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ASYMMETRIC RELATIONSHIP BETWEEN ENVIRONMENTAL PROTECTION EXPENDITURES AND ECONOMIC GROWTH: PANEL CAUSALITY FINDINGS FROM SELECTED OECD COUNTRIES

Abstract*. In this study, the causality relationship between environmental protection expenditures and economic growth is investigated for 13 selected OECD countries using the annual data set covering the period 1995-2019. First of all, the unit root test of the variables was carried out. The symmetric relationship for series found to be stationary at level values was investigated by Kónya (2006) bootstrap panel causality test. The asymmetrical relationship was carried out with the test applied by Yılancı and Aydın (2017) based on the tests of Granger and Yoon (2002) and Kónya (2006). According to the results of symmetric causality, a bidirectional relationship was found for Slovenia. A one-way relationship was found from environmental protection expenditures to the economic growth variable for Spain and Switzerland, and from the economic growth variable to environmental protection expenditures for Austria. It is seen that there are hidden relations for the Netherlands and Spain from the economic growth variable to the environmental protection expenditures for positive shocks, for France and Norway from the environmental protection expenditures to the economic growth variable for the negative shocks, and for the Czech Republic and Denmark from the economic growth variable to the environmental protection expenditures for the negative shocks.*

Keywords*: Environmental Protection Expenditure, GDP, Symmetric Causality, Asymmetric Causality.*

JEL Classification: O44, H50, Q56, C10

1. Introduction

The environment is a place where all living things continue their relationships throughout their lives. Environmental protection is one of the important issues for all countries. For this, governments make some expenditures for the protection of the environment, but the environmental protection levels of

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each country may differ. Broniewicz (2011) defined environmental protection expenditures as the total amount of capital and current expenditures made to minimise or zero the pollution of goods and services resulting from production and consumption activities. In addition, the author describes environmental protection investment expenditures as creating new and permanent resources and at the same time improving existing objects (restoration, enlargement, modernisation, rebuilding, etc.). Environmental protection current expenditures are expressed as the expenditures made to reduce, destroy, and eliminate the operating and maintenance costs, environmental pollution, and losses arising from the existing activities of the enterprises.

In 1776, Adam Smith saw the production of goods and services as an indicator of welfare and said that the more goods produced, the happier one would be. However, especially since the Brundtland Commission in 1987, it has become an important issue that the increase in welfare is not only dependent on economic growth, but that the environment should be of high quality and that this quality should be within the potential to increase it day by day. In other words, creating a quality environment at a certain level in order to increase the welfare of humanity is one of the main objectives of the economy (Ada, 2014). Therefore, environmental protection has become an important issue for developed countries. As a result of the production and consumption activities of developed countries, wastes and hazardous chemicals have been released, and biodiversity, air, soil, water, and pollution have occurred in many areas, leading to major problems such as climate change. As a result of the production and consumption activities of developed countries, big problems such as climate change have arisen by releasing wastes and hazardous chemicals, and by polluting biodiversity, air, soil, water, and many areas. This pollution is called "environmental pollution". Even if the economic growth of developed countries is similar, the level of care for environmental values, that is, environmental protection levels, may vary (Değirmenci and Aydın, 2020).

The rapidly increasing world economy, the world population, and the increasing demand for energy and natural resources have brought about environmental pollution and the problem of depletion of natural resources (OECD, 2012). Natural capital, which forms the basis for all economic activities and human welfare, is important because it is the most important asset of the world. However, they pose enormous risks to the finance, economic sectors and the well-being of the future, as people's demands for natural capital are unsustainable and unconsciously destroy natural capital. An example of one of the various risks caused by people's mismanagement of natural capital is the emergence of infectious diseases such as COVID-19, which emerged in the first months of 2020 and affected the whole world. The world has failed to sustainably manage its global asset portfolio. Global GDP per capita increased by more than 60% between 1992 and 2014, while natural capital stocks per capita fell by nearly 40%, undermining future economic growth and prosperity. In addition, one million animal and plant species are in danger of extinction (OECD, 2021).

The OECD, which is the subject of this study, within the scope of the welfare framework; It focuses on people rather than the economic system, the outcome instead of inputs and outputs, the distribution of welfare within the population, and both the objective and subjective aspects of welfare. It also considers sustainability in a cross-cutting way to identify how humanity's impact on a set of assets now will affect well-being in the future. The indicators developed by the OECD's Green Growth initiative in order to evaluate the environmental dimensions of welfare and economic production are defined as follows; i) environmental and resource productivity of the economy (e.g., environmentally adjusted multifactor productivity growth); ii) the natural asset base, which includes not only subsoil assets but also species and ecosystems; iii) environmental dimension of quality of life (e.g., air quality); iv) economic opportunities arising from environmental protection and policy responses to promote environmental sustainability (e.g., environmental taxes and expenditures) (OECD, 2021).

In this context, in this study, the objective is to examine the relationship between environmental protection expenditures and economic growth with the annual data set covering the period 1995-2019 for 13 selected OECD countries. For this, first of all, the unit root test of the variables was carried out, and Kónya (2006) bootstrap panel causality test was applied for the symmetrical relationship. For the asymmetrical relationship, analysis was performed with the Yılancı and Aydın (2017) test based on the Granger and Yoon (2002) and Kónya (2006) tests. In the second part of the study, an extensive literature review was included, in the third part, the data set and methods were introduced, and in the fourth part, the findings obtained from the analysis were shared with tables. Finally, in the fifth chapter, conclusions and policy recommendations are shared.

