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

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ABSTRACT

Recently, sustainable economic growth is one of the macroeconomic policies aimed by country governments. 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, 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. Therefore, this factor of production, whose source is nature, needs to be protected. However, countries do not show the necessary importance to the environment that creates itself in the process of economic growth. 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 result. Water pollution occurs in areas where there is water such as rivers, lakes, seas and oceans. Water

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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 emitted to the air during the production of the industrial sector is essential for ensuring sustainable economic growth. 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. In 2008, the effects of the mortgage crisis started to be seen in 2009. For this reason, 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 since production is therefore declining.

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. (Sakalasooriya, 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 OF ENVIRONMENT

The concept of environment has been on the agenda of people and societies since ancient times. The concepts of environment and ecology have led to the emergence of a new field of science over time and the development of the phenomenon of ecology. There are many definitions about the environment. In a general definition, the environment is the sum of physical, chemical, biological and social factors that may have direct or indirect effects on human activities and living beings immediately or over a long period of time (Torunoğlu, 2018: 3-4). According to another definition, in a narrow sense, the environment is expressed as the sum of natural environmental conditions. In a broad sense, it can be defined as the addition of social conditions to the conditions that constitute the source of human production and life. Environment is the totality of values that constitute the common existence of people (Karabıçak and Armağan, 2004: 207).

4. ENVIRONMENTAL PROBLEMS

Environmental problems differ in developed and developing countries. However, the environmental problems generally encountered include greenhouse gas emissions, reduction of forests, the danger of extinction of plant and animal species, depletion of the ozone layer, melting of glaciers leading to climate change, urbanization, wastes, etc. The reasons for the emergence of environmental problems include population growth rate, urbanization, industrialization and effect of greenhouse gas.

4.1. National Population Growth

It is known that the impact of population growth on the environment is mostly negative. As a result of the concentration of population growth in industrialized and underdeveloped countries, unconscious use of natural resources causes environmental pollution. In addition, the needs of the population cannot be met sufficiently due to unconscious consumption and insufficient natural resources (Aydın and Kaya, 2022: 200). Due to the increase in solid wastes as a result of population growth, bad odors and toxic gases sprawling into the environment negatively affect human health. A cramped life and noise caused by overpopulation deteriorate the quality of the environment in which the individual

lives and impair mental health. This situation is also reflected in work life and leads to a decrease in the efficiency of human capital in working life.

4.2. Effect of GHG (Greenhouse Gas)

Some of the gases in the atmosphere trap the sun's rays and do not allow them to be released into space. As a result of these gases trapping the rays, the earth overheats because it cannot release the rays into space. This is called the "GHG (Greenhouse Gas) effect". The increase in the amount of production brought about by industrialization and the increase in the amount of carbon dioxide gas and other gases that retain heat from energy sources used for heating purposes have caused the temperature of the atmosphere to rise today. As a result of the rapidly increasing temperature, the number of forest fires has increased worldwide. There have been changes in climates. In some regions, precipitation decreased and the danger of drought emerged, while some regions received excessive precipitation and flood disasters occurred. With increasing temperature, water resources started to decrease and dry up. The amount of drinkable water has decreased worldwide. As a result of the deterioration of the ecological balance, some species have disappeared (Aydın and Kaya, 2022: 201).

4.3. Climate Change

The factors that cause climate change are divided into two as natural and human-induced factors. Climate changes caused by natural factors include volcanic activities, changes in the amount of solar energy, changes in the tilt and orbit of the earth's axis, landforms and elevations and storms. Among the factors that cause climate change caused by human factors are greenhouse gases from industrial production, energy and transportation sectors, pollution from agricultural production, deforestation and wastes (Kahraman and Şenol, 2018: 355). In addition to natural events, human factors also play a major role in climate change. As technological development and industrialization increased, the release of greenhouse gases into the atmosphere also increased. This has caused climate change.

