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GREEN ECONOMY AND GROSS DOMESTIC PRODUCT IN 5 OECD MEMBER COUNTRIES (THE UNITED KINGDOM, UNITED STATES, GERMANY, FRANCE, CANADA)

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Abstract

The green economy is a global concern in sustainable development as it provides an approach that combines economic growth with environmental conservation. However, not all countries have managed to optimize the contribution of the green sector to economic income. This study aims to analyze the effect of several green economy indicators and other economic factors such as renewable energy, carbon emissions, nuclear energy, population, and foreign direct investment on Gross Domestic Product (GDP) in five OECD member countries in 2008-2023. This study uses quantile panel regression analysis tool. The regression results show that renewable energy variables are only significant in the middle and upper quantiles (0.50 and 0.75), while carbon emissions and population have significant positive effects in all quantiles, namely low, medium and high. Nuclear energy has a significant negative effect, while FDI has no effect and tends to have a negative impact on GDP. The contribution of green economy variables to economic growth varies depending on the income level of the country. Therefore, green economy policies need to be tailored to the economic characteristics of each country to be more effective in promoting sustainable growth.

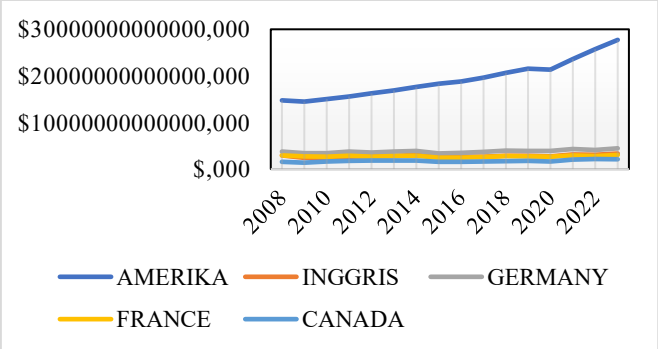
Keywords: Green Economy; Renewable Energy; Carbon Emissions; Nuclear Energy; Population; Foreign Direct Investment.

INTRODUCTION

The green economy has become one of the most discussed topics in the last decade, especially in large industrialized countries. The relationship between environmental performance and economic development is crucial. Environmental quality can impact economic growth in various ways. For example, a healthy environment can increase labor productivity because workers' health conditions are better. In addition, the environment can also affect the quality of a country's human resources, which is an important factor in the development process. Today's economic development often ignores environmental sustainability, even though a healthy environment and capital are important for long-term growth. The goal of the green economy is to improve human welfare and social justice by reducing environmental risks and scarcity of natural resources. The importance of green development in a fast-growing region is underscored by the fact that environmental pollution has become a global priority due to the rapid expansion and realization of the world economy (Wang & Yunfei Ge, 2023) This phenomenon is in line with the OECD's role as an organization that accommodates developed industrial countries. International organizations named *Organization For Economic Co-operation and Development* (EOCD) is an international organization that seeks to build better policies for a better life. The OECD has played an important role in fostering the economic growth, prosperity and social well-being of its member countries through policy analysis, research and cooperation between member and non-member countries. OECD member countries are increasingly recognized as the main drivers of global economic openness and austerity policies, with high income levels, open trade, and a broad financial system (Rong Wu & Zihan Xie, 2020).