2. Literature Review

In the literature, the Environmental Kuznets Curve (EKC) is one of the most important and long controversial issues among scientists who examine the relationship between environmental quality and economic growth by analogy with the income-inequality relationship.

A large literature review has been conducted examining the relationship between environment, environmental protection expenditures, and economic growth, and some studies are as follows; Steinbach (2006), after explaining the concept and methodology related to environmental protection expenditures in detail, it has collected and shared statistics on environmental industry data in this area in a comparable way and explained the supply and demand of environmental products and services. Sencar (2007) examined the relationship between environmental protection and economic growth for Turkey and showed that there is no contradiction between environmental protection and economic growth for Turkey. Nuţă (2011) examined the relationship between environmental protection expenditures and economic growth for Romania using GDP and environmental expenditure data for the period 1993-2009. According to the findings obtained from the analysis, the author concluded that there is a direct relationship between GDP representing economic growth and environmental responsibility representing public environmental expenditures. Ada (2014) examined the relationship between the government's environmental protection expenditures and economic growth with the data of 1996-2011 for Turkey and European Union countries, with unit root, cointegration, and causality analyses. According to the findings obtained from the analysis, the author concluded that economic growth, except Luxembourg, has a negative effect on environmental protection expenditures and that there is a reciprocal causality between growth and environmental protection expenditures. Badulescu et al. (2016) examined the relationship between economic growth and environmental protection expenditures of some selected European countries using SPSS analysis methods using data from 1995-2011. According to their findings, they concluded that there are different relationships between these two variables for most countries, and that there is no relationship between GDP and environmental protection investments in about half of the countries. Karajewski (2016) examined the effect of public environmental protection expenditures on economic growth for 11 countries of Central Europe (Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia) with the data for the period 2001-2012 and the estimates of the panel model. According to the estimates obtained from the analysis, the author concluded that the increase in public environmental protection expenditures has a positive effect on economic growth. Hájek and Kubová (2016) statistically examined the central public expenditures for environmental protection of the Czech Republic with data for the period 1998-2014. According to their analysis, they concluded that spending from the state budget of CZK 32,698.3 million in 2015 and CZK 36,302.7 million in 2016 can be statistically expected, and expenditure on removing old environmental burdens will also decrease. Ansuategi and Marsiglio (2017) used two simple endogenous growth models to show that in the long run, a lower level of environmental protection spending can be beneficial for both economic growth and environmental degradation. Their conclusions from the analysis were that in order to protect the environment, it is not enough to allocate larger shares from GDP to effectively achieve higher environmental standards. Ladaru and Dracea (2017) examined the data for Romania for the period 2008-2015 and the effects of environmental protection expenditures on economic growth with the correlation method applied in the SPPS programme. According to the findings they obtained from the correlation analysis, they concluded that environmental protection expenditures made by non-specialised producers have the largest share of investments in environmental protection and have the most important effect on economic growth. Drăcea et al. (2020) analysed both the direct effect of environmental expenditures on pollution reduction and the indirect effect of these expenditures on GDP per capita for Romania by analysing data covering the period 2009-2018 with unit root tests. In line with the findings of the analysis, they concluded that economic growth is an important factor for the improvement of environmental protection. Değirmenci and Aydın (2020) examined the relationship between environmental protection expenditures, income distribution, and economic growth for selected OECD countries by using panel causality tests (Emirmahmutoglu and Kose (2011) and Kónya (2006)) with data for the period 1995-2017. With the findings they obtained from the analysis, they concluded that there is a unidirectional causality relationship from environmental protection expenditures to economic growth, and a bidirectional causality relationship between environmental protection expenditures and income inequality. Turjak et al. (2021) examined the environmental protection expenditures of the European Union member states with the data for the period of 2011-2018. Their findings from the analysis conclude that there are significant differences in spending on environmental protection among EU member states, as countries like France, Germany, and Italy spend more than countries like Finland, Croatia, and Slovenia. Wekulom (2021) examined the effect of GDP (independent variable) on environmental spending (dependent variable) for 180 countries in the world. In addition, the author determined other independent variables such as carbon emissions, urbanisation rate, and income level of each observation, being a member of the OECD and the Environmental Policy Index. The author concluded that GDP is an important factor, positively correlated with environmental protection expenditures, in all models. Joldeş and Pohatá (2021) analysed the relationship between environmental protection and economic growth for the countries of Hungary, Czech Republic, and Austria by using unit root and causality tests with data from 1995-2017. Based on the evidence from the analysis, they concluded that there is a positive correlation between environmental protection expenditures and economic growth for each country.

According to the literature review, it is revealed that there is a positive relationship between these two variables in most of the studies examining the relationship between government environmental protection expenditures and economic growth with different country groups and different analyses. In this study, it is aimed that this study will contribute to the literature, since the selected OECD countries, which are the country group that have not been discussed much in the literature, are examined and comparative results are obtained by using two types of econometric analysis methods, where asymmetry is not taken into account and taken into account.

