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Analysis of Environmental Degradation in Indonesia Based on Value Added Industry, Economic Growth, and Energy Consumption

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ABSTRACT

The goal of this research is to assess the impact of economic expansion as measured by GDP, industrial value added, and energy consumption. The error correction model (ECM) method is used in this work, which takes a quantitative approach. This research is necessary in order to address Indonesia's environmental issues. The findings of this study suggest that economic expansion has a favorable short- and long-term impact on CO_2 emissions in Indonesia. The added value of the sector has an impact on both the short and long term rise in CO_2 emissions in Indonesia. The energy consumption variable then has no influence on CO_2 emissions in the short term but has a considerable positive effect on CO_2 emissions over time. This demonstrates that increased energy or ecologically friendly technology utilization is still required. So that environmental damage, particularly CO_2 emissions, can be considerably decreased.

1. INTRODUCTION

Economic activity is founded on a number of fundamental variables that contribute to its long-term viability, such as the natural environment. In many nations, the natural environment directly contributes to economic activity. This significant contribution entails the provision of natural resources and fundamental raw materials that are required as inputs in the manufacture of goods and services. Furthermore, natural resources and the environment indirectly contributes to economic growth and sustainable development through ecological systems such as carbon sequestration, water purification, and so on. As a result, natural resources are critical for future economic growth and development [1].

As the period progresses, new business prospects emerge in a variety of countries. The modern industrial sector has become more solid and efficient as a result of the change from the traditional business model for an innovative and creative one. The economy of a country nowadays is heavily reliant on the availability of economic inputs and their long-term viability [2]. Economic development will continue if economic inputs are not fully used in order to achieve maximum and structured growth.

Even with an economic model that began with a conventional economic model and gradually shifted to a modern economic model, economic growth has grown from year to year. The industrial economy has spread across the globe, especially in emerging countries like Indonesia. Indonesia has established a number of industrial zones around the region. Even people who had previously struggled and labored in the agricultural sector gravitated into the industrial sector. In order to improve the economic situation of some localities, some agricultural land is converted to be used for the development of industrial sectors [3].

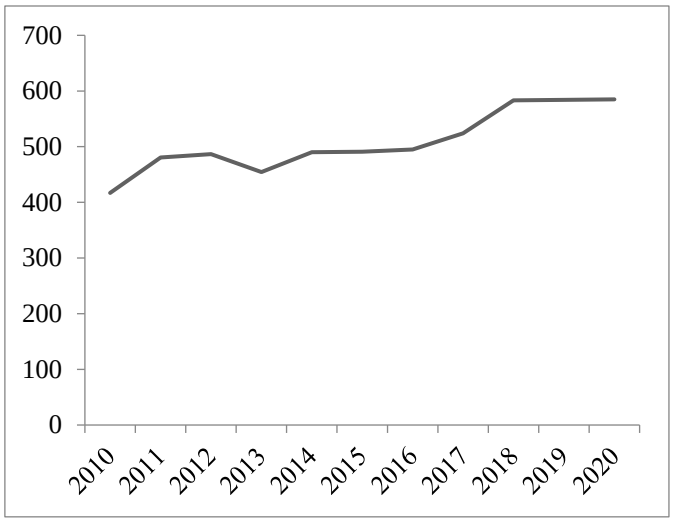
Indonesia is a developing country dominated by industrialization at the moment. Indonesia has grown and followed the international market trend as the industrial period progressed. This economic growth is coupled with an increase in environmental deterioration, as measured by rising CO_2 emissions each year. However, this deterioration is not always due to Indonesia's present economic progress. Because the majority of Indonesia's land is peat forest, which is presently being changed by burning forests to establish various factories. As a result, this research was carried out to assess the link between environmental deterioration and Indonesia's industrial economy in 2020-2020.

The fast expansion of the industrial economy cannot be isolated from various driving factors at this time, such as technological advancement and complexity, but technological development cannot be divorced from energy usage. As a result, the use of natural energy is becoming increasingly uncontrolled each year, because, in addition to industrial growth, the rise in energy consumption is attributable to the development of various modes of transportation. As a result, biophysicists and ecologists argue that energy is the most essential factor influencing the direction of economic growth [4-6]. Energy, on the other hand, is just a transition component in neo-classical growth theory, not a fundamental factor [1].