OECD countries play a crucial role in global efforts to reduce CO2 emissions by actively participating in various environmental policies and green energy transitions. Despite various obstacles such as high production costs, supply instability, high mining costs, and supply chain problems, developed countries such as those dependent on the OECD have managed to attract increasing investment in renewable energy projects (Thach, 2025) . OECD countries have about 85 percent of the installed capacity of global nuclear power reactors, which collectively meet 18 percent of the demand energy needs in those countries (Sadiq et al., 2022). The EIA estimates that in 2018, OECD countries produced significantly higher energy-related CO_2 emissions compared to non-OECD countries, averaging around 9.5 metric tons per capita. OECD economic activity continues to experience a decline in energy intensity due to this economic shift from the energy-intensive manufacturing sector to the more energy-efficient manufacturing and commercial services sector. The EIA explains that energy-related CO2 emissions from OECD countries will decrease slightly (-0.2%) from 2018 to 2050. Although CO2 emissions from the use of petroleum and coal liquids in the OECD have decreased, emissions resulting from natural gas consumption have actually increased. The increase in global energy demand is primarily driven by population and GDP growth rates, a symbol of an economy driven by growth energy, and accounts for nearly 35 percent of global carbon emissions (Behera et al., 2024). In addition, the economic growth of developed countries that are members of the OECD and make an important contribution to global economic growth has a strong impact on global energy demand.

In the context of the green economy, the increase in renewable energy indicates a shift towards a more sustainable economic model. Investment in clean energy not only helps reduce carbon emissions, but also contributes to the growth of a green economy and increased energy security in the future. The UK has large and relatively untapped wind and solar energy resources (Copping et al., 2024). These countries show concern for welfare and social justice by reducing environmental risks and scarcity of natural resources. This includes the efficient and sustainable use of natural resources.



Source : macrotrends, 2025 (processed)

Figure 1. GDP of 5 Developed Industrial Countries in 2008-2023

The transition to a green economy goes hand in hand with the economic growth achieved. Based on GDP data from 2008 to 2023, the five countries experienced varied economic growth. The United States has the highest average GDP of 19,221,962 billion USD, followed by Germany 3,783,890 billion USD, France 2,746,059 billion USD, the United Kingdom 2,833,518 billion USD, and Canada 1,749,159 billion USD. This growth reflects an increase in economic activity that drives industrial expansion, urbanization, and modernization in various sectors, which in turn require large amounts of energy consumption. To address the environmental challenges that arise due to these conditions, these countries implement policies that encourage the transition to renewable energy. Through strict regulations and policies, they are ready to invest in industrial technologies that are energy-efficient and produce lower emissions and waste. Renewable energy policies also play a role

in encouraging complementary technological innovations, especially to overcome the problem of intermittency from solar and wind energy sources (Sahu & Mahalik, 2025).

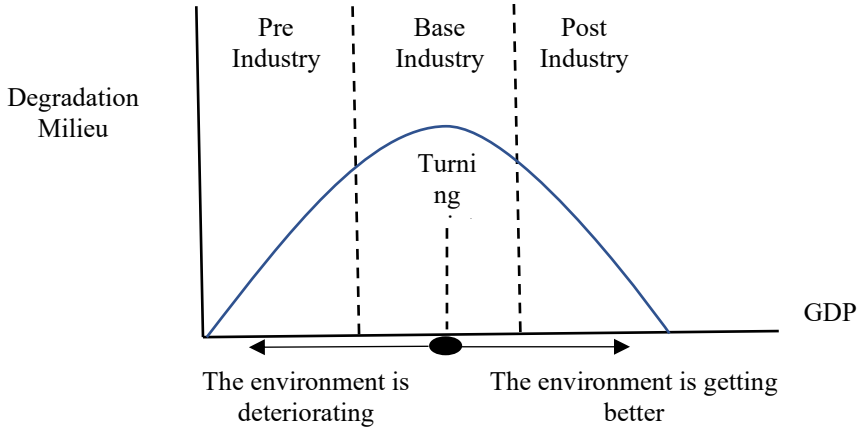
Therefore, it becomes relevant to examine the extent to which green economy indicators contribute to economic growth in OECD member countries. Several variables such as CO_2 emissions, use of renewable energy, nuclear energy consumption, population, and environmental investment can be important determinants of Gross Domestic Product (GDP). This study aims to analyze the influence of various green economic indicators on GDP in five OECD member countries, namely the United Kingdom, the United States, Germany, France, and Canada, during the period 2008–2023.