3. Data Set and Methodology

In this study, the symmetrical relationship between environmental protection expenditure (EPE) and economic growth (GDP) for 13 selected OECD countries (Austria, Czech Republic, Denmark, Estonia, France, Ireland, Netherlands, Norway, Portugal, Slovenia, Spain, Switzerland, and Great Britain) and the existence of an asymmetric causality relationship is desired to be revealed. For this purpose, annual data covering the period 1995-2019 were accessed from the official database of the International Monetary Fund (IMF) and the World Bank. Environmental protection R&D expenditures are taken as a percentage of GDP for the environmental protection expenditure variable and GDP per capita (constant 2010 US$) for the economic growth variable. In the IMF database, public environmental protection expenditures are shown in six items: waste management expenditures, wastewater management expenditures, pollution reduction expenditures, biodiversity, and natural life expenditures, R&D expenditures, and other unclassified expenditures (Değirmenci and Aydın, 2020).

For the econometric analysis, cross-sectional dependency research of the variables was carried out, and then it was seen that both EPE and GDP variables should be applied for the 2nd generation tests. In this direction, the unit root test (CIPS) was suggested by Pesaran (2007) to avoid the cross-section problem and the unit root test (PANIC) based on the stationarity of residuals and common factors proposed by Bai and Ng (2004, 2010) were applied. Then, the symmetric and asymmetric causality relationship between the variables was tested. For this purpose, Kónya (2006) bootstrap panel causality test was used for the symmetrical relationship, and the asymmetrical relationship was carried out with the panel causality test proposed by Yılancı and Aydın (2017) based on Granger and Yoon (2002) and Kónya (2006) tests.

3.1. PANIC (2010) Unit Root Test

This unit root test, which is performed by panel data analysis of residuals and common factors stationarity, was proposed by Bai and Ng (2004, 2010). The aim here is to examine the stationarity of the residuals and the factors separately. The data generation process is as follows:

$$X_{i,t} = D_{it} + \lambda_i' F_t + e_{i,t} \quad (1)$$

$$(1 - L)F_t = C(L)\eta_t \quad (2)$$

$$e_{i,t} = \rho_i e_{i,t-1} + \varepsilon_{i,t} \quad (3)$$

The variable X_{it} consists of the sum of the common factor and the residuals. The F_t variable is used to eliminate the cross-section dependency problem. Factor estimates were obtained as a result of applying the principal components method to the first difference data. Consistent estimation of factors, regardless of whether the residuals are stationary or not, does not require the residuals to be stationary. The advantage of this test is that when the unit root in the factors is rejected, the unit root in the residuals is tested. MQ_c^c and MQ_f^c tests are used to investigate the stationarity of the cofactors.

For the stationarity of the residuals, the PANIC test statistics P_a and P_b are used. They were constructed from the p values of the ADF test statistics investigating the individual stationarity of e_{it}. P_a shows the results of the constant ADF test, and P_b shows the results of the constant and trended ADF test. In addition, the results of the panel-corrected Sargan and Bhargava (PMSB) test developed by Stock (1999), in which e_{it} is autocorrelated, are also available.

3.2. Bootstrap Panel Asymmetric Causality Test (Yılancı and Aydın, 2017)

The asymmetry in variables is defined as the different responses of an economic time series to both positive and negative shocks, and the responses of such variables to shocks may be different. Therefore, ignoring these differences causes the existing relationship between the variables to appear as if they do not exist. This leads to debates on whether the tests are reliable or not. When considering the asymmetry, the existence of hidden relationships between the variables can be revealed, and thus the positive and negative components of the variables are analysed separately for each unit in the panel. For this reason, two types of econometric analysis methods, in which asymmetry is not taken into account and taken into account, were used in this study, and the objective was to contribute to the literature by presenting comparative results.

The symmetrical relationship between the variables was examined with the bootstrap panel causality Kónya (2006) test. This panel causality test is based on Seemingly Unrelated Regression (SUR). Since unit-specific bootstrap critical values are used in the Kónya (2006) causality test, no pre-test (unit root or cointegration) is required, except for the determination of any lag length. In structures where asymmetry is not taken into account, such as the Kónya causality test, it is assumed that the effect of negative shocks is the same as that of positive shocks. However, Granger and Yoon (2002) suggested that the relationship between positive and negative shocks may differ from the relationship between variables and suggested transforming the data to obtain positive and negative shocks and testing the long-run cointegration relationship between shocks. They defined the name of this approach as the hidden cointegration test. Inspired by the work of Granger and Yoon (2002), Yılancı and Aydın (2017) proposed a new panel causality test to test the asymmetric causality between variables. For this panel causality test, which is based on the Kónya causality test, first of all, the relevant variables of the units that make up the panel were divided into positive and negative shocks by Yılancı and Aydın (2017).

$$X_{it} = X_{it-1} + \varepsilon_{it} = X_{it,0} + \sum_{i=1,j=1}^{t,n} \varepsilon_{ij} \qquad (4)$$

$$Y_{it} = Y_{it-1} + e_{it} = Y_{it,0} + \sum_{i=1,j=1}^{t,n} e_{ij} \qquad (5)$$

