ANALYSIS OF THE EFFECT OF GROSS DOMESTIC PRODUCT, FINANCIAL DEVELOPMENT, FOREIGN DIRECT INVESTMENT, AND ENERGY ON CO2 EMISSIONS IN INDONESIA FOR THE 1990-2020 PERIOD

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Abstract

This study examines the factors influencing CO2 emissions from 1990 to 2020. In this study, CO2 emissions are the dependent variable, and the independent variables consist of financial development, foreign direct investment, economic growth, and energy, as measured by the Error Correction Model (ECM) method implemented in the E-views 10 software. This study discover that (1) Financial Development in the short and long term has no effect on carbon dioxide (CO2) emissions in Indonesia, (2) foreign direct investment in the short and long term has no effect on carbon dioxide (CO2) emissions in Indonesia, (3) economic growth in the short and long term has an insignificantly positive effect on carbon dioxide (CO2) emissions in Indonesia, and (4) energy has no effect on carbon dioxide (CO2) emissions in Indonesia.

Keywords: *CO2 Emissions, Energy, Financial Development, Foreign Direct Investment, Gross Domestic Product*

1. INTRODUCTION

According to population, Indonesia is the fourth largest country. Having the fourth largest population in the world has the advantage that it consumes quite a lot of energy (Trisiana, 2022). One important element in economic growth is energy consumption. With a large energy consumption will trigger the movement of the economy in the country. (Kartiasih & Setiawan, 2020) stated that the energy intensity in Indonesia has increased compared to the previous year. Indonesia's energy intensity in 2010 was 0,36 thousand BOE/billion rupiah, which is to create a Gross Domestic Product (GDP) of 1 billion rupiah, it required energy of 0,36 thousand BOE (barrel of oil equivalent) or a cost of energy of 53 million rupiah was required. This population in Indonesia has large human resources and abundant natural resources. Indonesia itself is also one of the developing countries whose economic growth has increased every year (Calder & Pearce, 2005; Nisa & Juliprijanto, 2022). There is a need for efficient policies to maintain investment stability, several steps are needed to ensure economic growth (Solodar et al., 2018; Zulfikar et al., 2021). Investments are required in a nation to support the government's economic policies, and investments play a crucial role in determining the direction of economic development (Sahu & Kumar, 2020; Santi & Sasana, 2021).

Regarding economic growth from the standpoint of sustainable development, there are two hypotheses, the Pollution Haven Hypothesis and the Pollution Halo Hypothesis, which assert that FDI and environmental pollution are mutually influential. This is how the

Pollution Halo Hypothesis might reduce pollution in a nation. According to Kizilkaya, foreign direct investment countries have more energy efficiency, advanced technology, and management abilities (Kizilkaya, 2017). However, in the economic growth and movement of capital has increased in the world, has led to different views on some environmental pollution (Abumunshar et al., 2020; Ma et al., 2019; Pratama, 2022). Especially developing countries have forgotten the problem of the environment to attract foreign direct investment to improve the economy of developing countries (Kurniarahma et al., 2020; Toto Gunarto, 2020). Companies that choose low taxes and regulations in investing in developing countries, therefore, foreign direct investment brings environmental problems in developing countries. This situation is referred to as the "Pollution Haven Hypothesis" in (Kizilkaya, 2017). Judging from the literature, foreign direct investment on the side of providing benefits to a country also causes problems in the environment.