LITERATURE REVIEW AND HYPOTHESIS FORMULATION

Gross Domestic Product (GDP) serves as a key indicator for evaluating a country's economic performance and standard of living. A nation is often deemed economically successful when its GDP demonstrates consistent annual growth. In addition to GDP, other indicators such as rising government revenues, fair income distribution, low unemployment rates, and stable inflation also reflect economic success. National income plays a crucial role in illustrating the overall condition of a country's economy and serves as a foundation for formulating economic policies and analyzing wealth distribution(Yossinomita, 2024).

Kuznets Curve Environmentalist Theory

Kuznets' Environmental Curve (EKC) theory is basically inspired by Kuznets' curve (1955) Kuznet explains that income inequality first increased, then reached a turning point and then declined during the economic revolution from a low-income country to a high-opinion country. Therefore, an inverse U-relationship is assumed between income inequality and economic growth, which means that income distribution is uneven in the early stages of economic growth, while income distribution is more even in the later stages of growth.



Source : (Grossman & Krueger, 1991)
Picture 1. Kuznets Curve Enviromental Curve (EKC)

In the early stages of development, the kuznet curve shows that people prioritize basic consumption to meet their immediate needs rather than looking at the quality of the environment. Low-income residents focus solely on consumption and can afford to invest in pollution reductions that can lead to degraded environmental quality. In this phase, the community exploits natural resources and technology excessively. The kuznet curve describes a shift toward improving environmental quality and decreasing marginal utility consumption, as people's incomes increase. This shows the increasing concern for better environmental quality. The curve shows that the population peaked during the median income range and subsequently declined beyond the turning point, in line with the increase in people's incomes. So, although early economic growth caused

pollution, it ultimately improved the quality of the environment as society gradually reduced economic activities with negative externalities.

Adam Smith's Theory

Economic growth is driven by population development. The increase in population expands the market, which in turn increases specialization in the economy. This specialization improves overall economic activity. The development of specialization and division of labor among the workforce accelerates economic development as it increases labor productivity and encourages technological advancements (Sukirno, 2017). According to the growth theory described in the book Sukirno (2017), the rate of economic growth is greatly influenced by population development, capital investment, and technological advancements. However, population growth does not always have a positive impact on economic development.

Harrod-Domar's investment theory

The formation of capital or investment is an important factor that determines economic growth. The formation of such capital can be obtained through the accumulation of savings. Harrod-Domar's theory takes a deeper look at how capital is formed in the wheels of the economy. In this theoretical view, capital formation is not just ordinary expenditure, but investment that strengthens a country's ability to produce more goods and services. This investment also increases the overall purchasing power of the people. In line with Keynes' thinking, Harrod-Domar argued that an increase in production capacity alone does not automatically guarantee the growth of national production and income.

Before formulating the hypotheses, this study first reviews relevant theories, previous research findings, and the logical relationships between the variables being examined. Gross Domestic Product (GDP), as an indicator of economic growth, can be influenced by several factors such as renewable energy use, CO_2 emissions, nuclear energy, population, and foreign direct investment. Based on these considerations, the hypotheses in this research are developed to test whether there is a relationship or effect between these variables and GDP.

H_0: It is suspected that there is no significant influence between Renewable Energy on GDP.
H_1: It is suspected that there is a significant influence between Renewable Energy on GDP.

H_0: It is suspected that there is no significant effect between CO_2 Emissions on GDP.
H_2: It is suspected that there is a significant influence between CO_2 Emissions on GDP.

H_0: It is suspected that there is no significant influence between Nuclear Energy on GDP.
H_3: It is suspected that there is a significant influence between Nuclear Energy on GDP.

H_0: It is suspected that there is no significant influence between the Number of Population on GDP.
H_4: It is suspected that there is a significant influence between the Number of Population on GDP.

H_0: It is suspected that there is no significant influence between Foreign Direct Investment on GDP.
H_5: There is a significant influence between Foreign Direct Investment on GDP.

