yönetim ve ekonomi araştırmaları dergisi
journal of management and economics research
Cilt/Volume: 23 Sayı/Issue: 2 Haziran/June 2025 ss. /pp. 314-331
S. Korkmaz, O. Korkmaz, http://dx.doi.org/10.11611/yead.1494597

THE IMPORTANCE OF ENVIRONMENTAL FACTORS IN ENSURING SUSTAINABLE ECONOMIC GROWTH IN OECD COUNTRIES

Prof. Suna KORKMAZ (Ph.D.)*

Prof. Oya KORKMAZ (Ph.D.)**

ABSTRACT

Recently, environmental factors play an important role in the sustainability of economic growth. For this reason, natural resources must be used effectively and efficiently and must be sustained. In addition, in order to achieve sustainable economic growth, it is necessary to protect the ecosystem and reduce environmental pollution that occurs with industrialization. One of the factors causing environmental pollution is carbon emissions. Therefore, in this study, it is aimed to investigate the negative repercussions of the economic growth that occurs as a result of production without the use of renewable energy resources on the environment. In line with this scope, in this study, the relationship between per capita CO_2 *emissions released in total industrial production and economic growth for 8 OECD countries was analyzed by panel causality test. In the analysis, annual data for the period 2010-2018 were used. As a result of the study, a unidirectional causality relationship was found from economic growth to* CO_2 *emissions.*

Keywords: *CO_2 Emissions, Economic Growth, Panel Causality Test.*

Jel Codes: *C23, O47, Q53*

1. INTRODUCTION

Natural resources are very important in the actualization of economic growth. Natural resources are one of the factors of production and are used as inputs in the production process. Therefore, natural resources play an important role in economic growth. This factor of production, whose source is nature, must therefore be protected. However, in the process of economic growth, countries do not show the necessary importance to the environment that brought them into existence. As a result of these behaviors of countries, both their production and income and the damage they cause to the environment increase. One of the damages that countries cause to the environment as a result of their industrial production is the release of some wastes and harmful chemicals into water resources and the pollution of water as a

* Bandırma Onyedi Eylül University, FEAS, Department of Economics, Balıkesir/ Türkiye, E-mail: skorkmaz@bandirma.edu.tr.
** Tarsus University, Faculty of Applied Sciences, Department of Internatıonal Trade and Logistics, Mersin/ Türkiye, E-mail: oyakorkmaz67@tarsus.edu.tr.

Makale Geçmişi/Article History

Başvuru Tarihi / Date of Application : 2 Haziran / June 2024
Düzeltme Tarihi / Revision Date : 4 Ağustos / August 2024
Kabul Tarihi / Acceptance Date : 2 Ekim / October 2024

Araştırma Makalesi/Research Article

result. Water pollution occurs in areas where there is water such as rivers, lakes, seas and oceans. Water pollution not only affects human life but also endangers the lives of many species. In addition, as a result of the use of these polluted waters for irrigation in agricultural areas, both soil quality deteriorates and human health is jeopardized. This situation may cause loss of labor, which is one of the driving forces of economic growth.

As a result of the industrial production of countries, air is polluted along with water and soil. Air pollution is caused by carbon emissions from production and production-related activities, i.e. energy sources used for heating, lighting and logistics in the workplace. Carbon emissions released into the environment during production and activities supporting production seriously affect the health of labor. Protecting the health of labor is very important in ensuring sustainable economic growth. Air pollution causes deterioration in many organs, especially the heart and circulatory system. The World Health Organization has also recognized that air pollution has a carcinogenic effect. Since air pollution causes lung cancer, it causes a decrease in labor productivity and loss of qualified labor force. Decreased labor productivity and loss of skilled labor in the workplace prevents economic growth from being sustainable.

As a result, for economic growth to be sustainable, environmental damage must be reduced. One of the measures to be taken in this context is to reduce the CO_2 emissions released into the air by the industrial sector as much as possible. Reducing the amount of CO_2 released into the air during the production of the industrial sector is essential for ensuring sustainable economic growth. Therefore, this study aims to show that the environmental pollution caused by economic growth cannot be eliminated with the available energy resources and to test the interrelationship between the two variables. For this reason, this study analyzes whether there is a relationship between economic growth and CO_2 emissions released by total industrial production in 8 OECD countries by using panel causality test. The effects of the mortgage crisis in 2008 started to be seen in 2009 and therefore 2010 was chosen as the starting year for the period. In other words, this study uses data from the period after the effects of the crisis. The year of 2018 was chosen as the last period of the analysis due to the fact that the coronavirus pandemic emerged worldwide in 2019, that people began to isolate themselves to reduce the infectious impact of the disease and that therefore the production declined.

The work plan of this article consists of seven sections. The first section is devoted to the introduction of the study. The second section is devoted to the concept of sustainability, the third section to the environmental dimension of sustainability and its problems, the fourth section to the definition and calculation of economic growth, the fifth section to the literature review, the sixth section to the methodology of the study, and the seventh section to the conclusions and recommendations of the study.

Cilt/Volume: 23 Sayı/Issue: 2 Haziran/June 2025 ss. /pp. 314-331
S. Korkmaz, O. Korkmaz, http://dx.doi.org/10.11611/yead.1494597

2. SUSTAINABILITY

The word sustainability originally comes from the Latin word "sustinere" meaning "to keep". Dictionary definitions of sustainability have the common meanings of "to sustain", "to support", "to endure" or etc. (Sakalasooriva, 2021: 398). The Oxford English Dictionary defines sustainability as being maintained at a certain rate or level. In the literature, sustainability is defined as economic development that takes full account of the environmental consequences of economic activities and is based on the use of resources that can be replaced or renewed and therefore inexhaustible (Gedik, 2020: 205). Sustainability is also defined as the fair, ethical and efficient use of natural resources to meet the needs of current and future generations and to increase their welfare. According to another definition, sustainability refers to preserving the capacity of ecological systems, supporting social systems and improving their quality (Sakalasooriya, 2021: 397).