4.4. Urbanization

The concentration of people in cities due to population growth and the concentration of industry in cities has led to inefficient and wasteful use of land resources. Due to this population density, more energy consumption and air pollution will occur as a result of more motorized transportation. With the increase in the rate of urbanization, the demand for materials such as cement, gravel, sand, timber, etc. will increase. These resources need to be consumed consciously. If consumed unconsciously, environmental balances will be disrupted. During the extraction process of natural resources, the quality of the soil may change, the natural environments where plants and animals live may deteriorate and cause air pollution (Özdemir and Özekicioğlu, 2006: 21). As a result of people consuming more as a culture brought about by urbanization, huge wastes have started to be generated. The functioning of the ecosystem is disrupted as a result of both industrial wastes and the wastes brought by urbanization. The

negative conditions brought about by urbanization cause the destruction of natural vegetation, pollution of air and water, decrease in soil fertility and create a greenhouse effect.

5. DEFINITION AND QUANTIFICATION 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:

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

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)

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

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%.

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

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

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

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%.

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

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

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

6. 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.

7. 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.

8. GROWTH MODELS

Many models and ideas about growth have been put forward in the economic literature. The most prominent of these are the classical growth model, Marxian growth model, neoclassical growth model, endogenous growth model and the Harrod-Domar growth model. However, from the beginning of economics to the present day, some schools of economics have views on growth. It is useful to summarize these views briefly.

8.1. Classical Economic Growth Model

In classical economics, the views of Adam Smith and David Ricardo are prominent on growth. According to Smith, economic growth continues for a certain period of time and then stabilizes. He stated that the realization of this event is a result of the natural functioning of the economy itself. According to him, the main source of growth and development is the division of labor and specialization. He sees the increase in labor productivity as the most important source of economic growth. Labor productivity increases with the effect of job sharing of labor and specialization. The increase in labor productivity leads to an increase in the level of savings in the economy. An increase in the level of savings increases capital accumulation. Job sharing of labor and specialization also contribute to the development of international trade by providing some advantages to countries. The fact that a country has absolute superiority in trade will positively affect economic growth by increasing the level of production (Uçak, 2013: 35).

Ricardo, like Smith, stated that growth would first be achieved spontaneously and then the economy would enter recession. Ricardo has emphasized that countries will increase their total production based on the theory of comparative advantages at this time and hence that growth would be relative. According to him, when there is an increase in population, the increase in production increases accordingly, the economy enters a growth process and profits are very high. As a result of the increase in profits, savings are directed to investment and capital accumulation increases. Workers' wages are also affected by this situation. Current wages rise above the minimum living wage. However, profits in the economy fall after a certain period of time, and as a result, capital accumulation and growth slow down (Aksu, 2014: 359).

8.2. Economic Growth Model in Marxian Thought

Karl Marx made the greatest contribution to the formation of the growth model in Marxian thought. To better understand Marx's growth model, it is necessary to comprehend the labor theory of value and theories of surplus value.

In the labor theory of value, Marx stated that there is a difference between the value of labor power and the value created by labor, which he called surplus value. The labor theory of value assumes that the value of labor and the price (wage) paid for it are equal when determining the labor value of labor (Korkmaz, 2018: 31).

The factor that determines growth is capital accumulation. Accumulation is the transformation of surplus value into capital. For this to happen, additional labor and means of production are needed. The growth of capital used to obtain surplus value grows cumulatively with the growth of surplus value. Total surplus value is determined by the rate of exploitation (s/v) and the amount of labor used. Marx stated that the rate of exploitation can be increased by making workers work longer, by lowering the

wage rate, or by increasing labor productivity (Özsağır, 2008: 336). As labor productivity increases, surplus value grows and accumulation increases. As the capital stock grows with accumulation, labor productivity also increases. With the accumulation in the capitalist economy, surplus-value also increases in an increasing manner.

Marx emphasized that the investment impulses in the economy are independent of profit and interest rates, and are entirely related to the psychology of the capitalist and the structure of society. The capitalist is neither interested in luxury consumption nor in incentives. A large part of the surplus-value is capitalized by the capitalist and thus the amount of capital entering production increases. As the surplus-value grows over time, capital accumulation accelerates (Kazgan, 2009: 320).