RESEARCH METHODS

Data

The data used in this study is secondary data collected from the calculations carried out, *the World Bank, macrotrends*, and *Our World In Data.* The types of information entered are *Gross Domestic Product* (Y), Renewable Energy (X_1), CO2 Emissions (X_2), Nuclear Energy (X_3), Population (X_4), Foreign Direct Investment (FDI) (X_5). In this study, Gross Domestic Product (GDP) is defined as the total value of final production of goods and services produced by a country in a given period and

measured in USD (US dollars). Renewable energy refers to a naturally renewable and sustainable source of energy, measured in percent (%).

CO_2 emissions are the amount of carbon dioxide produced from the activities of *the Industrial Processes* sector, excluding the energy, agriculture, and waste sectors, and expressed in units of $MtCO_2e$ (million metric tons of carbon dioxide equivalent). Nuclear energy is energy released through a reaction in the nucleus of an atom and acts as a low-carbon energy source, measured in TWh (Terawatt-hour). The population reflects the total number of individuals living in a country in a given year and is expressed in units of soul. Meanwhile, Foreign Direct Investment (FDI) is an investment made by foreign individuals or companies to a country, which in this study is measured in the form of a percentage of *net inflows* to the GDP of each country per year.

Analysis methods

This study uses quantile panel regression processed using stata. Panel data analysis is a combination of time series and cross section data. The countries that are the case studies are the United Kingdom, the United States, Germany, France, and Canada. With a time series of 16 years (2008-2023). Panel quanttile regression is applied to analyze the relationship between independent variables and dependent variables in various quantile distributions. The analysis is carried out through several stages, namely: (1) *pre-estimation diagnostics* to ensure data quality, (2) selection of the best model by testing various panel data regression estimates, (3) panel quantile regression estimation, and (4) test the influence of independent variables on dependent variables to evaluate the significance and magnitude of the effects of each variable in the model.

Using this approach, the study not only measured the average impact of independent variables on GDP, but also looked at how those impacts differed on specific quantities, such as the τ = 0.25, 0.50, and 0.75 quantities.

Thus, the quantile panel model in the form of logs can be written as:

$$\mathrm{Q}_{\tau}(\mathrm{GDP}_{\mathrm{it}}|\mathrm{X}_{\mathrm{it}}) = \beta_0^{(\tau)} + \beta_1^{(\tau)}\, In\mathrm{ET}_{\mathrm{it}} + \beta_2^{(\tau)}\, In\mathrm{CO2}_{\mathrm{it}} + \beta_3^{(\tau)}\, In\mathrm{EN}_{\mathrm{it}} + \beta_4^{(\tau)}\, In\mathrm{POP}_{\mathrm{it}} + \beta_5^{(\tau)}\, In\mathrm{FDI}_{\mathrm{it}} + \epsilon_{\mathrm{it}}^{(\tau)} \quad \text{.....(1)}$$

Where represents the second quantile of the conditional distribution of GDP to independent variables. $Q_{\tau}(GDP_{it}|X_{it})\tau$

Where:

$\mathrm{Q}_{\tau}(\mathrm{GDP}_{\mathrm{it}}\|\mathrm{X}_{\mathrm{it}})$	:	The ττττ quantile value (e.g. 0.25, 0.50, 0.75) of the country's GDP (GDP) in the t-year, given the independent variable XitX_{it}Xit
$\beta_j^{(\tau)}$	:	The regression coefficient in the ττh quantile for the j variable.
$In\mathrm{ET}_{\mathrm{it}}$	:	Logarithm of **Renewable Energy** (percent)
$In\mathrm{CO2}_{\mathrm{it}}$	:	Logarithm of **Carbon Dioxide Emissions** (Mt CO2e)
$In\mathrm{EN}_{\mathrm{it}}$	:	Logarithm of **Nuclear Energy** (TWh)
$In\mathrm{POP}_{\mathrm{it}}$	:	Logarithm of **Total Population (Soul)**
$In\mathrm{FDI}_{\mathrm{it}}$		Logarithm of **Foreign Direct Investment (FDI)** (percent of GDP)
$\epsilon_{\mathrm{it}}^{(\tau)}$	:	Term error for ττh quantity, ith country, t year

RESULTS AND DISCUSSION

The *Cross-sectional Dependence Test* occurs when the cross-sectional units in the data panel have a relationship or relationship with each other. Cross-sectional dependency testing is important in customizing the panel data model to produce more accurate analysis results.