The concept of sustainability first came to the agenda with the Brundtland Report. In this report, attention was drawn to the environmental problems caused by growth. This definition of sustainability has given sustainability a multidimensional meaning (Şen et al., 2018: 42).

Sustainability is a concept that has come to the agenda with the concern that the balance between natural resources and needs has deteriorated over time to the detriment of natural resources and that this will bring serious problems in the future (Şen et al., 2018: 42). People and businesses that meet human needs need to be more sensitive to the environment. Recently, the environmental dimension of sustainability has become important.

3. DEFINITION AND CALCULATION OF ECONOMIC GROWTH

The increase in the amount of goods and services produced in a country over time is called economic growth. Economic growth means a continuous increase in real GDP (Gross Domestic Product) over time. If real GDP in an economy increases compared to the previous year, it means that the economy is growing economically. The concept of growth rate is used as a measure of economic growth. Growth rate is the annual rate of increase in real GDP (Ünsal, 2011: 14).

Annual growth rate in an economy is calculated as follows:

$$g = \left[\frac{(Real\ GDP_t - Real\ GDP_{t-1}}{Real\ GDP_{t-1}}\right] x100 \qquad (1)$$

where g indicates growth rate, Y_t real GDP of the current year, and Y_{t-1} real GDP of the previous year.

Among the OECD countries included in the analysis, we can consider Türkiye as an example. In Türkiye, the GDP value in 2023 is 2,217,917,933 and the GDP value in 2022 is 2,122,066,634, the growth rate in Türkiye for 2023 according to expenditure approach is calculated as 4.5 % (Central Bank of the Republic of Türkiye, 2023).

$$g_{2023} = \left[\frac{(GDP_{2023} - GDP_{2022}}{GDP_{2022}}\right] x100$$

$$g_{2023} = \left[\frac{(2217917933 - 2122066634}{2122066634}\right] x100$$

$$g_{2023} = \left[\frac{95851299}{2122066634}\right] x100 = 0.045x100 = 4.5$$

The growth rate should not be considered separately from the population growth rate. In order to achieve a net growth in the economy, the growth rate should be higher than the population growth rate. Population growth rate is the annual rate of increase in the total population of a country. Population growth rate is calculated as follows (Bocutoğlu, 2011: 60)

$$Population\ Growth\ Rate = \left[\frac{(Total\ population\ of\ any\ year - Total\ population\ of\ the\ previous\ year)}{Total\ population\ of\ the\ previous\ year}\right] \text{x100} \quad (2)$$

While the total population of Türkiye in 2022 was 85 million 279 thousand 553, the total population in 2023 was 85 million 372 thousand 377 (Turkish Statistical Institute, 2023). Hence, the population growth rate in 2023 is 0.10%.

$$National\ Population\ Growth\ Rate_{2023} = \left[\frac{(85372377-85279553)}{85279553}\right] \text{x100}$$

$$National\ Population\ Growth\ Rate_{2023} = \left[\frac{92824}{85279553}\right] \text{x100}$$

$$National\ Population\ Growth\ Rate_{2023} = 0.0010 \text{ x } 100 = 0.10$$

Since the net growth rate is the difference between the growth rate and the population growth rate, hence Türkiye's net growth rate in 2023 is 4.4%.

$$\text{Net Growth Rate}_{2023} = \text{Growth Rate}_{2023} - \text{National Population Growth Rate}_{2023}$$

$$\text{Net Growth Rate}_{2023} = 4.5\% - 0.10\%$$

$$\text{Net Growth Rate}_{2023} = 4.4\%$$

3.1. Benefits of Economic Growth

When countries are compared with each other, how much growth they achieve is taken as a criterion. Every country desires a high rate of economic growth. This is because economic growth brings many benefits to countries. The benefits of growth can be classified as standard of living, national defense and prestige, redistribution of income and change in lifestyle (Dinler, 2011: 617).

- ***Standard of Living***: Growth, which is an indicator of the annual increase in national income per capita, also shows how much more goods and services the households of the country in question can purchase each year compared to the previous year, that is, the increase in the standard of living. Countries want to realize a higher growth target in order to raise the standard of living of their citizens.
- ***National Defense and Prestige****:* Countries with a higher growth rate in the world enjoy a higher international prestige and have the opportunity to spend more on national security. Countries with higher growth rates appear to be stronger both economically and in terms of prestige. Countries with high growth rates cause the balance of power in the world to change.
- ***Redistribution of Income****:* The growth rate is an important opportunity to reduce this inequality about the countries with highly inequitable per capita income distribution. For this purpose, it will be sufficient to pursue policies that ensure that low-income earners receive a higher share from growth. On the other hand, if the growth rate is low, it will be necessary to reduce the standard of living of high-income earners in order to reduce income inequality among individuals, which will lead to dissatisfaction in some segments of society.
- ***Lifestyle****:* Since the per capita income will increase as a result of a high growth rate in a country, this will lead to an increase in the demand for certain goods and services like culture, entertainment, health, transportation, etc., and hence an increase in expenditures. As per capita income increases, people will concentrate more on activities that will relax them outside of work life.