Several economic models, particularly growth from a macroeconomic viewpoint, have disregarded a number of environmental issues (Albra et al., 2019; Candra, 2018; Noor & Saputra, 2020). Generally, economic theory does not consider environmental issues to be a complicated problem. Economic growth and the environment have two directions that are not in harmony, the ongoing economic growth will cause damage to the environment (Cahya & Maula, 2021). Efforts to minimize environmental pollution by only maintaining economic growth have become a substantial problem when the process of forming a quality country's economy (Hong, et al 2017 in (Aisah, 2019)). Balance is achieved in the construction of a country's economy by considering environmental factors that do not change or produce difficulties, hence avoiding environmental degradation (P. Agus Widarjono, 2013).
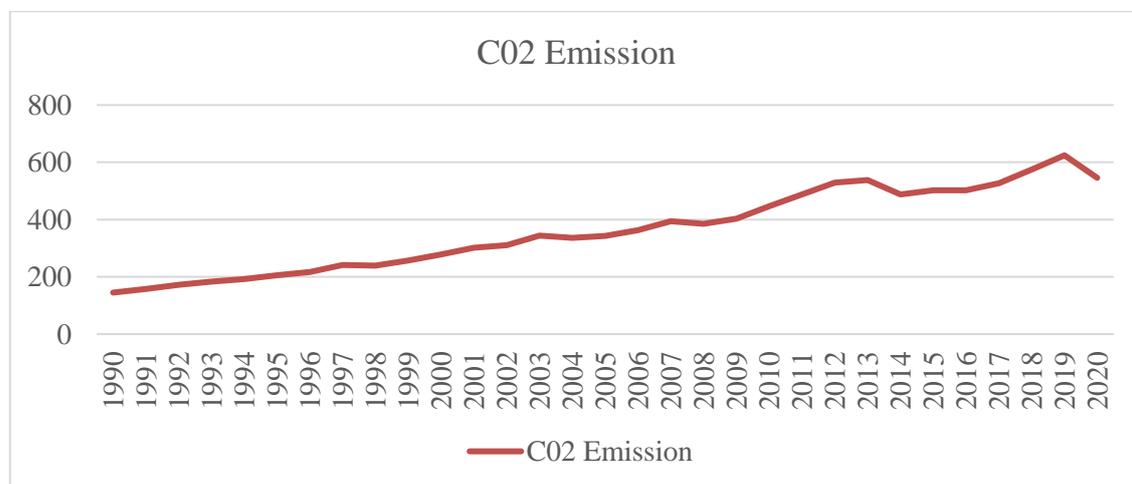
Source : BP Statistical Review of World Energy (2020)
Figure 1 Emissions of Carbon Dioxide (CO2) in Indonesia 1990-2020

From Figure 1 Above, it can be seen that during the period 1990-2020 carbon dioxide emissions have increased every year. In recent years, global warming and climate change have arisen, one of the main effects of increasing global warming is the emission of carbon dioxide (CO2) (Ghosh et al., 2010). With global warming and an increase in climate change will hamper some of the goals of the Sustainable Development Goals (SDGs). One of the biggest challenges in achieving the SDGs goals which will end in 2030 is the issue of

environmental degradation, which is getting worse due to economic activity (Zafar et al., 2019). Currently, economic growth is growing rapidly followed by industrial growth that causes air pollution which continues to increase which will affect global warming and decrease environmental quality (Chienwattanasook et al., 2021; Odugbesan & Adebayo, 2020). In particular, the increase in greenhouse gas emissions has led to changes in environmental policies to minimize the occurrence of rapid climate change without neglecting the targets of long-term economic growth. Several nations' use of sustainable long-term growth strategies in pursuit of sustainable development goals, particularly the SDGs, is evidence of this. Long-term development can be achieved if the economy has renewable energy that is affordable, economically viable and socially acceptable (Sinha et al., 2018).

The phenomenon is attempted to be explained by the Environmental Kuznets Curve (EKC) hypothesis, which states that economic growth will increase continuously, but at a certain point, the policies implemented will be more concerned with environmental conservation, as indicated by the turning point that will be reached when a country reaches a certain level of economic growth (Michael P. Todaro, 2006). According to the EKC theory, a country's pollution increases when it grows but then reduces the increase in income beyond the turning point. Thus, there is a threshold level of economic growth beyond which further amelioration of environmental consequences in the early phases of economic development is ineffective (Kizilkaya, 2017).

This study aims to analyze the factors that influence CO2 emissions for the period 1990-2020. As well as applying ECM econometric analysis to investigate the relationship between CO2 emissions, gross domestic product, financial development, foreign direct investment, energy in Indonesia.