Table 1. Cross-Sectoral Dependency Test

Pesaran's test	=	4,5	0,0000

Friedman's Test	=	36,3	0,0000
Miller's test	=	1,06	alpha = 0.10; 0.1612*
			alpha = 0.05; 0.2116*
			alpha = 0.01; 0.3125*

Source: Processed Stata17 (2025)
Description:*significant α = 0.05

The hypothesis formulation is *H0*: there is no cross-sectoral dependency and *H1*: there is cross-sectoral dependency with the chosen significant level of = α 0.05. The test criteria states that it subtracts *H0* if the probability value is < $\alpha$and fails to subtract *H0* if the probability value is > α. Based on table 1 In the cross-sectoral dependence test of the mind and the Friedman test, the probability value shows the number 0.0000 < α = 0.05. The decision to reject *H0* and accept *H1* means that the model has a dependence on sectoral or *cross section lists*. Meanwhile, in the Frees test, where the statistical value is greater than the critical value, which is 1.063 > 0.1612; 0.2116; 0.3125 (α= 0.05). The decision to fail to reject *H0* or accept *H0* means that the model has no dependence on cross-sectoral or *cross section.* In the cross-sectoral robustness test, the Frees test showed good results or there was no cross-sectoral dependence. Meanwhile, the Pesaran and Friedman tests showed a cross-sectoral or *cross-section dependence.*

One of the root unit tests for panel data is CIPS (*Cross-sectionally Augmented Im-Sin*) *Unit Root Test*. CIPS Concept *Root Test Unit* proposed by Squirrels (2007).

Table 2. Unit Root Test

Variable	Intercept		Intercept with Trend	
	Level	1st Diff	Level	1st Diff
LNGDP	-1.951	-4.153***	-2.314	-4.047***
lnetb	-2.335*	-4.220***	-3.373***	-4.414***
lnco2	-1.282	-4.642***	-3.183***	-4.915***
lnnlr	-2.999***	-3.985***	-2.103	-4.438***
lnpop	-1.632	-1.488	-0.565	-3.422***
FDI	-3.342***	-5.055***	-3.410***	-4.776***

Source : Processed *Stata17* (2025)

Description: ***CIPS* < 0.01 (critical value -2.60); **CIPS* < 0.05 (critical value -2.34); **CIPS* < 0.10 (critical value -2.21) on *intercept; CIPS* < 0.01 (critical value-3.15); **CIPS* < 0.05 (critical value -2.88); **CIPS* < 0.10 (critical value-2.74) *on intercept with trend*

The results of the analysis in Table 2 show that most of the variables are not stationary at the level, but become stationary after the first differentiation. The model with *intercept and trend* provides the most consistent results, where all variables (GDP, renewable energy, carbon emissions, nuclear energy, population and FDI) are significant after differentiation. On the other hand, in the model with *intercept only*, some variables such as population size are not significant, meaning that the model is better if it takes into account trends. Overall, it can be concluded that all variables are integrated in the first order (I(1)), i.e. they become stationary after the first difference. This indicates that the data is stable and ready for further analysis.

Cointegration shows that although the variables have short-term fluctuations that are independent of each other, it is possible to have a long-term relationship (Abimanyu et al., 2012). Cointegration testing is very important to better understand the long-term relationship between economic variables and produce more stable and consistent estimates (Anindya, 2015).