3.2. Costs of Economic Growth

Even if every country desires growth in order to raise living standards and gain power, it should not be ignored that growth also has social, environmental and personal costs (Dinler, 2011: 618)

- ***Social and Environmental Costs****:* With the gathering of the majority of the population in cities with industrialization, a social transformation has also taken place. Traffic problems, noise and air pollution put pressure on people and caused their psychology to deteriorate. Crime rates and deterioration in mental health have increased. On the other hand, the danger of a decrease in natural resource reserves, which are characterized as free goods, has been encountered. Streams, lakes and seas have been polluted, forests have been destroyed by fire and various other causes and have suffered great losses, and plant and animal species have decreased. Air pollution has seriously affected human health, causing many diseases, especially lung cancer, and leading to the end of human lives. It has led to a decrease in human capital. In addition, the natural balance of the world has been disrupted by melting glaciers due to global warming.

- ***Personal Costs**:* Technological advances brought about by growth lead to the loss of the functions of existing machines and the obsolescence of the knowledge of workers. In particular, the inability of older people to adapt to technological development compared to younger people causes them to become unemployed and unhappy. Savings that will enable the investments required for growth to be made are expected to be sacrificed, such as being willing to accept a decrease in the standard of living for a certain period of time. In particular, growth will be at a higher cost for older individuals by cutting their consumption compared to young people due to the fact that they (elder people) have a higher risk of leaving this world without seeing the results of their sacrifice.

4. SUSTAINABLE ECONOMIC GROWTH

What is important in economies is to ensure economic growth, and more importantly, sustainable growth. Sustainable growth refers to economic growth in which price stability does not deteriorate, economic indicators and macroeconomic balances are compatible, and growth rates close to the potential growth level are achieved permanently. The necessary elements to ensure sustainable economic growth are as follows (Erdinç, 2018: 16):

Macroeconomic stability: Price stability, sustainable public finance.

Structural reforms: Social security reform, tax reform*,* labor market regulations, *e*ducation reform, regulations for the energy market*,* competitive environment.

Good management: Political stability, rule of law, transparency and accountability, effectiveness of legislation and regulations, quality of government services, preventing corruption.

It has been observed that sustainable growth has two dimensions: environmental and economic. According to the environmental dimension, sustainable growth is the ability of a country to grow without deteriorating the quality of its natural environment and without gradually worsening the environment (Uysal, 2013: 111). Sustainable growth is to realize economic growth without reducing the quality and quantity of the environment and natural capital (Uysal, 2013: 117).

The economic dimension of sustainable growth is that the average GDP growth rate does not show a downward trend in the long term, its trend is positive, and the economy of a country with sound macroeconomic foundations grows steadily over the long term without economic crisis and inflation (Uysal, 2013: 111). Sustainable economic growth is also defined as a consistent increase in the production of goods, services, and job opportunities to increase the economic and financial welfare of those living in that country. The key word here is "consistent". Sustainable economic growth is the increase in a country's productive potential measured by the consistent increase in real national income divided by the total population of the country. Sustainable economic growth is an important issue in economics and finance.

This is because sustainable economic growth is seen as one of the preconditions for achieving improved social welfare outcomes, which is the main objective of economic policy. Sustainable economic growth is a critical component of long-term growth.

5. LITERATURE REVIEW

Kim et al. (2010) conducted a non-linear Granger causality test for Korea with data from January 1992 to October 2006 and found a bidirectional causality relationship between CO_2 emissions and economic growth. Jaunky (2011) conducted a panel causality analysis for 36 high-income countries with annual data for the period 1980-2005 and found a unidirectional causality relationship from economic growth to CO_2 emissions in both the short and long run. Saboori et al. (2012) proved that there is a long-run relationship between CO_2 emissions and economic growth as a result of ARDL analysis with annual data for Malaysia for the period 1980-2009. In addition, the Granger causality test revealed a unidirectional causality relationship from economic growth to CO_2 emissions in the long run. Chen & Huang (2013) found a positive relationship between CO_2 emissions and economic growth in the long run as a result of their panel data analysis for N-11 countries with annual data for the period 1981-2009. Muftau et al. (2014) found a statistically significant positive relationship between CO_2 emissions and economic growth as a result of their panel data analysis for West African countries with annual data for the period 1970-2011. Economic growth causes CO_2 emissions. Dritsaki & Dritsaki (2014) conducted FMOLS and DOLS analyses for three Southern European countries with annual data for the period 1960-2009 and found a unidirectional causality relationship from CO_2 emissions to economic growth in the long run. Bozkurt & Akan (2014) conducted a VAR cointegration test for Türkiye with annual data for the period 1960-2010 and proved that CO_2 emissions negatively affect economic growth. Kasperowicz (2015) proved that the relationship between economic growth and CO_2 emissions is positive in the short run according to the panel data approach with annual data for the period 1995-2012 for 18 EU member states. Albiman et al. (2015) conducted the Toda and Yamamoto causality test for Tanzania with annual data for the period 1975-2013 and found a unidirectional causality relationship from economic growth to CO_2. Economic growth causes environmental pollution by increasing CO_2. Uddin et al. (2016) conducted a Granger causality test for Sri Lanka with annual data for the period 1971-2006 and found a unidirectional causality relationship from economic growth to CO_2 emissions. Bouznit & Pablo-Romero (2016) conducted an ARDL model for Algeria with annual data for the period 1970-2010 and found that economic growth will continue to increase CO_2 emissions. Ozturk & Acaravci (2016) conducted a Granger causality test for Malta and Cyprus with annual data for the period 1980-2006 and found a unidirectional causality relationship from carbon emissions to economic growth for