$X_{it,0}$ and $Y_{it,0}$ represent the initial values and error terms with the white noise process $\varepsilon_{ij} \sim N(0, \sigma^2_{\varepsilon_{it}})$ and $e_{ij} \sim N(0, \sigma^2_{e_{it}})$ means. The positive and negative shocks for each variable are defined as follows:

$$\varepsilon^+_{it} = Max(\varepsilon_{it}, 0),\ \varepsilon^-_{it} = Min(\varepsilon_{it}, 0) \qquad (6)$$

$$e^+_{it} = Max(e_{it}, 0),\ e^-_{it} = Min(e_{it}, 0) \qquad (7)$$

The error terms are now $\varepsilon_{it} = \varepsilon^+_{it} + \varepsilon^-_{it}$ and $e_{it} = e^+_{it} + e^-_{it}$ and equations (4) and (5) are rewritten as follows:

$$X_{it} = X_{it-1} + \varepsilon_{it} = X_{it,0} + \sum_{i=1,t=1}^{t,n} \varepsilon^+_{it} + \sum_{i=1,t=1}^{t,n} \varepsilon^-_{it} \qquad (8)$$

$$Y_{it} = Y_{it-1} + e_{it} = Y_{it,0} + \sum_{i=1,t=1}^{t,n} e^+_{it} + \sum_{i=1,t=1}^{t,n} e^-_{it} \qquad (9)$$

Thus, Yılancı and Aydın (2017) defined positive and negative shocks for each variable as follows:

$$X_{it}^{+} = \sum_{i=1,j=1}^{t,n} \varepsilon_{ij}^{+},\ X_{it}^{-} = \sum_{i=1,j=1}^{t,n} \varepsilon_{ij}^{-} \quad (10)$$

$$Y_{it}^{+} = \sum_{i=1,j=1}^{t,n} e_{ij}^{+},\ Y_{it}^{-} = \sum_{i=1,j=1}^{t,n} e_{ij}^{-} \quad (11)$$

After this stage, Yılancı and Aydın (2017) suggested applying the bootstrap panel causality method of Kónya (2006) to test the causality relationship between both positive and negative components of the variables in the panel. Unit-specific bootstrap critical values are calculated, thus eliminating the need to search for the stationarity condition of the variables in the system. The SUR model of the asymmetric bootstrap panel causality test is as follows:

$$\begin{aligned} Y_{1,t}^{+} &= \alpha_{1,1} + \sum_{j=1}^{ly_1} \beta_{1,1,j} Y_{1,t-j}^{+} + \sum_{j=1}^{lx_1} \delta_{1,1,j} X_{1,t-j}^{+} + \varepsilon_{1,1,t}^{+} \\ Y_{2,t}^{+} &= \alpha_{1,2} + \sum_{j=1}^{ly_1} \beta_{1,2,j} Y_{2,t-j}^{+} + \sum_{j=1}^{lx_1} \delta_{1,2,j} X_{2,t-j}^{+} + \varepsilon_{1,2,t}^{+} \\ &\vdots \\ Y_{N,t}^{+} &= \alpha_{1,N} + \sum_{j=1}^{ly_1} \beta_{1,N,j} Y_{N,t-j}^{+} + \sum_{j=1}^{lx_1} \delta_{1,N,j} X_{N,t-j}^{+} + \varepsilon_{1,N,t}^{+} \end{aligned} \quad (12)$$

$$\begin{aligned} X_{1,t}^{+} &= \alpha_{2,1} + \sum_{j=1}^{ly_1} \beta_{2,1,j} Y_{1,t-j}^{+} + \sum_{j=1}^{lx_1} \delta_{2,1,j} X_{1,t-j}^{+} + \varepsilon_{2,1,t}^{+} \\ X_{2,t}^{+} &= \alpha_{2,2} + \sum_{j=1}^{ly_1} \beta_{2,2,j} Y_{2,t-j}^{+} + \sum_{j=1}^{lx_1} \delta_{2,2,j} X_{2,t-j}^{+} + \varepsilon_{2,2,t}^{+} \\ &\vdots \\ X_{N,t}^{+} &= \alpha_{2,N} + \sum_{j=1}^{ly_1} \beta_{2,N,j} Y_{N,t-j}^{+} + \sum_{j=1}^{lx_1} \delta_{2,N,j} X_{N,t-j}^{+} + \varepsilon_{2,N,t}^{+} \end{aligned} \quad (13)$$

Here, l represents the optimal lag length that can be selected using Akaike or Schwarz information criteria, and the error terms may also be cross-sectional related (Yılancı and Aydın, 2017). In testing the causality relationship, Wald tests are used here, as in the Kónya (2006) test. There are four types of causality relationships in the system for the asymmetric bootstrap panel causality test:

i. If all $\beta_{2,i} = 0$ (others nonzero), there is unidirectional causality from $X_t^{+}$to Y_t^{+}.

ii. In contrast to the first premise, there is unidirectional causality from Y_t^{+} to X_t^{+} when all $\delta_{1,i} = 0$ and some $\beta_{2,i} \neq 0$.

iii. When $\delta_{1,i} \neq \beta_{2,i} \neq 0$ there is bidirectional causality between the variables Y_t^{+} and X_t^{+}.

iv. When $\delta_{1,i} = \beta_{2,i} = 0$, there is no causality relationship between Y_t^{+} and X_t^{+} variables.

For negative shocks, equations are established similarly to the equations (12) and (13), and these four situations are valid for causality.

4. Findings

4.1. Descriptive Statistics

The descriptive statistics of the variables are presented in the table below. While the average environmental protection expenditure value of the 13 OECD countries considered was calculated as 0.031, the average GDP per capita was calculated as US$ 41879.623.