Table 3. Cointegration Test

Testing	Type	Statistics	Prob.
Westerlund		2.4451	0.0072*
Pedroni	Modified Phillips–Perron	3.5991	0.0002*

	Phillips–Perron	2.0111	0.0222*
	Augmented Dickey–Fuller	1.8786	0.0302*

Source : Processed *Stata17* (2025)

Description:*significant α = 0.05

Hypothesis formulation H0: there is no cointegration and H1; there is cointegration with a significant degree α = 0.05. The test criteria states that subtract H0 if the probability value is < = 0.05 and fail to subtract αH0 if the probability value is > α = 0.05. Based on these results, the cointegration test with the kao and pedroni methods can be seen showing the results that the probability value < = 0.05 can be concluded that the decision to reject Hα_0 and accept H1 means that there is cointegration or there is a relationship between variables in the long term.

Table 4. Quantile Panel Regression

Variable	Quantils	Coefficient	z-Statistics	Prob
lnetb	0,25	0.0629076	1.41	0.159
	0,50	0.0835987	2.45	0.014**
	0,75	0.1049304	2.13	0.033**
lnco2	0,25	0.4272166	2.95	0.003***
	0,50	0.5143263	4.59	0.000***
	0,75	0.6041332	3.78	0.000***
lnnlr	0,25	-0.0700399	-3.41	0.001***
	0,50	-0.0606488	-3.89	0.000***
	0,75	-0.050967	-2.26	0.024**
lnpop	0,25	1.956438	3.66	0.000***
	0,50	1.773162	4.38	0.000***
	0,75	1.584211	2.70	0.007***
FDI	0,25	-0.0038172	-0.62	0.532
	0,50	-0.0044833	-0.98	0.328
	0,75	-0.0051701	-0.77	0.441

Source : Processed *Stata17* (2025)

Description: ***significant α = 0.01; **significant α = 0.05; * significant α = 0.10

The Influence of Renewable Energy on *Gross Domestic Product*

The quantile regression estimation results across the three main quantiles (0.25, 0.50, and 0.75) indicate that renewable energy exerts a positive influence on economic income at all distribution levels, albeit with varying degrees of significance. At the 0.25 quantile, which represents countries with relatively lower income levels, the positive impact of renewable energy on GDP is present but statistically insignificant. This suggests that in lower-income countries, the adoption of renewable energy is not yet sufficient to substantially drive economic growth. Conversely, at the 0.50 and 0.75 quantiles corresponding to middle- and high-income countries renewable energy demonstrates a significantly positive effect on economic performance. These findings align with the Environmental Kuznets Curve (EKC) hypothesis, which posits that during the early stages of development, economic growth may be associated with increased emissions and environmental degradation. However, as income levels and environmental awareness improve, countries tend to transition toward cleaner and more efficient energy sources that support sustainable economic growth. This result is also consistent with the findings of Cahyani et al. (2020), who reported that renewable energy positively affects economic income while contributing to long-term reductions in carbon dioxide emissions. However, it contrasts with the study by Rahmandani & Dewi (2023), which found that, when analyzed separately for different income groups, renewable energy has a significant negative impact on economic growth. Based on the results of the study Chavda & Mehta,

(2025) Gross Domestic Product (GDP) shows that higher GDP encourages the adoption of renewable energy, thus supporting the conservative hypothesis. Many developed countries have made efforts to reduce carbon emissions and adopt cleaner energy sources. This is evident in the substantial share of renewable energy in these countries. Countries with high shares of renewable energy should lead the way in eliminating fossil fuel subsidies, setting an example and accelerating the transition to clean energy