The emergence of negative environmental impacts is inextricably linked to the development of industry, which causes land conversion from the agricultural sector and the emergence of statements that the industrial sector plays an important role in increasing energy consumption [7]. Starting with the development of the industrial sector, the conversion of agricultural land to industrial development, and the use of uncontrolled energy to promote the advancement of industrial

technology all have an impact on environmental degradation, namely increased greenhouse gas emissions, particularly carbon dioxide (CO_2).

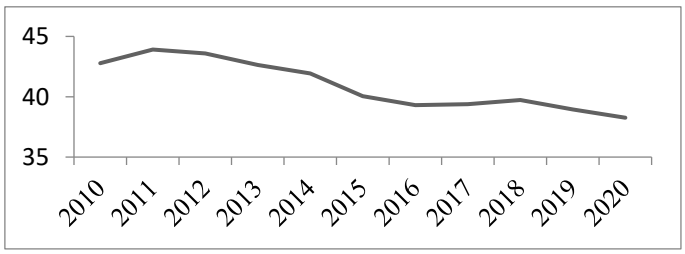
CO_2 emissions in Indonesia are growing year after year, according to statistics from the World Bank and the Indonesian Central Statistics Agency. This suggests that various activities, particularly those connected to the combustion of fossil fuels, are to blame for Indonesia's high pollution levels. From 2010 to 2020, we obtained statistics on the amount of CO_2 emissions in Indonesia from the World Bank and the Indonesian statistical center agency.



Source: (Dunne, 2021)

Figure 1. Indonesia's total CO_2 emissions (kt) from 2010 to 2020

Figure 1 depicts the growth in CO_2 emissions in Indonesia during the previous ten years; the figure shows that CO_2 emissions in Indonesia rose from year to year from 2010 to 2020. This is in contrast to the situation of industrial value in Indonesia, which has actually decreased. Figure 2 shows a quick breakdown of Indonesian industrial value-added statistics from 2010 to 2020.



Source: (IMF, 2021)

Figure 2. Indonesian industry added value 2010-2020 (percent of total GDP)

Because of the significance of conducting research on the relationship between economic activity, energy consumption, and environmental degradation, particularly the direct relationship to CO_2 emissions, this study aims to examine the relationship between industrial value-added, energy consumption levels, and economic growth on CO_2 emissions in Indonesia over the last ten years. There is a lot of empirical literature used in this study with various variables and research methods used including the studies in ref. [8-11].

Many research on environmental and economic deterioration have been conducted both domestically and internationally. The findings of these research, however, vary widely, such as Saboori et al. [11], who claim that there are three types of long-term relationships between CO_2 emissions, economic growth, and energy consumption. Then there's Rajagukguk [12] study, which claims that economic progress and CO_2 emissions are linked. Indonesia has not reduced CO_2 emissions since economic and community activities have a detrimental impact on the environment, and EKC has not been shown in the country. This assertion, however, contradicts the findings of Bowo P & Masykur W's study, which found that EKC is demonstrated in Indonesia with a turning point of Rp. 1,846,000. In the long run, greater revenue will help Indonesia lessen environmental damage. These studies' findings must still be validated utilizing new data and research methods in order to create relevant and trustworthy results.

Part one of this study covers the research's basis. The second section of the study included various earlier studies that were cited as references in this one. Because this is empirical research, part three presents the econometric model that was utilized. Part four displays the findings of empirical calculations and interprets them descriptively. The author's summary, consequences, and policy suggestions for future stakeholders and researchers are found in section five.

2. LITERATURE REVIEW

Many economic and environmental research have been conducted both locally and internationally. However, several of these research' findings are still inconclusive. According to Kuznet's argument, the majority of environmental deterioration occurs mainly in industrialized nations that have created an industrial economy. However, multiple studies have shown that there is a positive link between the economy and CO_2 emissions, with CO_2 rising in tandem with economic growth and then falling once the economy reaches a certain threshold, owing to the budget for ecologically friendly instruments and activities. This is also linked to the negative externality idea. External costs incurred by third parties as a result of an activity are known as negative externalities. As a result, the economy and the environment, particularly in Indonesia, must be thoroughly researched and assessed.