Malta. Magazzino (2016) conducted Toda and Yamamoto Granger causality test for Italy with annual data for the period 1970-2006 and found a bidirectional causality relationship between CO_2 emissions and economic growth. Azam et al. (2016) proved that CO_2 emissions have a significant positive relationship with economic growth for China, USA, India and Japan as a result of panel group FMOLS method with annual data for the period 1971-2013. Ahmad et al. (2017) conducted a Granger causality test based on the VECM approach for Croatia with data for the period 1992Q1-2011Q1 and found a bidirectional relationship between economic growth and CO_2 emissions in the short run and a unidirectional relationship from economic growth to CO_2 emissions in the long run. Odhiambo (2017) conducted an ECM-based panel causality test with annual data for the period 1986-2013 for 10 sub-Saharan African countries and proved a unidirectional causality relationship from economic growth to CO_2 emissions. Appiah et al. (2017) conducted an OLS analysis for Ghana with annual data for the period 1970-2016 and found that CO_2 emission level is affected by economic growth. Mahmoodi (2017) conducted a panel causality test with annual data for the period 2000-2014 for 11 developing countries and found that there is a bidirectional causality relationship between economic growth and CO_2. Mikayilov et al. (2018) conducted cointegration tests using Johansen, ARDLBT, DOLS, FMOLS and CCR methods with annual data for the period 1992-2013 for Azerbaijan and found that economic growth has a positive and statistically significant effect on emissions in the long run. Zou & Zhang (2020), using the panel data method with annual data for the period 2000-2017 for 30 regions in China, found that the level of economic growth has become a positive driving force for CO_2. Onofrei et al. (2022) found that economic growth has a statistically significant effect on CO_2 emissions as a result of DOLS analysis with annual data for the period 2000-2017 for 27 EU member countries. Ghazouani & Maktouf (2024) found a bidirectional causality relationship between economic growth and CO_2 emissions as a result of the panel autoregressive distributed lag model for oil exporting countries with annual data for the period 1971-2014. Yahyaoui (2024) conducted Toda-Yamamoto Granger causality test for Tunisia and Morocco with annual data for the period 1980-2018 and found a bidirectional causality relationship between economic growth and CO_2 emissions in both countries. Naseem et al. (2024) conducted FMOLS and DOLS analysis for G-20 countries with annual data for the period 1990-2020 and found that economic growth reduces CO_2 emissions. This is because there is a shift towards renewable energy sources. Kumar & Radulescu (2024) conducted panel DOLS, Dumitrescu-Hurlin, Johansen Fisher panel co-integration test, and Vector Error Correction Model for 45 SSA (Sub-Saharan Africa) countries with annual data for the period 1991-2020 and proved that there is a strong positive relationship between GDP per capita and CO_2 emissions. Ali et al. (2024) conducted Dumitrescu-Hurlin causality test for Southern European countries with annual data for the period 1990-2018 and found that GDP causes an increase in CO_2 intensity. A 1% increase in economic growth caused a 0.2568% increase in CO_2 emissions. Sharma et al. (2024) conducted SVAR analysis for the rich countries of Europe and Asia with annual data for the period 1965-2021 and found that there is a positive relationship between GDP growth and the increase in CO_2 emissions in all countries.

In this study, second generation unit root tests were applied. The post-crisis period in 2008 and the pre-pandemic period when goods production/service supply and human mobility were intense were selected for the analysis. This study differs from the others in terms of both the analysis method and the period examined.

6. DATA AND METHODOLOGY

This study tested the relationship between CO_2 emissions and economic growth (GDP) for eight selected OECD countries (Germany, Greece, Spain, France, Italy, Finland, Türkiye, and the UK). Annual data for the period 2010-2018 are taken. The reason for taking this period is that the mortgage crisis occurred in 2008 and the economic effects of this crisis started to be seen in 2009. According to World Bank data, in 2009 there was a decrease in the production of goods and the purchase of services, that is, in economic growth. However, the economic crisis lost its effect in 2010. With the disappearance of the impact of the economic crisis, there was an increase in the production of goods and the purchase of services again. This situation also increased CO_2 emissions. For this reason, 2010 has been chosen as the starting year of the analysis. As the end of the analysis period, 2018 has been preferred. The reason for this is the COVID-19 pandemic that started in 2019. During the COVID-19 pandemic, as the time people stayed at home increased, the total demand for goods and services decreased and as a result, CO_2 emissions decreased. Considering these developments in the world economy, 2018 has been chosen as the end of the analysis period. As data CO_2 emissions per capita in total industrial production are taken as air pollution. The annual percentage growth rate is taken as the growth rate. CO_2 and GDP variables were taken from the OECD electronic database. The panel causality test is used to analyze whether there is a relationship between both variables.

6.1. Panel Unit Root Tests

Before proceeding to panel data analysis, cross-sectional dependence should be examined to test for the presence of a unit root. If the presence of cross-sectional dependence is rejected, first generation unit root tests should be applied, and if it is accepted, second generation unit root tests should be applied. In the presence of horizontal cross-sectional dependence in panel data, the use of second generation unit root tests will provide more consistent and robust estimations.

Before proceeding to the unit root test, the homogeneity test is applied to check whether the variances of the data are equal to each other. The results of homogeneity test are provided in Table 1.

Table 1. Homogeneity Test Results

Method	GDP		CO_2	
	Statistic	Prob.	Statistic	Prob.
Delta Tilde	4.974	0.000*	7.115	0.000*
Delta Tilde Adjust	5.022	0.000*	7.693	0.000*

Not: * indicates statistical significance at the 1% level.

The hypotheses for the delta homogeneity test are as follows:

H_0: Slope coefficient is homogeneous

H_1: Slope coefficient is heterogeneous

The null hypothesis is rejected because the probability values are less than 1% significance level. The slope coefficients are homogeneous.

The Breush-Pagan Lagrange multiplier (LM) test (1980) is used to investigate horizontal cross-sectional dependence in the panel data model. Panel data model is a test used when N is constant and T goes to infinity, that is, when T>N. In this study, there are 9 years (T) and 8 OECD countries (N) covering the period 2010-2018. This condition ensures that the cross-sectional dimension is larger than the time dimension.

