statistically significant and negative. It confirms the validity of the EPC hypothesis, which assumes a negative relationship between environmental pollution and unemployment for N-11 countries. Accordingly, the increases in unemployment decrease the environmental pollution. In both estimators, the results showed that economic growth coefficients were statistically significant and positive. This finding indicated that, as expected, economic activities increased environmental pollution in N-11 countries. Based on the AMG estimation results, it was determined that the renewable energy consumption and population were found to be statistically significant and negative. This finding means that renewable energy consumption and population growth decreased environmental pollution. The fact that renewable energy consumption, as a clean and alternative source, decreased environmental pollution overlapped with the expectations. Besides, the finding that population growth would reduce environmental pollution suggests that environmental consciousness has arisen in N-11 countries.

Examining all the results, some policy suggestions aim to reduce environmental pollution with economic growth and employment increase in N-11 countries.

- Economic growth and employment policies should be compatible with sustainable environmental policies.
- Less-pollutant industries should be given priority, and employment and entrepreneurship in these industries should be encouraged.
- Renewable energy and carbon-retaining clean technologies should be supported. Renewable energy investments should be accelerated, tax incentives should be provided for direct or indirect industries, and bureaucratic burdens should be minimised.
- To reduce the pressure on the environment, clean production methods should be adopted.
- For a sustainable environment, society's level of environmental consciousness should be increased through practices like training, seminar, etc.

In further studies, the relationship between environmental pollution and unemployment might be investigated within various countries' Environmental Kuznets Curve (EKC) hypothesis.

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