Much research has been carried out, particularly on the impact of economic activity and energy usage in different nations. However, no consensus has been reached in the literature review on the exact link between economic activity and energy usage. According to Saboori and Soleymani [13], there are three types of long-term relationships between CO_2 emissions, economic growth, and energy consumption. The study was done in Malaysia using the VECM technique. Similarly, Azlina [8] demonstrates a directed causal relationship between economic activity and energy use.

Fossil fuels have been employed as a driving factor for numerous technologies in the manufacturing process, particularly in the industrial sector. Current industrial developments are expected to stimulate the economy in various regions, even though industrial developments have a positive impact on the economy but a negative impact on CO_2 emissions, as evidenced by the findings of a study conducted in China by Xu and Lin [14] using the panel data regression method.

The process of industrialization has a good influence on economic development, but a bad impact on the environment

[15]. The pace of exploitation and usage of natural resources, as well as the amount of energy consumption, continues to rise. It will have major environmental effects if industrial process activities that are not ecologically friendly are permitted to continue indefinitely [16]. The environmental theory of Kuznets [17] is another theory that addresses the link between economic growth and environmental deterioration. This theory explains the environmental harm that happens in emerging nations that are still in the early stages of industrialization. During this period, there will be a positive association between environmental deterioration and an increase in CO_2 emissions, as defined in this study. Rapid economic expansion will be accompanied by significant deterioration, although this will diminish with time [18].

3. RESEARCH METHODS

This section gives a brief summary of the data sources and econometric methodologies utilized to evaluate these problems in order to validate the link between industrial value-added, energy consumption, GDP, and CO_2 emission levels in Indonesia. This study relies on secondary time series data from a number of reputable institutional sources. Table 1 shows the variables used in this study.

Table 1. Data variable

No	Variable	Unit	Source
1	Gross Domestic Product (GDP)	USD$	The world bank
2	Industry Added	% of GDP	The world bank
3	Energy Consumption	Kg of oil equivalent	The world bank
4	CO_2 emission	kt	The world bank

This study uses an error correlation model, or ECM, to counteract the regression's stark findings. When the variables in a model are not associated, the regression results reveal a substantial and high-value regression coefficient, this is known as absent regression [19]. Abrupt regression has a high likelihood of short-term imbalance, but long-term balance.

Because this study investigates lengthy time series data, ECM was chosen as the solution to avoid the problem of non-stationary data, which would lead the regression findings to be erroneous. Furthermore, ECM is utilized in this work because it can aid in the resolution of sophisticated data processing issues such as data multicollinearity, which can result in extremely high error standards. ECM can also discriminate between long-term characteristics, making it perfect for evaluating hypothesis correctness.

Four procedures will be utilized to experimentally test the link between GDP, industrial value-added, energy consumption, and CO_2 emissions. A stationary test is an initial stage [20, 21]. The second stage is to estimate the long-term equilibrium ratio between the integrated variables using Johansen [22] cointegration approach. This strategy takes into account a variety of endogenous factors, each of which is characterized by the lag value in the model. Following the stationarity and cointegration tests, ECM estimation was used to identify the short-term connection, and classical assumption detection was continued.

The unit root test and the degree of integration test are both parts of the stationary test. If the absolute value of the ADF statistic is negative or less than the critical value, the data are considered to be stationary. The cointegration test is then used to determine whether or not the variable is impacted by stationary disturbance. These variables are in long-term equilibrium if all of the variables are stationary. When the data is integrated at the same degree level, this test is performed. If the absolute ADF statistic is negative or less than the MacKinnon critical value, the residual value is considered to be stationary.

Following the completion of the two tests, the next stage is to execute a short-term estimation, also known as an ECM estimation. In this work, the error correction model is employed to rectify the blunt regression findings by describing the short-term and long-term parameters [23]. The ECM equation model for short-term estimation is as follows when expressed mathematically:

$$CO2_t = \alpha_1 GDP_t + \alpha_2 IA_t + \alpha_3 EC_t \quad (1)$$

From Eq. (1), it is known that CO_2 *t* is a variable of carbon dioxide emission (CO_2) which in this study is the dependent variable. Then for GDP_t is the GDP variable for a certain year as the independent variable, IA_t is the added value of the industry in a certain year and is also the independent variable, EC_t is the total energy consumption for a certain year which is also the independent variable in this study. When written into the ECM equation for long-term estimation it becomes as follows:

$$CO_2 = \beta_o + \beta_1 DGDP_t + \beta_2 IA_t + \beta_3 EC_t + \beta_4 GDP_{t-1} + \beta_5 IA_{t-1} + \beta_6 EC_{t-1} + \beta_7 ECT \quad (2)$$

In Eq. (2), inertia is represented by *ECT*, which is a combination of each variable *t*, namely $GDP_{t-1} + IA_{t-1} + EC_{t-1}$, and *D* is the first *Difference* variable.