The Effect of Carbon Emissions (CO2) on *Gross Domestic Product*

Based on the results presented in Table 5 across each quantile, for countries within the low to medium income group, the regression coefficients at the 0.25, 0.50, and 0.75 quantiles are all statistically significant at the 0.000 level. This indicates that increases in CO_2 emissions have a strong and significant positive effect on economic growth. These results imply that the economies of these countries remain heavily reliant on high-emission sectors, such as large-scale manufacturing and fossil fuel consumption. This finding contradicts the Environmental Kuznets Curve (EKC) hypothesis, which suggests that while emissions tend to rise during early stages of economic development, they should eventually decline once a certain income level is reached due to the adoption of cleaner technologies. Similarly, Rajagukguk, (2019) also found that CO_2 emissions are positively associated with economic growth. This suggests that the development process in these countries continues to contribute to environmental degradation, as evidenced by the positive relationship between development indicators and CO_2 emissions. In contrast to the study (Marra et al., 2024) which says that technological changes show a full impact on carbon dioxide emissions exclusively in the identified clusters. Structural changes do not directly affect emissions reductions, but appear to act as a catalyst for green innovation and energy intensity reduction. Technological change seems to be the main way out of the dire environmental situation we are currently facing. Technological transformation encompasses all activities that contribute to the creation of new solutions and technologies to reduce environmental pollution, the negative consequences of resource exploitation, and energy consumption. Technological changes improve energy efficiency. Energy efficiency, which means using less energy to perform the same tasks, is unanimously recognized as one of the easiest and most cost-effective ways to combat climate change, which is fundamental to reducing CO2 emissions.

The Influence of Nuclear Energy on Gross Domestic Product

The nuclear energy variable shows a statistically significant coefficient across all quantiles, indicating that increased use of nuclear energy has a negative impact on economic growth at various levels of national income (GDP). At the 0.25, 0.50, and 0.75 quantiles, the influence remains significant at the 5% level (p-value = 0.001). However, the decreasing absolute value of the coefficient suggests that the negative effect of nuclear energy on GDP tends to diminish as a country's GDP increases. This implies that in higher-income countries, nuclear energy can be better managed and integrated, thereby reducing its adverse impact on economic growth. Nuclear energy is essential in advancing sustainable development, improving environmental health, securing energy availability, and controlling CO2 emissions. Nuclear energy has attracted global attention as an efficient method of reducing pollution, which is attributed to its low-carbon power production capabilities. Nuclear energy consumption has significant potential to mitigate critical challenges, including greenhouse gas emissions and carbon reduction (Kartal, 2022). These findings contradict the Environmental Kuznets Curve (EKC) hypothesis, which argues that in advanced stages of development, the use of cleaner energy sources such as nuclear should promote more sustainable economic growth.

This contrasts with the findings of Cahyani & Marhaeni (2022), who observed a significant positive impact of nuclear energy consumption on economic performance. Similarly (Zhou et al., 2025)concluded that nuclear power contributes to energy efficiency and produces low-carbon energy, helping to reduce overall environmental degradation. Within the framework of the green economy, nuclear energy is expected to be part of the clean energy mix that supports national energy

security and long-term economic resilience. However, if not carefully managed and planned, its development may pose both economic and social challenges. Therefore, the advancement of nuclear energy in the context of sustainable development must be approached with structured and strategic planning. The results of the study (Yang et al., 2025) that the findings show that the role of nuclear energy in promoting CE is negative in all quantiles.

The Effect of Population on *Gross Domestic Product*

The estimation results indicate that the population variable has a consistently positive and significant effect on economic growth across all quantiles (0.25, 0.50, and 0.75), with a probability value of 0.000, which is well below the 0.05 significance threshold. However, the declining coefficient values at higher quantiles suggest that the positive influence of population tends to diminish as a country's GDP increases. These findings align with previous studies; Arza (2023)found that population positively affects GDP per capita, while Santi & Hadi (2020) also reported a significant impact of population on economic outcomes. Overall, this study confirms that population has a positive and statistically significant effect on economic income (GDP) in the five OECD member countries under investigation namely the United Kingdom, the United States, Germany, France, and Canada during the 2008–2023 period. The results imply that population growth contributes to GDP expansion, supporting classical economic theory which views a larger population as a driver of economic growth through greater market size, increased consumption, and expanded labor supply.