2. THEORETICAL BASIS

2.1. Environment Kuznets Curve (EKC)

The relationship of economic growth to environmental pollution, as well as the effects of economic growth on energy consumption have been studied empirically and extensively over the past two decades. The Environmental Kuznets Curve (EKC) theory explains the overall relationship between economic growth and pollution. The development of the hypothesis of Simon Kuznets in his research "Economic Development and Income Inequality" in 1955 marked the beginning of the theory of economic growth. Economic growth was introduced as a component explaining shifts in the distribution of income over time in the Kuznets hypothesis of 1955 (Kartiasih & Setiawan, 2020).
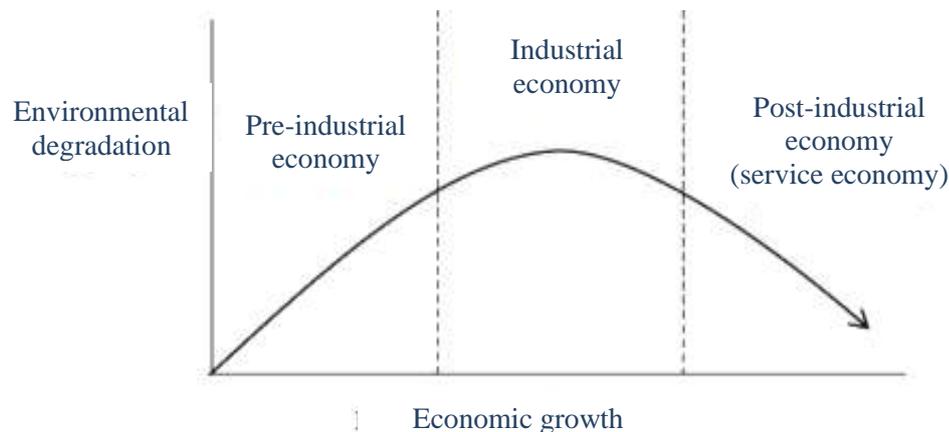
Source: Nikensari (2019)
Figure 2 EKC Hypothesis Turning Point Process

The hypothesis according to the EKC theory is that economic development will initially exacerbate environmental damage. This is important because the state will prioritize increasing production over environmental concerns. Continuous production operations will damage the environment, resulting in soil, water and air pollution. At some point, economic prosperity will realize the importance of quality and a healthy environment. The turning point is the point at which economic development reduces environmental damage. That is, the EKC hypothesis shows that long-term economic growth will benefit the environment and provide welfare for the environment (Nikensari et al., 2019)

2.2. CO2 Emissions

Carbon emissions are gaseous substances released from the combustion of compounds containing carbon, such as CO_2, diesel, and other fuels. Carbon emissions are a contributor to climate change along with greenhouse gas emissions. Carbon dioxide is a material composed of one carbon atom (C) and two oxygen atoms (O2) (UND EERC, 2016). Carbon dioxide (CO2) is one of the many gases that make up the Earth's atmosphere, such as nitrogen, oxygen, and argon. The composition of the gases that make up the atmosphere is not always constant, but changes from time to time and between places (Lutgen & Helmers, 1979).

With the increase in infrastructure such as industry, it results in an increase in environmental pollution where from that pollution there is one substance that will cause environmental damage, namely carbon dioxide (CO2). Meanwhile, according to Richard in (Hasni et al., 2021) The majority of Indonesia's carbon emissions are caused by industrial activities, which are characterized by the rising number of foreign investments entering Indonesia. Cash inflows to Indonesia were partly channeled through the business sector, particularly in the manufacturing, trade and service sectors. Every industry, of course, engages in waste-generating manufacturing activities that elicit stronger emotional responses.

2.3. Financial Development

Domestic Credit to the private sector is utilized for financial development in this study. Levine (2000) classifies the primary functions of the financial system as mobilizing savings, allocating resources, monitoring managers and conducting corporate oversight, facilitating trade, hedging, diversification, and risk pooling, and facilitating efficient transactions of goods and services. Each of these financial system functions can impact economic growth via two channels. Second, the path of technological innovation. Some of these pathways are the two primary sources of long-term economic growth identified in the economic growth theory literature.

The financial system influences the level of savings (supply side of funds) by reallocating savings into various investment options (demand side of funds), including physical capital investment, human resource investment, and technology investment. With the improvement of the financial system's ability to carry out some of its fundamental functions, and with the financial system's increased contribution to fostering economic growth. Without access to a variety of funding sources (investors), many business activities can only produce in relatively small quantities, reducing their efficiency. The financial system can generate a variety of instruments that can be used to distribute relatively small but substantial sums of money (Riza, 2018).

Financial development will diversify investment in various investment intermediary institutions, thereby reducing the risk of investment. Decreased transaction costs in gathering information from investment intermediaries and increased capital accumulation. The development of the financial sector also opens access to groups of people who have low incomes, so that it will increase participation in economic activities and productive assets, so that the poverty rate can be reduced (Odhiambo, 2010).

2.4. Foreign Direct Investment

Foreign direct investment (FDI) or foreign investment (PMA) based on Law No. 1 of 1967 No. 11 of 1970 Concerning Foreign Investment is a direct foreign investment carried out based on several provisions of law in Indonesia, in the sense that the capital owner directly bears the risk of the investment (Suharyono, 2017).

Zaenuddin (2018) argues that foreign direct investment is an investment that directly involves investors in the business operations carried out so that business dynamics related to established company policies, goals to be achieved, cannot be separated from interested parties (foreign investors).