Table 1. Descriptive Statistics of Variables

Variable	Country	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
EPE	Austria	0.027	0.026	0.035	0.020	0.004	0.307	2.405	0.761 (0.684)
	Czech Republic	0.025	0.024	0.031	0.019	0.004	0.218	1.775	1.761 (0.415)
	Denmark	0.061	0.042	0.151	0.018	0.047	0.942	2.197	4.369 (0.113)
	Estonia	0.064	0.062	0.131	0.033	0.027	0.623	2.605	1.777 (0.411)
	France	0.020	0.017	0.036	0.005	0.010	0.397	1.960	1.782 (0.410)
	Ireland	0.005	0.006	0.009	0.001	0.002	-0.206	1.832	1.598 (0.450)
	Netherlands	0.016	0.016	0.019	0.011	0.002	-0.694	2.712	2.090 (0.352)
	Norway	0.042	0.033	0.135	0.016	0.031	1.810	5.381	19.554 (0.000)
	Portugal	0.036	0.026	0.059	0.019	0.016	0.341	1.371	3.251 (0.197)
	Slovenia	0.026	0.018	0.051	0.004	0.016	0.241	1.529	2.496 (0.287)
	Spain	0.021	0.020	0.029	0.015	0.005	0.403	1.827	2.108 (0.349)
	Switzerland	0.030	0.031	0.035	0.023	0.004	-0.419	1.788	2.263 (0.323)
	Great Britain	0.030	0.032	0.049	0.011	0.010	-0.405	2.155	1.428 (0.490)
GDP	Austria	44933.290	46123.490	50654.730	36537.990	4097.894	-0.633	2.254	2.248 (0.325)
	Czech Republic	18353.440	19424.270	23833.520	13462.990	3256.334	-0.078	1.737	1.687 (0.403)
	Denmark	57829.690	58487.790	65147.430	49122.870	4059.862	-0.401	2.689	0.772 (0.679)
	Estonia	14279.870	14790.820	20741.910	7209.403	4005.650	-0.289	1.883	1.648 (0.439)
	France	39849.230	40638.330	44317.390	33917.930	2793.302	-0.697	2.743	2.093 (0.351)
	Ireland	51142.620	48715.180	79703.410	29694.650	12764.140	0.606	3.035	1.533 (0.465)
	Netherlands	48816.510	50533.510	55689.990	38676.070	4540.581	-0.698	2.733	2.104 (0.349)
	Norway	85794.460	88174.160	92556.320	70409.720	5997.013	-1.070	3.240	4.831 (0.089)
	Portugal	21718.520	21858.120	24590.430	18059.220	1488.883	-0.662	3.686	2.317 (0.314)
	Slovenia	21742.400	22989.930	27152.130	15141.930	3472.270	-0.421	2.102	1.580 (0.453)
	Spain	29625.200	30147.000	33349.710	23737.480	2613.161	-0.847	2.929	2.997 (0.223)
	Switzerland	71644.810	73189.190	79406.660	61773.100	5503.846	-0.390	1.877	1.945 (0.378)
	Great Britain	38705.060	39731.490	43688.440	30679.540	3759.900	-0.743	2.508	2.552 (0.279)

Note: Values in parentheses indicate probability values.

As can be seen in Table 1, it is seen that for the 13 selected OECD countries, both the EPE and the GDP variables have a normal distribution, excluding Norway. Denmark had the largest share of environmental protection expenditures in 2003 with 0.151, while Ireland had the lowest share with 0.001 in 1996. In addition, it is seen that the standard deviation values are not very high and are reported to be almost the same. Therefore, this shows that the data for each variable does not follow a very scattered structure. The highest GDP per capita was recorded for the country of Norway in 2019, while the lowest value was reported for the country of Estonia in 1995.

A cross-sectional dependency test was performed to decide which of the panel data analysis methods (1st generation tests or 2nd generation tests) would be applied to the variables in question, and the results are presented in the table below:

Table 2. Cross-Section Dependency Test Results

	EPE	GDP
	Statistics	Statistics
Breusch-Pagan LM	485.166 (0.000)***	1720.821 (0.000)***
Pesaran scaled LM	32.599 (0.000)***	131.531 (0.000)***
Bias-corrected scaled LM	32.329 (0.000)***	131.260 (0.000)***
Pesaran CD	6.251 (0.000)***	41.437 (0.000)***

Note: *** indicates significance at the 1% level and values in parentheses indicate probability values.

According to the results obtained from Table 2, it is seen that the main hypothesis that there is no cross-sectional dependence will be rejected at the 1% significance level. Therefore, it is seen that there is a cross-sectional dependence for the panel members, and 2nd generation tests should be used. For this reason, the results of the unit root research carried out by PANIC (2010) and CIPS (2007) tests for the two variables discussed are presented in the tables below.

Table 3. PANIC Unit Root Test Results

			Constant			Constant and Trend	
			Test Stat.	Prob.		Test Stat.	Prob.
EPE	$Idiosyncratic\ Components$	P_a	-19.890	0.000***	P_a	-9.425	0.000***
		P_b	-7.834	0.000***	P_b	-6.309	0.000***
		PMSB	-2.900	0.002***	PMSB	-2.489	0.006***
	$Common\ Factors$	MQ_c^c	-8.433	0.000***	MQ_c^c	-9.906	0.000***
		MQ_f^c	-10.500	0.000***	MQ_f^c	-10.604	0.000***
GDP	$Idiosyncratic\ Components$	P_a	-27.523	0.000***	P_a	-17.732	0.000***
		P_b	-9.523	0.000***	P_b	-10.803	0.000***
		PMSB	-2.560	0.005***	PMSB	-2.807	0.003***
	$Common\ Factors$	MQ_c^c	-11.846	0.000***	MQ_c^c	-11.835	0.000***
		MQ_f^c	-10.056	0.000***	MQ_f^c	-9.905	0.000***

Note: *** indicates significance at the 1% level.