In this study, tests which are developed by Breusch and Pagan (1980) LM are calculated as below (Burdisso & Sangiácomo, 2016: 433).

$$LM = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^2 \quad (3)$$

The Breusch and Pagan (1980) test, which has a Chi-squared distribution with N(N-1)/2 degrees of freedom, is used when N is constant and T→∞. Here ρij is the sample estimate of the pairwise correlation of the residuals arising from the Monte Carlo optimization estimate of the regression for each unit of the panel. The null hypothesis and alternative hypothesis are stated below.

H_0: There is no cross-sectional dependency.

H_1: There is cross-sectional dependency.

The cross-sectional dependency test results are given in Table 2.

Table 2. Cross-Sectional Dependence Test Results

Method	GDP		CO_2	
	Statistic	Prob.	Statistic	Prob.
Breusch-Pagan LM	65.539	0.000*	103.327	0.000*
Pesaran Scaled LM	5.016	0.000*	10.066	0.000*
Bias-Corrected Scaled LM	4.516	0.000*	9.566	0.000*
Pesaran CD	4.996	0.000*	2.668	0.007*

Not: * indicates statistical significance at the 1% level.

As can be seen in Table 2, since the probability values obtained according to the Breusch-Pagan LM, Pesaran Scaled LM, Bias-Corrected Scaled LM, Pesaran CD test results are less than 1% for both series, the H_0 hypothesis is rejected. As a result of the test, the null hypothesis that there is no horizontal cross-sectional dependence is rejected at 1% significance level and the alternative hypothesis that there is horizontal cross-sectional dependence is accepted. Since there is an interdependence relationship between countries, second generation unit root tests are required.

Therefore, this study utilizes the second generation unit root tests CADF and CIPS. The CADF test was introduced in the literature by (Pesaran, 2007) and was extended with the lagged cross-sectional averages of the ADF test. This test is based on Monte Carlo residuals and can provide efficient results in both N>T and N<T cases. While CADF provides information on the stationarity of individual series, CIPS test provides results for the overall series in the panel (Çakır, 2022: 76). The second generation unit root test results are given in Table 3.

Table 3. Unit Root Test Results

Cross-Sections	Level	Critic Values			Difference	Critic Values		
	CADF Test Statistics	1%	5%	10%	CADF Test Statistics	1%	5%	10%
Germany	-1.437	-4.67	-3.87	-3.49	-3.502***	-4.67	-3.87	-3.49
Greece	-2.047	-4.67	-3.87	-3.49	-5.048*	-4.67	-3.87	-3.49
Spain	-1.992	-4.67	-3.87	-3.49	-4.338**	-4.67	-3.87	-3.49
France	-3.002	-4.67	-3.87	-3.49	-8.045*	-4.67	-3.87	-3.49
Italy	-2.665	-4.67	-3.87	-3.49	-5.273*	-4.67	-3.87	-3.49
Finland	-2.148	-4.67	-3.87	-3.49	-5.992*	-4.67	-3.87	-3.49
Türkiye	-2.810	-4.67	-3.87	-3.49	-4.271**	-4.67	-3.87	-3.49
UK	-1.094	-4.67	-3.87	-3.49	-2.627	-4.67	-3.87	-3.49
CIPS(Panel)	-2.490	-3.98	-3.26	-2.97	-5.894*	-3.98	-3.26	-2.97

Note: *,,*** show 1%, 5% and 10% indicate significance levels. Critical table values are taken from the critical table values of Pesaran (2006).**

CADF and CIPS examine the unit root across the model for cross-sectional units. CADF examines each country, while CIPS the panel as a whole. While the cross-sectional units in the model under consideration were not stationary at the level values by the relevant variables, they became stationary except for the UK when their differences were taken. Although UK does not seem to be stationary on its own, the CIPS test provides the stationarity condition for the panel as a whole.

6.2. Panel Causality Test

Dumitrescu and Hurlin (2012) panel causality test is a robust and widely used method for examining Granger causality in a panel data setting. This methodology extends the traditional Granger causality test to account for cross-sectional dependence and individual heterogeneity often encountered in panel data sets. Dumitrescu and Hurlin (2012) present an extension designed to detect causality in panel data. The underlying regression is (Tekin and Tekin, 2023: 96);

$$y_{i,t} = \alpha_i + \sum_{k=1}^{K} \gamma_{ik}\, y_{i,t-k} + \sum_{k=1}^{K} \beta_{ik}\, x_{i,t-k} + \varepsilon_{i,t} \text{ with i=1,…, N and t=1,…,T} \quad (4)$$

Here, $x_{i,t}$ and $y_{i,t}$ are individual observations of two stationary variables in the period. The coefficients are assumed to be time invariant but are permitted to vary between individuals. The panel must be balanced, and it is assumed that all members have the same lag order K. Testing for significant effects of past values of x on the present value of y is the procedure to ascertain the existence of causality, as in Granger (1969). The Dumitrescu and Hurlin test assumes that causality may exist for some individuals but is not the case for all. Thus, the alternative hypothesis (Tekin and Tekin, 2023: 96);

$$H_1: \beta_{i1} = \ldots = \beta_{iK} = 0 \quad \forall i = 1,\ldots,N_1 \quad (5)$$

$$\beta_{i1} \neq 0 \text{ or } \ldots \text{ or } \beta_{iK} \neq 0 \quad \forall i = N_1+1,\ldots,N \quad (6)$$

Where N_1 € [0,N-1] is unknown. If N_1=0, there is causality for all individuals in the panel. N must definitely be less than zero, otherwise, there is no causality for all individuals (Tekin and Tekin, 2023: 97). As a result of this information, the results of the Dumitrescu and Hurlin panel causality test are given in Table 4.