Foreign direct investment is also able to increase tax revenues and improve technology, management, financial resources, job creation, marketing, and human resource development such as job skills in the home country (Kariuki, 2015; Todaro & Smith, 2003). Likewise, foreign direct investment also plays an important role in filling the gaps in development, foreign exchange, investment, and taxes in developing countries (Anyanwu, 2011; Quazi, 2007; Smith, 1997). With direct foreign investment, it can increase productivity so that economic development runs properly and is achieved properly.

2.5. Economic Growth

The definition of economic growth is an increase in national income based on constant prices or the difference between one year's Gross Domestic Product (GDP) and the previous year's GDP. GDP is the total value of all goods and services produced by a nation. When the total output of goods and services in a given year exceeds the previous year, the economy is growing (Setiawan, 2020). According to Todaro, the economic growth of a nation is determined by a number of factors, including capital accumulation, which encompasses all forms or types of new investments in land, physical equipment, and human resources; population growth, which increases the number of workers in the coming years; and technological advancements. According to Kuznets, economic growth is an increase in a country's long-term capacity to provide its population with various economic goods. The expansion of capacity occurs as a result of technological advancement or the adaptation of institutions and ideologies to the various demands of the current situation (Ma'ruf & Wihastuti, 2008).

2.6. Energy

The expansion of global market processes and the employment of more modern technology result in an increase in energy consumption in a variety of industries, which has a detrimental effect on environmental degradation. Specifically the use of energy in numerous industries, including the manufacturing and agricultural sectors. Given that agriculture is one of the most important businesses in every country, especially in industrialized nations where energy consumption is so high in terms of population and per capita consumption, there is a significant opportunity for energy conservation (Zhang et al., 2020).

3. RESEARCH METHOD

This study utilizes secondary data and time series data from the World Bank and BP Statistical Review of World Energy. This study requires information on carbon dioxide (CO2) emissions, financial growth, foreign direct investment, economic expansion, and energy from 1990 to 2020. The data were analyzed using EViews 10 and the ECM (Error Correction Model) method. This model is anticipated to explain both short- and long-term relationships.

$$CO_{2t} = (\ ,\ ,\ )FD_t FDI_t GDP_t TEC_t$$

Information:
CO_{2t} = Carbon Dioxide Emissions/year
FD_t = Financial Development/year
FDI_t = Foreign Direct Investment/year
GDP_t = Economic Growth/year
TEC_t = Energy/year

So the equation of the long-run model is:

$$CO_{2t} = a_0 + \beta_1 FD_t + \beta_2 FDI_t + \beta_3 GDP_t + \beta_4 TEC_t + \mathcal{E}_t$$

Information:
CO_{2t} = Carbon Dioxide Emissions/year
FD_t = Financial Development/year
FDI_t = Foreign Direct Investment/year
GDP_t = Economic Growth/year
TEC_t = Energy/year
$\mathcal{E}_t$ = error term

While the equations of the short-term model are:

$$D(CO_{2t}) = a_0 + \beta_1 D(FD_t) + \beta_2 D(FDI_t) + \beta_3 D(GDP_t) + \beta_4 D(TEC_t) + \beta_5 ECT + \mathcal{E}_t$$

Information :
$D(CO_{2t})$ = Carbon Dioxide Emissions/year/differentiated at first difference
$D(FD_t)$ = Financial Development/year/ already differentiated on first difference
$D(FDI_t)$ = Foreign Direct Investment/year/differentiated at first difference
$DGDP_t$ = Economic Growth/year/differentiated at first difference
$D(TEC_t)$ = Energy/year/differentiated at first difference
$\mathcal{E}_t$ = error term

All variables must be stationary before estimating the Error Correction Model (ECM). For this reason, a unit root test is required to determine whether all variables are stationary at what level.
1) Stationary Test
   The stationary test is the first test to be carried out in this study. Each variable was tested using the ADF (Augmented Dickey-Fuller) test, and must be stationary at the same level. In comparing the absolute value of the calculated ADF with the table ADF, the critical value developed by Mc-Kinnon's Cointegration Degree Test is used.
2) Cointegration Test
   Cointegration test was carried out after the stationary test, where all variables were at the same degree of integration. In this study, using the Johansen Cointegration System Test. The Johansen test is used because in addition to being more accurate, it is also easier to understand. If all the variables are cointegrated, then it is continued to the ECM (Error Correction Model) test.
3) ECM (Error Correction Model) Test
   This model is used to find short-term balance or correct short-term imbalances towards long-run equilibrium. To determine whether the ECM (Error Correction Model) model used is valid, it can be determined from the ECT (Error Correction Term) value whether it is significant or not; if it is significant, it indicates that the model specification is supported by ECM (Error Correction Model).