Table 3 shows the PANIC panel unit root test results. According to the test results, it is seen that both EPE and GDP variables are stationary at the level.

Table 4. CIPS Unit Root Test Results

	Constant	Constant and Trend
EPE	-3.529***	-3.881***
GDP	-4.028***	-4.009***

Note: *** indicates significance at the 1% level. For critical values, see Pesaran (2007).

The CIPS test results obtained from Table 4 are similar to the PANIC panel unit root test results, and it is seen that both EPE and GDP variables are I (0).

The causality relationship tests between the variables found to be stationary at the level were examined both symmetric and asymmetric, and the results are presented in the tables below.

Table 5. Symmetric Causality Test Results (Kónya (2006)

H_0: EPE does not cause GDP	**Wald Stat.**	**Bootst. Prob**	**1%**	**5%**	**10%**
Austria	5.183	0.195	21.539	12.494	9.244
Czech Republic	1.725	0.813	102.763	56.761	42.218
Denmark	0.784	0.502	12.213	6.579	4.713
Estonia	0.651	0.623	21.032	12.686	8.319
France	5.652	0.866	98.820	59.129	46.253
Ireland	0.315	0.658	10.193	6.160	3.817
Netherlands	0.011	0.990	76.161	51.200	36.816
Norway	2.844	0.603	30.378	17.555	13.808
Portugal	1.576	0.443	19.523	10.616	7.918
Slovenia	10.756	0.036**	16.732	9.861	6.558
Spain	55.864	0.000***	23.707	14.457	9.358
Switzerland	13.722	0.047**	25.128	12.882	8.739
Great Britain	0.460	0.899	73.477	42.366	28.610
H_0: GDP does not cause EPE					
Austria	4.773	0.022**	5.604	3.791	2.951
Czech Republic	13.092	0.621	68.644	43.857	35.556
Denmark	0.820	0.195	3.896	2.002	1.382
Estonia	5.206	0.568	37.004	21.884	16.642
France	3.195	0.986	36.075	27.179	22.268
Ireland	1.171	0.809	15.287	9.874	7.452
Netherlands	0.125	0.741	11.442	5.020	3.461
Norway	0.636	0.429	6.042	3.321	2.341
Portugal	3.065	0.723	22.657	13.549	11.367
Slovenia	11.092	0.085*	17.305	13.084	10.706
Spain	0.417	0.787	8.598	5.505	4.336
Switzerland	6.953	0.314	19.744	14.567	11.421
Great Britain	1.495	0.981	49.124	34.060	27.412

Note: *** and ** indicate 5% and 1% significance level, respectively. Analyses were performed with 10000 bootstrap simulations.

According to the Kónya (2006) causality analysis results obtained from Table 5, while there is a symmetric causality relationship from the EPE variable to the GDP variable for Slovenia, Spain, and Switzerland, there is a symmetrical causality from the GDP variable to the EPE variable for Austria and Slovenia. For other countries, no causality could be determined according to the test result.

Kónya (2006) cannot reveal the hidden relationship between shocks because it is a symmetric test. For this reason, Yılancı and Aydın (2017) asymmetric panel causality results are as follows:

Table 6. Asymmetric Causality Test Results (Yılancı ve Aydın (2017)

H_0: EPE^+ does not cause GDP^+	Wald Stat.	1%	5%	10%	Bootst. Prob
Austria	7.136	95.978	63.610	52.209	0.963
Czech Republic	30.729	199.628	124.379	101.864	0.818
Denmark	4.319	26.079	17.801	14.456	0.621
Estonia	11.529	70.246	45.887	37.054	0.667
France	1.258	33.751	22.266	17.896	0.991
Ireland	0.242	19.276	12.087	9.236	0.904
Netherlands	11.240	41.612	27.585	21.923	0.439
Norway	8.903	29.925	22.227	18.498	0.557
Portugal	6.399	53.305	37.365	31.155	0.932
Slovenia	8.196	20.791	14.996	12.585	0.354
Spain	2.803	22.687	15.070	11.849	0.707
Switzerland	14.793	39.911	26.941	21.822	0.267
Great Britain	8.607	77.662	55.768	44.576	0.896
H_0: GDP^+ does not cause EPE^+					
Austria	0.099	147.569	93.274	73.417	0.997
Czech Republic	0.965	174.797	101.059	74.744	0.973
Denmark	3.456	15.527	7.832	5.288	0.175
Estonia	2.288	14.651	8.531	6.185	0.344
France	6.795	36.715	22.016	16.529	0.377
Ireland	0.880	14.133	7.947	5.754	0.554
Netherlands	46.800	41.973	24.557	17.208	0.007***
Norway	2.718	8.543	5.004	3.498	0.157
Portugal	7.800	43.051	28.848	22.412	0.601
Slovenia	0.684	9.281	10.677	7.450	0.673
Spain	8.189	16.192	8.563	5.731	0.055*
Switzerland	1.702	27.934	15.155	11.081	0.604
Great Britain	11.105	32.091	20.075	15.622	0.206
H_0: EPE^- does not cause GDP^-					
Austria	0.229	13.244	8.955	7.448	0.972
Czech Republic	0.971	12.458	8.650	6.972	0.742
Denmark	1.184	50.200	34.382	28.132	0.763
Estonia	25.762	51.748	38.155	32.390	0.238
France	19.285	31.793	22.216	17.795	0.078*
Ireland	4.397	20.264	13.761	10.972	0.553