Table 4. Dumitrescu and Hurlin Panel Causality Test Results

Null Hypothesis	Obs.	Test Statistics	Prob.
ΔGDP does not Granger cause ΔCO2	56	$W_{N,T}^{HNC}$: 11.467	0.000*
		$Z_{N,T}^{HNC}$: 8.021	0.000*
		$\tilde{Z}_{N,T}^{HNC}$: 5.128	0.000*
ΔCO2 does not Granger cause ΔGDP		$W_{N,T}^{HNC}$: 2.742	0.394
		$Z_{N,T}^{HNC}$: 1.382	0.562
		$\tilde{Z}_{N,T}^{HNC}$: 0.996	0.716

Not: * indicates statistical significance at the 1% level.

As can be seen from Table 4, while economic growth is the cause of CO_2 emissions at a 1% significance level, CO_2 emissions are not the cause of economic growth. In other words, a unidirectional causality relationship was found from economic growth to CO_2 emissions. As total industrial production increases, it causes more CO_2 emissions to the environment. This negatively affects and pollutes the environment. To ensure sustainable growth, the environment should be protected and not polluted as much as possible.

7. CONCLUSION AND RECOMMENDATION

After the industrial revolution, there was a great increase in production as a result of the use of machines in the production process. The industrialization process has been an important turning point in ensuring economic growth. But, over time, with the increase in the use of fossil fuels due to the increase in production, harmful gases emitted into the air and negative externalities given to the environment have started to negatively affect human life and life. The more economic growth is achieved; the more polluted nature is today. To ensure sustainable economic growth, scarce resources should be used effectively and nature should remain as clean as possible. Renewable energy sources should be used instead of fossil fuels that harm nature. The quality of human health should be improved by minimizing environmental pollution. Because in the production process, labor is used in addition to the use of machinery, so the productivity of labor becomes important. For this reason, it is necessary to increase the quality of life of labor by minimizing environmental pollution. In this way, the continuity of a qualified labor force should be ensured.

In this study conducted with this awareness, to reveal whether economic growth causes air pollution, the relationship between CO_2 emissions per capita in total industrial production and economic growth was analyzed by Dumitrescu and Hurlin panel causality test. 8 OECD countries with industrial production were selected. Annual data for the period 2010-2018 were taken. As a result of the analysis, a unidirectional causality relationship was found from economic growth to CO_2 emissions per capita. This finding shows that economic growth resulting from the increase in industrial production increases the amount of CO2 emitted to the environment. In order to ensure economic growth without harming the environment, it is necessary to use renewable energy sources in production, use energy-efficient office equipment, minimize the use of personal vehicles by employees, minimize business travel, hold online meetings instead, purchase raw materials made from recycled materials and use resources effectively.

This study reveals similar results with Jaunky (2011), Saboori et al. (2012), Muftau et al. (2014), Albiman et al. (2015), Uddin et al. (2016), Bouznit & Pablo-Romero (2016), Odhiambo (2017), Mikayilov et al. (2018), Zou & Zhang (2020), Kumar & Radulescu (2024), Ali et al. (2024), Sharma et al. (2024) and different results with Kim et al. (2010), Dritsaki & Dritsaki (2014), Bozkurt & Akan (2014), Ozturk & Acaravci (2016), Magazzino (2016), Mahmoodi (2017), Ghazouani & Maktouf (2024), Yahyaoui (2024), Naseem et al. (2024) among the studies in the literature.

To reduce air pollution, industrial enterprises that consume fossil fuels should be converted to operate with electric energy, renewable energy sources (solar, wind, etc.) should be used instead of fossil fuel power plants, and electric vehicles should be emphasized in transportation. The use of natural gas and easily obtainable biogas should be increased instead of fossil-based fuels for heating purposes in residences. Factories should build chimneys of sufficient height and use filters, install treatment facilities, discharge their wastes without harming the environment, and locate their production facilities outside settlements as much as possible. Policymakers can impose zoning restrictions and ensure emissions in areas with low population density. They can also organize public service announcements on the harmful effects of air pollution. They can increase incentives for individuals to invest in environmental improvements. Public transportation systems should be preferred for transportation. Particle filter and catalyst cleaning of gasoline vehicles should be done frequently. Sustainable agriculture should be practiced. Garbage should be separated to prevent air pollution. Green areas should be protected and forest areas should be increased.

REFERENCES

Ahmad, N., Du, L., Lu, J., Wang, J., Li, H-Z. ve Hashmi, M.Z. (2017) "Modelling the CO_2 Emissions and Economic Growth in Croatia: Is There Any Environmental Kuznets Curve?", Energy, 123: 164-172. doi: 10.1016/j.energy.2016.12.106

Albiman, M.M., Suleiman, N.N. ve Baka, H.O. (2015) "The Relationship between Energy Consumption, CO_2 Emissions and Economic Growth in Tanzania", International Journal of Energy Sector Management, 9(3): 361-375. doi: 10.1108/IJESM-05-2014-0006

Ali, M., Kirikkaleli, D. ve Altuntaş, M. (2024) "The Nexus between CO_2 Intensity of GDP and Environmental Degradation in South European Countries", Environment, Development and Sustainability, 26(5), 11089-11100.

Appiah, K., Du, J., Musah, A-A.I. ve Afriyie, S. (2017) "Investigation of The Relationship between Economic Growth and Carbon Dioxide (CO_2) Emissions as Economic Structure Changes: Evidence from Ghana", Resources and Environment, 7(6): 160-167. doi: 10.5923/j.re.20170706.02

Azam, M., Khan, A.Q., Abdullah, H.B. ve Qureshi, M.E. (2016) "The Impact of CO_2 Emissions on Economic Growth: Evidence from Selected Higher CO_2 Emissions Economies", Environmental Science and Pollution Research, 23: 6376-6389. doi: 10.1007/s11356-015-5817-4

Bocutoğlu, E. (2011) "Makro İktisat Teoriler ve Politikalar", Trabzon: Murathan Yayınevi.