The Effect of Foreign Direct Investment on Gross Domestic Product

Based on the analysis results, the estimated quantile panel model indicates that Foreign Direct Investment (FDI) consistently exhibits a negative coefficient across all observed quantiles namely at the 0.25, 0.50, and 0.75 quantiles. This suggests a negative association between FDI and GDP, implying that there is insufficient evidence to confirm a significant positive impact of FDI on GDP across different income distributions. The relationship observed in this study contrasts with the Harrod-Domar growth theory, which posits that FDI should positively influence GDP by enhancing production capacity, transferring technology, and generating employment opportunities to stimulate economic growth. However, the findings reveal that higher levels of FDI tend to coincide with lower GDP levels, although the effect is generally statistically insignificant across most income brackets.

These results differ from previous studies that reported a positive relationship between FDI and economic growth, such as Jamshed et al., (2024), which examined countries in the Asian region. This divergence highlights that the impact of FDI on economic performance may vary depending on a country's structural characteristics, especially when comparing developed and developing nations. The positive effect of FDI on economic output, as expected in theory, may only be realized under certain conditions particularly when supported by sufficient local technological capacity and stable policy environments. This aligns with the findings of Chen et al (2023) in *Environmental Science and Pollution Research*, which emphasize that FDI can contribute to green growth only when accompanied by domestic readiness in technology and governance. The Sustainable Development Goals of the Countries, which are targeted for 2030 and 2045. Second, evidence on the relationship between FDI and GDP can help assess whether FDI in the region lacks adequate environmental regulation or, alternatively, whether FDI makes a positive contribution to environmental quality in the long term (Numan et al., 2025).

CONCLUSION (Calibri Light 11, Bold, spasi 1,5, spacing before 12 pt, after 0 pt)

Based on the results and discussions that have been presented in the previous chapter, this study proves that there are several factors that affect economic income (GDP) in five developed OECD member countries. The conclusions of this study are as follows:

1. Renewable energy has a positive influence on *Gross Domestic Product* at every level of distribution, both in countries with middle, medium, and high income levels. However, at the 0.25 quantity, the effect was not significant. On the other hand, at the 0.50 and 0.75

quantities, renewable energy was shown to have a significant positive effect. This is in accordance with the condition that 5 OECD member countries have used renewable energy as an environmentally friendly energy transition and sustainable economic development.

2. The carbon emission factor (CO_2) has been proven to have a positive and significant effect on *Gross Domestic Product* (GDP) in all quantiles analyzed, both in countries with medium and high income levels. The findings suggest that economies in these countries are still quite dependent on high-emission sectors, such as large manufacturing industries and fossil energy use. In the 5 OECD countries studied, the transition to clean technology is not yet clear, as economic growth is still strong and the industrial and energy sectors are still dependent on unsustainable systems.
3. The nuclear energy factor has a negative effect on economic growth at various levels of *Gross Domestic Product* (GDP), both in countries with medium and high income levels. This impact can be caused by high initial costs, security risks, and long development times, so the economic benefits tend to be delayed and burden the fiscal in the short term. In addition, the issue of social acceptance of nuclear energy can also hinder its productive use, so that although it is significant, its effect actually decreases on GDP.
4. The population factor has a significant positive effect on *the Gross Domestic Product* (GDP) in all quantils. These results show that the increase in population is getting stronger as the income level of a country increases. This phenomenon can be seen in the United States which has a high GDP rate in line with the trend of increasing population. This is also seen in the United Kingdom, Germany, France, and Canada where population growth is in line with increased economic activity.
5. The *Foreign Direct Investment* (FDI) factor has a negative effect on reducing economic growth in all groups of countries, both those with *low, medium, or high levels of Gross Domestic Product* (GDP). In this case, there is a potential inaccuracy that incoming foreign investment has not been fully directed to sectors that support long-term productivity.

Based on the findings of the empirical results and the discussion that has been described above, the suggestions that researchers can give are encourage development that is balanced between economic growth and environmental sustainability by gradually reducing dependence on fossil energy, iImplementing environmentally friendly production in the industrial sector through the use of clean technology to reduce carbon emissions and increase public awareness of environmental issues, and attracting green-oriented foreign investment through incentives and simplification of regulations in sustainable sectors.

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