Following the two tests, the normality test, multicollinearity test, heteroscedasticity test, and autocorrelation test were used to examine the classical assumptions. To get regression findings that satisfy the BLUE rule, a traditional assumption test is used.

4. DISCUSSION AND RESULTS

The researcher must first identify the classical assumptions before calculating the ECM. Based on the results of this study's output, it has met the requirements of classical assumptions such as data normality or normally distributed data, then autocorrelation detection, multicollinearity detection, and heteroscedasticity detection, indicating that this research is already BLUE and free of classical assumption problems.

The findings of the stationary test in this study are shown in Table 2. The table reveals that all variables in this study were pronounced non-stationary at the level because the ADF value was higher than the critical value. All variables in the research will be re-tested by examining the degree of integration at the 1st difference level if the assumption of stationarity at zero or *I(o)* are violated.

A stationary test is performed at the 1st difference level since the stationary test is not stationary at the level. The findings of the stationary test at the first difference level are shown in Table 3. It is clear from the table that all variables in this study have been pronounced stationary at a significance of 5% and 10% since the ADF value is less negative than the critical value.

Table 2. Unit root test results (in level)

Variable	ADF	Test Critical Values			Prob.	Description
		1%	5%	10%		
CO_2	-0.993	-3.670	-2.964	-2.621	0.743	not stationary
GDP	-0.319	-3.679	-2.968	-2.623	0.910	not stationary
IA	-1.622	-3.570	-2.964	-2.621	0.459	not stationary
EC	0.483	-3.670	-2.964	-2.62	0.983	not stationary

Source: data processed with EViews

Table 3. Unit root test results (in 1st difference)

Var.	ADF	Test Critical Values			Prob.	Description
		1%	5%	10%		
CO_2	-5.274	-3.689	-2.972	-2.625	0.0002	Stationary
GDP	-3.578	-3.679	-2.968	-2.623	0.0128	Stationary
IA	-5.916	-3.689	-2.972	-2.625	0.0000	Stationary
EC	-5.210	-3.679	-2.968	-2.623	0.0002	Stationary

Source: data processed, 2022

Table 4. Cointegration test results

	Augmented Dickey-Fuller test statistic	**-9.085989**	**0.0000**
Test critical values:	1% level	-3.699871	
	5% level	-2.976263	
	10% level	-2.627420	

Source: data processed, 2022

Table 4 illustrates the results of the cointegration test in this study, with a probability value of 0.0000, which is below the significance level. The residuals in this investigation are stationary at all levels of significance, according to the findings of the cointegration test. The stationary cointegration regression residual demonstrates that all variables have a long-term equilibrium connection and may be used to create Engle-short-term Granger's ECM model.

Table 5. Short-term VECM estimation results

Variable	Coefficient	Prob.
c	6.427	0.477
D(GDP)	0.370	0.007
D(IA)	10.372	0.009
D(EC)	-0.182	0.499
Res(-1)	-0.740	0.000
Prob(F-statistic)	0.000	

Source: data processed with EViews

The short-term output equation may be seen in Table 5, which is as follows:

$$\Delta CO2_t = 6.427 + 0.370\Delta GDP_t + 10.372\Delta IA_t - 0.182\Delta EC_t - 0.740RES_{t-1}$$

In the near run, the variables of GDP, industrial value added, and energy consumption are related to the amount of CO_2 emissions in Indonesia, as shown in the equation. It is known that an increase in changes in the GDP variable in year *t* by 1% will cause an increase in changes in CO_2 emissions by 0.37%, then for an increase in changes in the industrial value added variable in year *t* by 1%, it will increase changes in CO_2 emissions by 10.37% and if an increase in changes in energy consumption variables by 1% in year *t* will reduce changes in CO_2 emissions by 0.18%. based on the speed of adjustment value, there is an imbalance of 74% in the short-term effect between the variables of GDP, industrial value added, and energy consumption on the level of CO_2 emissions in each period.