Bouznit, M. ve Pablo-Romero, M. del P. (2016) "CO_2 Emission and Economic Growth in Algeria", Energy Policy, 96: 93-104. doi: 10.1016/j.enpol.2016.05.036

Bozkurt, C. ve Akan, Y. (2014) "Economic Growth, CO_2 Emissions and Energy Consumption: The Turkish Case", International Journal of Energy Economics and Policy, 4(3): 484-494.

Breusch, T.S. ve Pagan, A.R. (1980) "The Lagrange Multiplier Test and Its Applications to Model Specification in Econometrics", The Review of Economic Studies, 47(1): 239-253.

Burdisso, T. ve Sangiácomo, M. (2016) "Panel Time Series: Review of the Methodological Evolution", The Stata Journal, 16(2): 424-442.

Central Bank of The Republic of Türkiye. (2023) https://evds2.tcmb.gov.tr/index.php?/evds/serieMarket, (25.04.2024)

Chen, J-H. ve Huang, Y-F. (2013) "The Study of The Relationship between Carbon Dioxide (CO_2) Emission and Economic Growth", Journal of International and Global Economic Studies, 6(2): 45-61.

Çakır, M. (2022) "Ekonomik Büyüme ve Verimlilik Politikası", Konya: Eğitim Yayınevi.

Dinler, Z. (2011) "İktisada Giriş", Bursa: Ekin Yayınevi.

Dritsaki, C. ve Dritsaki, M. (2014) "Causal Relationship between Energy Consumption, Economic Growth and CO_2 Emissions: A Dynamic Panel Data Approach", International Journal of Energy Economics and Policy, 4(2): 125-136.

Dumitrescu, E-I. ve Hurlin, C. (2012) "Testing for Granger Non-Causality in Heterogeneous Panels", Economic Modelling, 29(4): 1450-1460.

Erdinç, Z. (2018) "İktisadi Büyüme Kavramı" Günsoy, G. ve Erdinç, Z. (eds.) İktisadi Büyüme, Eskişehir, Anadolu Üniversitesi Açıköğretim Fakültesi Yayınları.

Gedik, Y. (2020) "Sosyal, Ekonomik ve Çevresel Boyutlarla Sürdürülebilirlik ve Sürdürülebilir Kalkınma", International Journal of Economics, Politics, Humanities & Social Sciences, 3(3): 196-215.

Ghazouani, T. ve Maktouf, S. (2024) "Impact of Natural Resources, Trade Openness, and Economic Growth on CO_2, Emissions in Oil-Exporting Countries: A Panel Autoregressive Distibuted Lag Analysis", Natural Resources Forum, 48(1): 211-231. doi: 10.1111/1477-8947.12318

Granger, C.W.J. (1969) "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods", Econometrica, 37(3): 424-438. doi: 10.2307/1912791

Jaunky, V.C. (2011) "The CO_2 Emissions-Income Nexus: Evidence from Rich Countries", Energy Policy, 39(3): 1228-1240. doi.org/10.1016/j.enpol.2010.11.050

Kasperowicz, R. (2015) "Economic Growth and CO_2 Emissions: The ECM Analysis", Journal of International Studies, 8(3): 91-98. doi: 10.14254/2071-8330.2015/8-3/7

Kim, S-W., Lee, K. ve Nam, K. (2010) "The Relationship between CO_2 Emissions and Economic Growth: The Case of Korea with Nonlinear Evidence", Energy Policy, 38(10): 5938-5946. doi: 10.1016/j.enpol.2010.05.047

Kumar, P. ve Radulescu, M. (2024) "CO_2 Emission, Life Expectancy, And Economic Growth: A Triad Analysis of Sub-Saharan African Countries", Environment, Development and Sustainability, 1-28. doi: 10.1007/s10668-023-04391-7.

Magazzino, C. (2016) "The Relationship between CO_2 Emissions, Energy Consumption and Economic Growth in Italy", International Journal of Sustainable Energy, 35(9): 884-857. doi.org/10.1080/14786451.2014.953160

Mahmoodi, M. (2017) "The Relationship between Economic Growth, Renewable Energy, and CO_2 Emissions: Evidence from Panel Data Approach", International Journal of Energy Economics and Policy, 7(6): 96-102.

Mikayilov, J.I., Galeotti, M. ve Hasanov, F.J. (2018) "The Impact of Economic Growth on CO_2 Emissions in Azerbaijan", Journal of Cleaner Production, 197, Part 1: 1558-1572. doi: 10.1016/j.jclepro.2018.06.269

Muftau, O., Iyoboyi, M. ve Ademola, A.S. (2014) "An Empirical Analysis of The Relationship between CO_2 Emission and Economic Growth in West Africa", American Journal of Economics, 4(1): 1-17. doi: 10.5923/j.economics.20140401.01

Naseem, S., Hu, X., Sarfraz, M. ve Mohsin, M. (2024) "Strategic Assessment of Energy Resources, Economic Growth, and CO_2 Emissions in G-20 Countries for A Sustainable Future", Energy Strategy Reviews, 52: 1-12. doi: 10.1016/j.esr.2024.101301

Odhiambo, N.M. (2017) "CO_2 Emissions and Economic Growth in Sub-Saharan African Countries: A Panel Data Analysis", International Area Studies Review, 20(3): 264-272. doi: 10.1177/2233865917715943

Onofrei, M., Vatamanu, A.F. ve Cigu, E. (2022) "The Relationship between Economic Growth and CO_2 Emissions in EU Countries: A Cointegration Analysis", Frontiers in Environmental Sciences, 10: 1-11. doi.org/10.3389/fenvs.2022.934885

Ozturk, I. ve Acaravci, A. (2016) "Energy Consumption, CO_2 Emissions, Economic Growth, and Foreign Trade Relationship in Cyprus and Malta", Energy Sources, Part B: Economics, Planning, and Policy, 11(4): 321-327. doi: 10.1080/15567249.2011.617353

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.