4) Classic Assumption Test
   a) Normality Test
   This test aims to assess the distribution of data on a variable, whether the distribution is normally distributed or not. There are 2 methods that can be used, namely histogram and test developed by Jarque-Bare (J-B).
   b) Multicollinearity Test
   The objective of this test is to determine whether there is a correlation between independent variables in a regression model. If there is a correlation, we can say there is a multicollinearity issue. Using the VIF calculation, multicollinearity was also evaluated (Variance Inflating Factor).
   c) Heteroscedasticity Test
   This test aims to determine whether a regression model contains elements of heteroscedasticity or not. There are 2 methods used to detect heteroscedasticity problems, namely formal methods and informal methods(P. D. Agus Widarjono, 2013).
   d) Autocorrelation Test
   The literal definition of autocorrelation is the correlation between members of a single observation and other observations made at different times. Using the Breusch-Godfrey Serial Correlation LM Test, the autocorrelation test can be determined.

4. RESULT AND DISCUSSION
4.1. Research Results
4.1.1. Stationary Test
Augmented Dickey-Fuller Unit Root Level
1) Carbon dioxide (CO_2) emissions

Table 1 CO_2 Stationary Test Result at Level

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics		-2.302073	0.1778
Test critical values:	1% level	-3.670170	
	5% level	-2.963972	
	10% level	-2.621007	

Source: Eviews 10 (data processed)

The estimation above shows that the carbon dioxide emission variable from 1990-2020 is not stationary at the 1%, 5%, and 10% confidence levels because it has a probability above 0.05. Therefore it is necessary to perform a degree of integration test to ascertain the extent to which the data will be stationary.

2) Financial Development (FD)

Table 2 Financial Development Stationary Test Result at Level

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics		-2.090506	0.2496
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

Source: Eviews 10 (data processed)

The estimation above shows that the Financial Development variable from 1990-2020 is not stationary at the confidence level of 1%, 5%, and 10% because it has a probability above 0.05. Therefore it is necessary to perform a degree of integration test to ascertain the extent to which the data will be stationary.

3) Foreign Direct Investment (FDI)

Table 3 Foreign Direct Investment Test Result at Level

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics		-4.263923	0.0023
Test critical values:	1% level	-3.670170	
	5% level	-2.963972	
	10% level	-2.621007	

Source: Eviews 10 (data processed)

The estimation above shows that the Foreign Direct Investment variable from 1990-2020 is stationary at a confidence level of 1%, 5%, and 10% because it has a probability of <0,05. Therefore it is not necessary to continue with the degree of integration test to ascertain the extent to which the data will be stationary.

4) Economic Growth (GDP)

Table 4 Gross Domestic Product Test Result at Level

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics		-2.361962	0.1605
Test critical values:	1% level	-3.670170	
	5% level	-2.963972	
	10% level	-2.621007	

Source: Eviews 10 (data processed)

The estimation above shows that the variable of economic growth from 1990-2020 is not stationary at the confidence level of 1%, 5%, and 10% because it has a probability above 0.05. Therefore it is necessary to perform a degree of integration test to ascertain the extent to which the data will be stationary.

5) Energy (TEC)

Table 5 Energy Test Result at Level

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics		-4.224954	0.0033
Test critical values:	1% level	-3.737853	
	5% level	-2.991878	
	10% level	-2.635542	

Source: Eviews 10 (data processed)

The estimation above shows that the Energy variable from 1990-2020 is stationary at a confidence level of 1%, 5%, and 10% because it has a probability of <0.05. Therefore it is not necessary to continue with the degree of integration test to ascertain the extent to which the data will be stationary.

Augment Dickey-Fuller Root Unit First Difference Test
1) Carbon dioxide (CO_2) emissions

Table 6 CO2 Test Result at First Difference

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics		-4.239543	0.0025
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

Source: Eviews 10 (data processed)

The estimation above shows that the carbon dioxide (CO2) emission variable from 1990-2020 is stationary at 1%, 5%, and 10% confidence levels because it has a probability of <0.05. It is therefore not necessary to continue with the degree of integration test to ascertain the extent to which the data will be stationary.