Netherlands	13.595	23.911	17.704	15.193	0.148
Norway	39.922	40.772	33.009	29.770	0.011**
Portugal	14.811	95.526	63.390	52.619	0.951
Slovenia	9.695	27.449	19.915	16.709	0.508
Spain	28.806	55.508	43.568	39.006	0.405
Switzerland	0.554	20.797	14.026	11.126	0.941
Great Britain	3.635	23.502	16.880	13.561	0.697
H_0: GDP^{-} does not cause EPE^{-}					
Austria	62.446	166.825	114.660	94.987	0.289
Czech Republic	134.713	168.166	122.454	106.104	0.034**
Denmark	516.918	517.159	371.814	315.817	0.010**
Estonia	0.012	176.350	122.677	106.170	0.999
France	144.143	386.566	290.871	249.036	0.697
Ireland	6.919	76.334	50.609	41.394	0.866
Netherlands	82.974	191.346	148.500	132.634	0.570
Norway	35.319	73.302	49.293	38.523	0.124
Portugal	7.730	174.290	118.741	98.552	0.951
Slovenia	18.496	185.062	128.602	109.067	0.947
Spain	41.090	201.050	141.963	117.735	0.672
Switzerland	46.125	125.391	77.953	60.403	0.198
Great Britain	11.131	225.811	150.473	126.420	0.971

According to the results obtained from Table 6, no causal relationship was found between the positive shocks of the environmental protection expenditures variable (EPE^{+}) to the positive shocks of the economic growth variable (GDP^{+}). A causal relationship was found between the Netherlands and Spain from the positive shocks of the economic growth variable (GDP^{+}) to the positive shocks of the environmental protection expenditures variable (EPE^{+}). There is a causal relationship between France and Norway from the negative shocks of the environmental protection expenditures variable (EPE^{-}) to the negative shocks of the economic growth variable (GDP^{-}). It is concluded that there is causality for the Czech Republic and Denmark from the negative shocks of the economic growth variable (GDP^{-}) to the negative shocks of the environmental protection expenditures variable (EPE^{-}).

5. Conclusions

In this study, it is desired to test the symmetric and asymmetric causal relationship between environmental protection expenditures and economic growth with data sets obtained from IMF and World Bank official databases for 13 selected OECD countries. Yılancı and Aydın (2017) asymmetric causality tests based on Kónya (2006) chimeric and Granger and Yoon (2002) and Kónya (2006) tests were carried out with annual observations covering the period 1995-2019. Kónya (2006) completed the test procedure without considering the stationarity degrees of the series in his test. However, the levels of stationarity of the variables discussed in this study were investigated by PANIC and CIPS tests and were found to be stationary at the level. In addition, the Kónya (2006) test does not search for a cointegration relationship between the variables, the only important criterion being the presence of cross-section dependence. As a result of the cross-sectional dependency test, it is seen that there is a cross-sectional dependence for the panel units. As a result of the symmetric causality test, while there is a relationship between the environmental protection expenditure variable to the economic growth variable for Slovenia, Spain, and Switzerland, the causality finding is reached for Austria and Slovenia from the economic growth variable to the environmental protection expenditure variable. However, in this study, a clear and direct result could not be obtained to support the fact that they attach more importance to environmental protection expenditures, or that the national income per capita rises as environmental protection expenditures increase, although they have achieved economic growth for the other nine countries that are the subject of the study. This may be due to; since a significant part of the countries subject to the study - excluding countries such as Estonia and Slovenia- were already in the category of developed countries before the data period (1995-2019) used in the study, their per capita income levels are high and environmental protection expenditures are at a certain level. For this reason, it can be said that there is no significant jump in the positive or negative direction in the time period used in the study. As a result of the asymmetric causality test, no causality relationship was found from the positive shocks of the environmental protection expenditures variable to the positive shocks of the economic growth variable. It can be thought that this is due to the fact that environmental protection expenditures do not have a large weight in the expenditure items that affect the GDP, which will positively affect the per capita national income. A causal relationship was obtained for the Netherlands and Spain from the positive shocks of the economic growth variable to the positive shocks of the environmental protection expenditures variable. This shows that the increase in the gross domestic product per capita has a positive effect on environmental protection expenditures indirectly in these countries. There is a causal relationship between France and Norway from the negative shocks of the environmental protection expenditures variable to the negative shocks of the economic growth variable. This means that the decrease in environmental protection expenditures has a negative impact on per capita national income, which may mean that sectoral employment in these countries in terms of environmental awareness is much more common and higher than in other countries. It is concluded that there is causality for the Czech Republic and Denmark from the negative shocks of the economic growth variable to the negative shocks of the environmental protection expenditures variable. From this, we can think that economic growth causes an increase in environmental protection expenditures, which is a reflection of the increase in environmental negative effects of economic growth (such as increases in particulate matter emissions) in these countries.