Pesaran, M.H., Ullah, A. ve Yamagata, T. (2008) "A Bias-Adjusted LM test of Error Cross-Section Independence", The Econometrics Journal, 11(1): 105-127.

Pesaran, M.H. (2021) "General Diagnostic Tests for Cross-Sectional Dependence in Panels", Empirical Economics, 60(1): 13-50.

Saboori, B., Sulaiman, J. ve Mohd, S. (2012) "Economic Growth and CO_2 Emissions in Malaysia: A Cointegration Analysis of The Environmental Kuznets Curve", Energy Policy, 51: 184-191. doi: 10.1016/j.enpol.2012.08.065

Sakalasooriya, N. (2021) "Conceptual Analysis of Sustainability and Sustainable Development", Open Journal of Social Sciences, 9(03): 396-414. doi: 10.4236/jss.2021.93026

Şen, H., Kaya, A. ve Alpaslan, B. (2018) "Sürdürülebilirlik Üzerine Tarihsel ve Güncel Bir Perspektif", Ekonomik Yaklaşım, 29(107): 1-47. doi: 10.5455/ey.39101

Sharma, K., Bal, D.P. ve Mohanty, S. (2024) "The Dynamic Relationship between Nuclear Energy, CO_2 Emissions, and Economic Growth: Evidence from The Richest Countries in Europe and Asia", Environmental Science and Pollution Research, 31(10): 14820-14830. doi: 10.1007/s11356-024-32125-3

Tekin, B. ve Tekin, N. (2023) "Biofuel Production and Economic Globalization Nexus in developing Countries", Yılmaz, S. (eds.) Contemporary Business and Economic Issues II, Ankara, Akademisyen Kitabevi.

Turkish Statistical Institute. (2023) "Adrese Dayalı Nüfus Kayıt Sistemi Sonuçları 2022 Yılı", https://data.tuik.gov.tr/Bulten/Index?p=49685, (08.04.2024).

Turkish Statistical Institute (2023) "Adrese Dayalı Nüfus Kayıt Sistemi Sonuçları 2023 Yılı", https://data.tuik.gov.tr/Bulten/Index?p=Adrese-Dayali-Nufus-Kayit-Sistemi-Sonuclari-2023-49684, (15.04.2024).

Uddin, M.G.S., Bidisha, S.H. ve Ozturk, I. (2016) "Carbon Emissions, Energy Consumption, and Economic Growth Relationship in Sri Lanka", Energy Sources, Part B: Economics, Planning, and Policy, 11(3): 282-287. doi: 10.1080/15567249.2012.694577

Uysal, Ö. (2013) "Sürdürülebilir Büyüme Kavramının Çevre ve Ekonomik Boyutlarının Ayrıştırılması", Uluslararası Alanya İşletme Fakültesi Dergisi, 5(2): 111-118.

Ünsal, E.M. (2011) "Makro İktisat", Ankara: İmaj Yayıncılık.

Yahyaoui, I. (2024) "Does The Interaction between ICT Diffusion and Economic Growth Reduce CO_2 Emissions? An ARDL Approach", Journal of The Knowledge Economy, 15(1): 661-681.

Zou, S. ve Zhang, T. (2020) "CO_2 Emissions, Energy Consumption, and Economic Growth Nexus: Evidence from 30 Provinces in China", Mathematical Problems in Engineering, 2020(Special Issue): 1-10. doi: 10.1155/2020/8842770

KATKI ORANI / *CONTRIBUTION RATE*	**AÇIKLAMA / *EXPLANATION***	**KATKIDA BULUNANLAR / *CONTRIBUTORS***
Fikir veya Kavram / *Idea or Notion*	Araştırma hipotezini veya fikrini oluşturmak / *Form the research hypothesis or idea*	Prof. Suna KORKMAZ Prof. Oya KORKMAZ
Tasarım / *Design*	Yöntemi, ölçeği ve deseni tasarlamak / *Designing method, scale and pattern*	Prof. Suna KORKMAZ Prof. Oya KORKMAZ
Veri Toplama ve İşleme / *Data Collecting and Processing*	Verileri toplamak, düzenlenmek ve raporlamak / *Collecting, organizing and reporting data*	Prof. Suna KORKMAZ Prof. Oya KORKMAZ
Tartışma ve Yorum / *Discussion and Interpretation*	Bulguların değerlendirilmesinde ve sonuçlandırılmasında sorumluluk almak / *Taking responsibility in evaluating and finalizing the findings*	Prof. Suna KORKMAZ Prof. Oya KORKMAZ
Literatür Taraması / *Literature Review*	Çalışma için gerekli literatürü taramak / *Review the literature required for the study*	Prof. Suna KORKMAZ Prof. Oya KORKMAZ

Hakem Değerlendirmesi: Dış bağımsız.

Çıkar Çatışması: Yazar çıkar çatışması bildirmemiştir.

Finansal Destek: Yazar bu çalışma için finansal destek almadığını beyan etmiştir.

Teşekkür: -

Peer-review: Externally peer-reviewed.

Conflict of Interest: The author has no conflict of interest to declare.

Grant Support: The author declared that this study has received no financial support.

Acknowledgement: -