2) Financial Development (FD)

Table 7 Financial Development Test Result at First Difference

	t-Statistic	Prob.*

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics	-4.241495	0.0025
Test critical values: 1% level	-3.679322	
5% level	-2.967767	
10% level	-2.622989	

Source: Eviews 10 (data processed)

The estimation above shows that the Financial Development variable from 1990-2020 is stationary at a confidence level of 1%, 5%, and 10% because it has a probability of <0.05. It is therefore not necessary to continue with the degree of integration test to ascertain the extent to which the data will be stationary.

3) Foreign Direct Investment (FDI)

Table 8 Foreign Direct Investment Test Result at First Difference

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics	-9.050156	0.0000
Test critical values: 1% level	-3.679322	
5% level	-2.967767	
10% level	-2.622989	

Source: Eviews 10 (data processed)

The estimation above shows that the Foreign Direct Investment variable from 1990-2020 is stationary at a confidence level of 1%, 5%, and 10% because it has a probability of <0.05. Therefore it is not necessary to continue with the degree of integration test to ascertain the extent to which the data will be stationary.

4) Economic Growth (GDP)

Table 9 Gross Domestic Product Test Result at First Difference

	t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics	-4.255350	0.0025
Test critical values: 1% level	-3.689194	
5% level	-2.971853	
10% level	-2.625121	

Source: Eviews 10 (data processed)

The estimation above shows that the variable of economic growth from 1990-2020 is stationary at the confidence level of 1%, 5%, and 10% because it has a probability of <0.05. Therefore it is not necessary to continue with the degree of integration test to ascertain the extent to which the data will be stationary.

5) Energy (TEC)

Table 10 Financial Development Test Result at First Difference

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistics		-4.900888	0.0005
Test critical values:	1% level	-3.679322	
	5% level	-2.967767	
	10% level	-2.622989	

Source: Eviews 10 (data processed)

The estimation above shows that the gross domestic product variable from 1990-2020 is stationary at the 1%, 5%, and 10% confidence levels because it has a probability of <0.05. Therefore it is not necessary to continue with the degree of integration test to ascertain the extent to which the data will be stationary.

4.1.2. Cointegration Test

Table 11 Cointegration Test Results

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistics	0.05 Critical Value	Prob.**
None *	0.811958	109.0325	69.81889	0.0000
At most 1 *	0.665775	60.57092	47.85613	0.0021
At most 2	0.416380	28.78862	29.79707	0.0650
At most 3	0.274515	13.17200	15.49471	0.1086
At most 4 *	0.124791	3.865479	3.841466	0.0493

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistics	0.05 Critical Value	Prob.**
None *	0.811958	48.46160	33,87687	0.0005
At most 1 *	0.665775	31.78229	27.58434	0.0136
At most 2	0.416380	15.61663	21.13162	0.2480
At most 3	0.274515	9.306516	14.26460	0.2615
At most 4 *	0.124791	3.865479	3.841466	0.0493

Max-eigenvalue test indicates 2 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Source: EViews 10 (processed data)

Moreover, cointegration test using the Johansen Cointegration System Test by combining all variables (groups) indicates a long-term relationship if variables are cointegrated. Comparing the trace statistic and critical value reveals the outcome. The trace statistic value in the Trace results is 109.0325 greater than the critical value of 69.81889. This is supported by the Maximum Eigenvalue results, which indicate that the max-eigen statistic is 48.46160 times greater than the critical value of 33,87687. It can be concluded from these findings that carbon dioxide emissions, financial development, foreign direct investment, economic growth, and energy are cointegrated. And this has resulted in a long-term equilibrium.

4.1.3. ECM (Error Correction Model) Test

Table 12 Short-term Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FD)	-0.018256	0.044738	-0.408073	0.6868
D(FDI)	0.012078	0.009214	1.310822	0.2023
D(GDP)	0.035902	0.018288	1,963137	0.0613
D(TEC)	0.403276	0.278538	1.447832	0.1606
ECT(-1)	-0.446615	0.129359	-3.452534	0.0021
C	0.035198	0.011452	3.073356	0.0052

Source: EViews 10 (processed data)

Based on the estimation results of the short-term ECM (Error Correction Model), it can be seen from the probability value that is more than 0.05 or 5%. Which means that from the short-term ECM calculation of all variables there is no short-term relationship.