8.3. Neoclassical Growth Model

In the neoclassical growth model, the economy is closed to the outside world. A single good is produced in the economy. Production activity is carried out by private firms. Two factors of production, labor and physical capital, are used in the production process. These inputs are purchased by firms at the equilibrium wage and capital rental rate in labor markets under perfect competition. Unemployment and overcapacity problems are not encountered in the market. Goods produced in the economy are both consumption and investment goods. Perfect competition conditions also apply in goods markets. There is no excess supply or demand in the goods market (Turan, 2001: 132).

The basic neoclassical model was developed by Solow-Swan. The aggregate production function used in this model is based on three basic assumptions (Masoud, 2013: 11)

1. Labor grows at a constant exogenous rate.

2. Output is a function of capital and labor and is shown as Y=F(K,L). The production function operates according to constant returns to scale.

3. There is an independent investment function: S=1=sY.

In the Solow-Swan model, the marginal productivity of capital decreases. The state has a limited role in economic life. Technological changes are completely exogenous. There is no foreign trade due to a single-sector economic structure and single commodity. Full employment and perfect competition conditions apply. Substitution of factors of production is possible.

The neoclassical growth model introduced by Solow-Swan is shown as follows (Alper, 2019: 208):

$$Y_t=A_tF(K_t,L_t) \quad (3)$$

In equation 3, Y is output, K is capital, L is labor factor and A is the exogenously determined technology known as total factor productivity. At is assumed to be $A_t=0$ due to the assumption that technological progress is exogenous. If both sides of equation 3 are divided by L;

$$Y_t/L_t=F(K_t/L_t, L_t/L_t) \quad (4)$$

In equation 4, (Yt/Lt) is output per labor, (Kt/Lt) is capital per labor and (Yt/Lt) is output per labor. If output per labor is denoted by y and capital per labor is denoted by k, the production function can be represented as follows;

$$y=f(k) \quad (5)$$

In equation 5, technological progress is neglected. When the amount of capital per labor increases, the amount of output per labor will also increase. Technological progress plays an important role in increasing the productivity of labor. In order to include technological progress in the model, the production function can be shown as follows;

$$Y=F(K,AL) \quad (6)$$

In equation 6, A represents the efficiency of labor. In the long run, total output depends on the efficiency of labor resulting from capital and technological development. The Solow model, known as the exogenous growth model, emphasized that economic growth in the short run will be achieved through capital accumulation and technological development in the long run (Alper, 2019: 209).

8.4. Endogenous Growth Models

Endogenous growth models generally emphasize technological development, savings, investment, learning by doing, human capital and public spending. Competitive market conditions prevail. The assumption of diminishing marginal returns to capital is abandoned.

The endogenous growth models developed by Arrow, Romer and Lucas internalized knowledge, RandD (research and development studies), human capital, technological development and economies of scale, which are considered exogenous in other growth models. Unlike other models, the role of the state in the economy has also changed. The state pursues an active policy that encourages RandD studies and the development of education, protects property rights, regulates market functioning, and reduces transaction costs (Çiftçi and Aykaç, 2011: 162).

Contrary to the neoclassical theory, Romer (1986) argued that the marginal productivity of capital will not decrease as the physical capital stock of the economy increases. This is because knowledge is a public good and externalities exist. Knowledge production is a by-product of all production and investment activities. As long as firms continue their production activities, knowledge production will always occur (Yardımcı, 2006: 101).

In the Lucas (1988) model, human capital is important role in growth. To increase economic growth, individuals must acquire more skills and spend more time on education. According to him, growth can only be achieved through the accumulation of knowledge and the increase in the growth rate of human capital. Investments made to increase human capital can also increase economic growth by

stimulating other sectors of the economy. Lucas emphasized that sustainable growth will be achieved if human capital is increased unlimitedly in the long run (Uğur and Atılgan, 2023: 182). The model developed by Robert E. Lucas is as follows (Duman, 2018: 110);

$$Y=AK^{\beta}(H)^{1-\beta} \quad ; 0\leq \beta \leq 1 \tag{7}$$

If H=hL then the new production function will be as in equation 8.

$$Y=AK^{\alpha}(hL)^{1-\alpha} \tag{8}$$

In equation 8, Y is the level of production, A is the fixed level of technology, K is physical capital, L is the amount of labor, α is the production elasticity of capital stock and h is human capital per labor. As a result of the inclusion of human capital in the production process, the assumption of increasing returns to scale in production is valid.