In this context, important steps should be taken, both economically and environmentally, and well-designed policies should be determined. Due to the increasing world population and the rapid increase in the demand for energy and natural resources, more effective policies should be adopted because the world economy consumes much more energy. It is obvious that the benefits of early and correct actions to be taken on environmental problems will outweigh the costs of protecting the environment. International cooperation is indispensable for both economic and environmental problems, and international financing is required for this. Also, green innovations should be encouraged and investments should be made in public support for R&D.

REFERENCES

[1] **Ada, A.A. (2014),** ***Environmental protection Expenditure and Economic growth: A panel Data Analysis for the EU and Turkey.*** *British Journal of Economics, Finance and Management Sciences*, 9(2), 11-23;

[2] **Ansuategi, A., Marsiglio, S. (2017),** ***Is environmental protection beneficial for the environment?.*** *Review of Development Economics*, 21(3), 786-802;

[3] **Badulescu, D., Badulescu, A., Rangone, A., Sipos-Gug, S. (2016),** ***Different or alike? Investigating the impact of GDP on environmental protection expenditure in selected European States.*** *Global & Local Economic Review,* 20(1), 55-75;

[4] **Bai, J., Ng, S. (2004),** ***A PANIC attack on unit roots and cointegration***. *Econometrica,* 72(4), 1127-1177;

[5] **Bai, J., Ng, S. (2010),** ***Panel unit root tests with cross-section dependence: a further investigation.*** *Econometric Theory,* 26(4), 1088-1114;

[6] **Broniewicz, E. (2011),** ***Environmental protection expenditure in European Union.*** *Environmental Management in Practice*, 21-36. https://www.intechopen.com/chapters/16281;

[7] **Değirmenci, T., Aydın, M. (2020),** ***Çevre Koruma Harcamaları ile Gelir Dağılımı ve Ekonomik Büyüme Arasındaki Dinamik İlişkiler: Seçili OECD Ülkeleri için Panel Nedensellik Yaklaşımı.*** *Sosyoekonomi*, 28(46), 391-406;

[8] **Drăcea, R. M., Ciobanu, L., Buziernescu, A. A. (2020),** ***The Impact of Environmental Protection Expenditure on Environmental Protection in Romania.*** *Empirical Analysis. Strategica*, 106;

[9] **Emirmahmutoğlu, F., Köse, N. (2011),** ***Testing for Granger causality in heterogeneous mixed panels.*** *Economic Modelling,* 28(3), 870-876;

[10] **Granger, C. W. J., Yoon, G. (2002),** ***Hidden Cointegration (SSRN Scholarly Paper ID 313831).*** *Social Science Research Network.* https://doi.org/10.2139/ssrn.313831;

[11] **Hájek, M., Kubová, P. (2016),** ***Identification of Basic Trends in Public Expenditures of Environmental Protection in the Czech Republic***. *Theoretical and Practical Aspects of Public Finance*, 2016, 146;

[12] **Joldeş, C., C., Pohatá, D. G. (2021),** ***Economic Growth and Environmental Protection***. *Ecoforum Journal*, 10(1);

[13] **Kónya, L. (2006),** ***Exports and Growth: Granger Causality Analysis on OECD Countries with a Panel Data Approach***. *Economic Modelling* (23), 978-992;

[14] **Krajewski, P. (2016),** ***The impact of public environmental protection expenditure on economic growth.*** *Problemy ekorozwoju–problems of sustainable development*, 11(2), 99-104;

[15] **Ladaru, G. R., Dracea, R. (2017),** ***Influence of the Environmental Protection Expenditure Dynamics on the Economic Growth in Romania During 2008-2015***. *Rev. Chim.(Bucharest)*, 67, 2166;

[16] **Nuţă, F. M. (2011),** ***Public environmental spending and the economic growth in Romania***. *Euro Economica*, 29(03), 109-113;

[17] **OECD, (2012),** ***OECD Environmental Outlook to 2050***. *OECD Publishing*. 1-349. https://doi.org/10.1787/9789264122246-en;

[18] **OECD, (2021),** ***Biodiversity, natural capital and the economy.*** *OECD Environment Policy Paper*, (26), 1-81. https://doi.org/10.1787/1a1ae114-en;

[19] **Pesaran, M. H. (2007),** ***A simple panel unit root test in the presence of cross‐ section dependence.*** *Journal of applied econometrics*, 22(2), 265-312;

[20] **Sencar, P. (2007),** ***Türkiye'de Çevre Koruma ve Ekonomik Büyüme İlişkisi,*** *Yayımlanmamış Yüksek Lisans Tezi, Edirne: Trakya Üniversitesi Sosyal Bilimler Enstitüsü.*1-198;

[21] **Steinbach, N. (2006),** ***Environmental protection expenditure and environmental industry in the EU-two sides of one coin.*** 205-216;

[22] **Stock, J. H. (1999),** ***A class of tests for integration and cointegration. Cointegration, Causality and Forecasting***. *A Festschrift in Honour of Clive WJ Granger*, 137-167;

[23] **Turjak, S., Unukic, I., Kristek, I. (2021),** ***Expenditure on Environmental Protection in the EU.*** *Economic and Social Development: Book of Proceedings*, 246-253;

[24] **Wekulom, A. (2021), The Effect of Gross Domestic Product on Environmental Expenditures;**

[25] **Yılancı, V., Aydın, M. (2017),** ***Oil prices and stock prices: An asymmetric panel causality approach.*** *Journal of Applied Research in Finance and Economics*, 2(4), 9–19.