Table 13 Long-Term Estimation Results

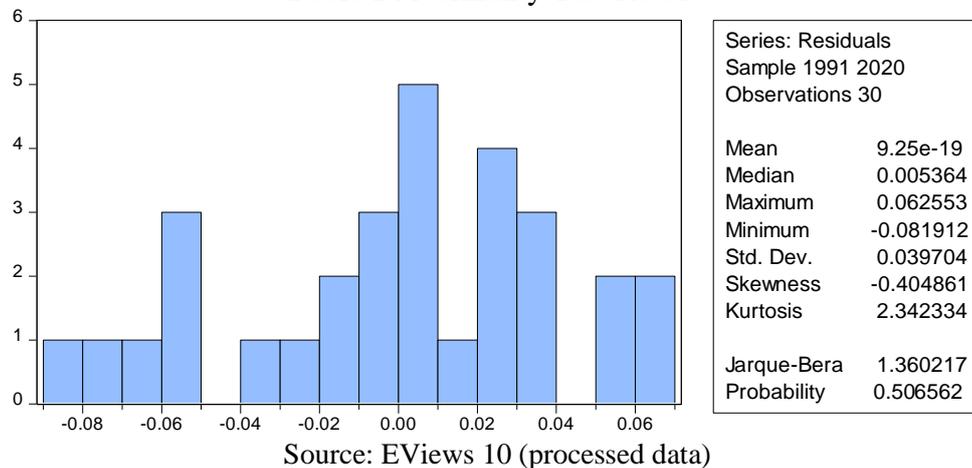| Variable	Coefficient	Std. Error	t-Statistic	Prob.
FD	0.032467	0.046568	0.697205	0.4919
FDI	0.011482	0.020807	0.551853	0.5858
GDP	-0.000570	0.022094	-0.025801	0.9796
TEC	1.707508	0.065425	26.09860	0.0000
C	-3.043600	0.454272	-6.699945	0.0000

Source: EViews 10 (processed data)

Based on the estimation results of the ECM (Error Correction Model) it shows that in the long term only energy variables have a significant effect on carbon dioxide emissions. It can be seen from the probability value of less than 0.05 or 5%.

4.1.4. Classic Assumption Test
1) Normality Test

Table 14 Normality Test Results

Series: Residuals	
Sample 1991 2020	
Observations 30	
Mean	9.25e-19
Median	0.005364
Maximum	0.062553
Minimum	-0.081912
Std. Dev.	0.039704
Skewness	-0.404861
Kurtosis	2.342334
Jarque-Bera	1.360217
Probability	0.506562

Source: EViews 10 (processed data)

From the results of the normality test above, it is known that the Error Correction Model (ECM) is normally distributed. This is based on the jarque-fall probability value greater than 0.05, which is 0.506562, which means that it is free from the normality test.

2) Multicollinearity Test

Table 15 Multicollinearity Test Results

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
D(FD)	0.002001	1.079989	1.073535
D(FDI)	8.49E-05	1.026366	1.025896
D(GDP)	0.000334	1.588587	1.565644
D(TEC)	0.077583	2.477411	1.570981
ECT(-1)	0.016734	1.037119	1.037083
C	0.000131	2.065704	0

Source: EViews 10 (processed data)

Multicollinearity test results can be seen using VIF (Variance Inflation Factors), if the Cetered VIF value is < 10 then there is no multicollinearity. From the test results above, it can be seen that the Cetered VIF value in all variables < 10, it can be stated that the results do not experience multicollinearity.

3) Heteroscedasticity Test

Table 16 Heteroscedasticity Test Results

F-statistics	2.187749	Prob. F(5,24)	0.0892
Obs*R-squared	9.392506	Prob. Chi-Square(5)	0.0944
Scaled explained SS	4.034523	Prob. Chi-Square(5)	0.5445

Source: EViews 10 (processed data)

In the Breusch Pagan-Godfrey heteroscedasticity test, where the value of Prob. Obs*R-squared was 9.392506 and the value of Prob. Chi-Square (4) was 0.0944, the null hypothesis was rejected. This value is greater than 0.05 (5%), so H0 is accepted, indicating that heteroscedasticity does not occur in the research model used.

4) Autocorrelation Test

Table 17 Autocorrelation Test Results

F-statistics	0.591381	Prob. F(2.22)	0.5621
Obs*R-squared	1.530571	Prob. Chi-Square(2)	0.4652

Source: EViews 10 (processed data)

The autocorrelation test performed on the research model using the Breusch-Godfrey Serial Correlation LM Test yielded the results presented in the table above, where the value of Obs*R-squared is 1.530571 and the value of Prob. Chi-Square (2) is 0.4652. This value is greater than 0.05 (5%), indicating that the null hypothesis H0 is accepted, i.e., autocorrelation does not exist in the research model used.