Romer emphasized that commodity differentiation and the free market will have an impact on growth as well as increasing income and wealth. As markets expand, RandD studies increase accordingly. RandD studies have a positive effect on economic growth. According to Romer, firms and countries operating in markets with a large stock of human capital will grow faster (Çiftçi and Aykaç, 2011: 164).

According to Barro (1990), tax-financed public expenditures have significant effects on the per capita growth rate. Public expenditures are considered as a production input in the economy. Government spending in productive areas has a positive impact on growth. A relatively large increase in the weight of the public sector in the economy will lead to a decrease in efficiency and have negative repercussions on the growth rate. According to Barro, the relative efficiency of public expenditures constitutes the growth differences between countries (Kar and Taban, 2003: 152).

According to Rebello (1991), the differences in the growth rate between countries stem from the different economic policies implemented by countries. Tax rates are an important factor affecting growth. An increase in income tax will both reduce the aggregate demand for goods and services and reduce the investment activities of the private sector. Capital accumulation decreases, leading to a decline in growth (Taşar, 2016: 7).

G. Grossman and E. Helpman (1991) saw the source of economic growth as the phenomenon of innovation that increases the variety and quality of intermediate goods as a result of RandD studies. According to them, knowledge moves freely between countries without incurring any cost. Countries with more human capital engage in more RandD activities. As a result, it produces more innovative goods. The share of high-tech industries is higher in countries with more human capital than in countries with less qualified human capital. As a result of RandD studies in countries with high technology, innovative goods are produced and those countries gain a competitive advantage over other countries and accelerate their economic growth (Türker, 2009: 90).

8.5. Harrod-Domar Growth Model

Harrod mentioned two concepts in his growth model: savings and investment. In this model, savings is an important variable for maintaining equilibrium in the economy and is assumed to be an increasing function of national income. To maintain the full employment equilibrium, investment must conform to the marginal productivity of capital and the accelerating propensity to save. In the Harrod growth model, the accelerator coefficient is used to determine planned investments. Harrod accepts three different growth rates. These are the necessary growth rate, actual growth rate, and natural growth rate. Domar, on the other hand, tried to explain economic growth by considering the income-increasing and capacity-increasing effects of investments. Domar revealed that economic growth will be realized if the capacity-enhancing effect of investments and the income-enhancing effect are equal (Aksu, 2018: 61).

In the Harrod-Domar model, it is assumed that an economy produces only one good that can be used for consumption and investment, there are no monetary prices in the economy, the economy is closed to the outside and the state should not be involved in economic activities.

In the Harrod-Domar model, since economic growth is a function of savings, ex-post investments should be equal to ex-ante savings. They stated that when the balance is disturbed due to inequality between investment and savings, there will be an unstable situation in the economy and growth will stop. According to this growth model, for an economy to grow by maintaining price stability, the capacity-increasing effect of investments, and the income-increasing effect; for an economy to grow by maintaining full employment, actual growth, guaranteed growth and natural growth rates should be equal to each other (Aksu, 2018: 63).

Harrod-Domar emphasized that the marginal saving rate and the capital-output coefficient are important in determining the growth rate. While the growth rate in an economy is positively related to the marginal savings rate, it is negatively related to the capital-productivity coefficient. The higher the marginal saving rate and the smaller the capital-productivity coefficient, the higher the growth rate of an economy. If the opposite is true, i.e. the lower the marginal saving rate and the larger the capital-output coefficient, the lower the growth rate of the economy will be.

9. 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.

10. 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 and 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 and 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 and 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 and 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 and 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 and 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.

11. 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 repercussions of the 2008 mortgage crisis were observed in 2009. Therefore, the period after 2009 was taken. Since production decreased with the emergence of the pandemic, it was terminated in the pre-pandemic period. 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 logarithm of both data has been taken. The panel causality test is used to analyze whether there is a relationship between both variables.