Table 6. The findings of the long-term ECM estimate

Variable	Coefficient	Prob.
c	-353.965	0.003
GDP	0.339	0.000
IA	9.984	0.000
EC	0.166	0.118
Prob (F-statistic)	0.000	

Source: data processed with eviews

Based on the results of the long-term ECM estimation output, the following equation can be written:

$$CO2_t = -353.965 + 0.339GDP_t + 9.984IA_t + 0.166EC_t$$

The GDP variable and the industrial value-added variable both have a positive and substantial influence on rising CO_2 emissions, as seen in Table 6. The energy consumption variable, on the other hand, has a small but a favorable influence on the growth in CO_2 emissions.

In this study, the rise in CO_2 emissions in both the short and long term is influenced by Indonesia's GDP from 1990 to 2020. This demonstrates that the process of boosting GDP in Indonesia has a negative impact on CO_2 emissions. The process of growth and rising economic advancement in order to raise GDP in Indonesia is still destructive to the environment since it has not yet incorporated environmentally friendly technologies. According to this remark, the government must be conscious of economic expansion that is not accompanied by environmental consciousness. As a result, the government must take a more proactive approach to enact environmental legislation in order to further reduce CO_2 emissions that can pollute the environment. These findings are consistent with Haizam et al., Noor & Saputra; Talukdar & Meisner studies [1, 24, 25].

Other studies claim that a rise in GDP has no effect on CO_2 emissions in some nations. These nations have policies in place to encourage the adoption of environmentally friendly technology, particularly in the industrial sector, Azlina [8],

Basbeth [26], Behnaz Saboori et al. [11], Abro et al. [27] and Iskandar [28] are among these researches.

In this study, the industrial value-added variable influences both the short and long-term increases in CO_2 emissions in Indonesia from 1990 to 2020. The industrial sector, according to the Intergovernmental Panel on Climate Change (IPCC), is one of the most significant contributors to CO_2 emissions. The rise in CO_2 emissions is proportional to the increase in industrial activity. The findings of this study show that industrial growth has a considerable influence on CO_2 growth in Indonesia, implying that the expansion of industrial activities by a number of enterprises has a negative impact on CO_2 emissions, particularly in Indonesia. Acid rain is caused by excessive CO_2 emissions in the air, which causes the soil and water composition to become unhealthy for plants and animals [29].

This remark is in accordance with Pangestu's findings [30], which show that the rise in CO_2 emissions in ASEAN is influenced by industrial value addition. The rise of the industry, particularly those in the manufacturing sector that employ chemical primary materials, will need a sufficient amount of fossil fuel to contribute to the increase in CO_2 emissions [14]. The industrial sector will be unable to function without the use of fossil fuels and other forms of energy. The more developed a country's industrial sector is, the more energy it consumes.

This research also examines the impact of energy consumption factors on CO_2 emissions in Indonesia from 1990 to 2020. In this study, energy consumption has no effect on CO_2 emissions in Indonesia in the near term, but it does influence CO_2 emissions in the long run, but not considerably. The findings of this study contradict studies [29] that claim Indonesia continues to be a leader in the usage of ecologically friendly energy. Due to the high cost of ecologically friendly energy sources such as solar panels, the usage of fossil fuels such as oil and coal as a source of electrical energy is a viable choice.

5. CONCLUSION

Based on the findings of this study's empirical research, it was discovered that economic development in Indonesia between 1990 and 2020, as measured by gross domestic product, had a considerable short- and long-term impact on CO_2 emissions. The industrial value variable then has an impact on both the long and short term increases in CO_2 emissions in Indonesia. However, energy consumption in Indonesia has had no influence on CO_2 emissions in the short term, whereas energy consumption has a positive but minor effect on CO_2 emissions in the long run. In order to limit negative externalities, the government should enact regulations such as the use of ecologically friendly technologies and prohibitions on the use of fossil fuels that cause environmental deterioration.

This article uses the error correction model (ECM) method, which is a quantitative approach. The outcomes of this study imply that Indonesia's economic progress offers both short- and long-term benefits for CO_2 emissions. The sector's added value has an influence on Indonesia's increased short- and long-term CO_2 emissions. In the near term, the energy consumption variable has no influence on CO_2 emissions, but has a considerable positive effect on CO_2 emissions from time to time.

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