4.2. Discussion
4.2.1. The Effect of Financial Development on Carbon Dioxide Emissions

The results of this study indicate that financial development has a negative and insignificant effect on carbon dioxide emissions over the short term. This is evident from the t-count value of -0.408073 and the fact that the probability of 0.6868 is not statistically significant at $\alpha = 0.05$ or $\alpha = 5\%$. Financial development has a positive and insignificant effect over the long term. This is demonstrated by the t-count value of 0.697205; the probability is 0.4919, which means it is not statistically significant at $\alpha = 0.05$ or $\alpha = 5\%$. This demonstrates that the variable of financial development has no effect on carbon dioxide emissions.

4.2.2. The Effect of Foreign Direct Investment on Carbon Dioxide Emissions

This study indicates that the variable of foreign direct investment has a positive and insignificant effect on carbon dioxide emissions over the short term. This is evident from the t-count value of 1.310822, and the probability of 0.2023 is not statistically significant at the $\alpha = 0.05$ or = 5% significance level. Foreign direct investment has a positive but insignificant effect over the long term. This is evidenced by the t-count value of 0.551853, which corresponds to a probability of 0.5858 and a significance level of $\alpha = 0.05$ or $\alpha = 5\%$. This indicates that the variable of foreign direct investment has no impact on carbon dioxide emissions.

4.2.3. The Effect of Economic Growth on Carbon Dioxide Emissions

This study's findings indicate that the variable of short-term economic growth has a positive but insignificant effect on carbon dioxide emissions. This is evident from the t-count value of 1.963137, and the probability of 0.0613 is not statistically significant at the $\alpha = 0.05$ or $\alpha = 5\%$ significance level. Long-term economic growth has a negative but insignificant impact. This is indicated by the t-count value of -0.025801, which corresponds to a probability of 0.9796 and a significance level of $\alpha = 0.05$ or $\alpha = 5\%$. Each one percent of economic growth will reduce carbon dioxide emissions by -0.000570 percent.

4.2.4. The Effect of Energy on Carbon Dioxide Emissions

This study indicates that the energy variable has a positive and insignificant effect on carbon dioxide emissions over the short term. This is evident from the t-count value of 1.447832 and the fact that the probability of 0.1606 is not statistically significant at $\alpha = 0.05$ or $\alpha = 5\%$. Long-term energy effects are positive and significant. This is demonstrated by the t-count value of 26,09860, which corresponds to a probability of 0.0000 and a significance level of $\alpha = 0.05$ or $\alpha = 5\%$. Every 1% increase in energy consumption will increase carbon dioxide emissions by 1.707508. This result is also supported by research conducted by Kurniarahma, Laut, and Prasetyanto (2018), which concludes that energy consumption has a significant impact on carbon dioxide (CO2) emissions. This is due to a number of factors, such as the pattern of consumption in Indonesia in the use of energy to promote economic growth, as well as technological constraints and inefficient equipment by international standards.

5. CONCLUSION

5.1. Conclusion

On the basis of the aforementioned research findings and research reviews, the following conclusion can be drawn:

1) The variable Financial Development (FD) in the short term has a negative and insignificant effect on carbon dioxide (CO2) emissions in Indonesia from 1990 to 2020, while in the long term positive and insignificant effect on carbon dioxide (CO2) emissions in Indonesia 1990-2020.
2) The variable of foreign direct investment (FDI) in the short and long term has a positive and insignificant effect on carbon dioxide (CO2) emissions in Indonesia from 1990 to

2020. Therefore, with an increase in investment, it will not always increase the level of carbon dioxide (CO2) emissions, this can be anticipated by investors where they will minimize the impact of environmental problems that will occur through careful design and environmentally friendly technology.

3) Short-term economic growth (GDP) has a positive and insignificant effect on carbon dioxide (CO2) emissions in Indonesia between 1990 and 2020, whereas long-term economic growth has a negative and insignificant effect on carbon dioxide (CO2) emissions in Indonesia between 1990 and 2020.

4) The short-term effect of the energy variable (TEC) on carbon dioxide (CO2) emissions in Indonesia from 1990 to 2020 is positive but insignificant, whereas the long-term effect is positive and significant. This means that a rise in energy consumption in Indonesia will lead to a rise in carbon dioxide (CO2) emissions over the short and long term.

5.2. Suggestions

With the increase in carbon dioxide (CO2) emissions in Indonesia, the government can take immediate action, namely to make a policy to minimize a significant increase in the future of the problem of carbon dioxide (CO2) emissions in Indonesia. The government can provide counseling to the public to use environmentally friendly technology and urge the industrial sector to reduce energy use or use renewable energy to minimize non-renewable energy running out.

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