11.1. Panel Unit Root Tests

Before the analysis, we must conduct a unit root test to avoid spurious regression and gather meaningful results. Various panel unit root tests have been developed (Baltagi and Kao, 2000), such as Levin and Lin (1992), Quah (1994), Im et al. (2003), Maddala and Wu (1999), Choi (1999, 2001), Kao (1999), Harris and Tzavalis (1999), Hadri (1999), Levin et al. (2002), Breitung (2000), and Harris and Sollis (2003).

In our study, the stability of the constants was examined by using first-generation stability tests such as the LLC, IPS, ADF, and PP tests. In all tests, for the CO_2 and GDP series at the first difference, the 5% significance level was constant and fixed stationary. The CO_2 and GDP series unit root test results are shown in Table 1.

Table 1. Panel Unit Root Test Results

		Level Constant and Trend		**First Differences Constant**	
Variables	**Method**	Statistic	Prob*	Statistic	Prob*
LCO2	LLC	-5.467	0.000*	-7.779	0.000*
	IPS W-stat	0.148	0.559	-2.701	0.003*
	ADF-FisherChi-Square	14.204	0.583	37.916	0.001*
	PP-FisherChi-Square	10.916	0.814	47.123	0.000*
LGDP	LLC	-12.711	0.000*	-7.015	0.000*
	IPS W-stat	-1.214	0.112	-2.317	0.010*
	ADF-FisherChi-Square	20.582	0.008*	21.444	0.006*
	PP-FisherChi-Square	26.190	0.001*	38.651	0.000*

*IPS, ADF, LLC and PP implies Im, Pesaran and Shin Test; ADF Fisher Chi Square; Levin, Lin and Chu Test and PP Fisher Chi Square Test respectively. *,**,*** represent 1%, 5% and 10% level of significance respectively.

As can be seen in Table 1, the CO_2 variable is non-stationary at constant and trend levels according to IPS, ADF, and PP test results. When the first difference is taken, the constant becomes stationary at

a 1% level. GDP variable is non-stationary according to IPS at constant and trend levels. When its first difference is taken, it becomes stationary at a 1% level at a constant.

11.2. Panel Causality Test

Granger's (1969) causality test was used to test the direction of the relationship between variables.

$$\Delta LCO2_{i,t} = \theta_{1,i} + \sum_{k=1}^{m} \theta_{1,1,i,k}\, \Delta LCO2_{i,t-k} + \sum_{k=1}^{m} \theta_{1,2,i,k}\, \Delta LGDP_{i,t-k} + u_{1,i,t} \quad (9)$$

$$\Delta LGDP_{i,t} = \theta_{2,i} + \sum_{k=1}^{m} \theta_{2,1,i,k}\, \Delta LCO2_{i,t-k} + \sum_{k=1}^{m} \theta_{2,2,i,k}\, \Delta LGDP_{i,t-k} + u_{2,i,t} \quad (10)$$

where the term Δ denotes first differences, $\theta_{j,i,t}$ (j=1,2,3) represents the fixed country effect, k (k=1,…,m) is the optimal lag length determined by the Schwarz information criterion, $u_{i,t}$ is the disturbance term assumed to be uncorrelated with zero means.

Panel causality test results for 2 lags are presented in Table 2.

Table 2. Panel Causality Test Results

Null Hypothesis	Obs.	F-statistics	Prob.
ΔLGDP does not Granger cause ΔLCO2	28	2.781	0.082***
ΔLCO2 does not Granger cause ΔLGDP		0.092	0.912

*** indicates statistical significance at the 10% level.

As can be seen from Table 2, while economic growth is the cause of CO_2 emissions at a 10% 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.

12. 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. People flocked to cities and collective life began. 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. In this way, the continuity of a qualified labor force should be ensured.

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 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 study reveals similar results with Jaunky (2011), Saboori et al. (2012), Muftau et al. (2014), Albiman et al. (2015), Uddin et al. (2016), Bouznit and Pablo-Romero (2016), Odhiambo (2017), Mikayilov et al. (2018), Zou and Zhang (2020) and different results with Kim et al. (2010), Dritsaki and Dritsaki (2014), Bozkurt and Akan (2014), Ozturk and Acaravci (2016), Magazzino (2016), Mahmoodi (2017) 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.

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