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The Effects of Air Quality on Economic Activity in Indonesia

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Abstract

Air pollution may contribute to climate change in Indonesia, and it has the potential to undermine national economy over the long term due to the high expenses of dealing with environmental damage. The study's goal was to investigate and assess the impact of the industrial sector's GDRB, the mining sector's GDRB, the agricultural sector's GRDB, the level of education, the level of poverty, the quantity of trash generated, and the rate of deforestation on air quality in Indonesia. Secondary data types include time series and cross section (panel data) covering 34 provinces in Indonesia from 2016 to 2019. Descriptive statistical research approach using a step-by-step panel data regression model (fixed or random effect) with Chow test, Hausman test, and Lagrange multiplier method. Then, partly and concurrently, the classical assumption test and the statistical test (t-test and F-test). This research found that GRDB growth in the industrial sector has a positive significantly effect on air quality, GRDB growth in the mining sector has a negative significantly effect on air quality, GRDB growth in the agricultural sector has a negative significantly effect on air quality, and education level has a positive effect. Poverty level has no effect on air quality, waste generation has no effect positive on air quality, and deforestation rate has a negative significantly effect on air quality in Indonesia.

Keywords: sectoral GRDB, air quality, deforestation, waste generation, air pollution

1. Introduction

In emerging nations, environmental contamination is an issue that requires optimum resolution. Increased economic activities such as manufacturing, distribution, and consumption that disregard environmental considerations may lead to environmental contamination. This may have repercussions, including an increase in air pollution that has the potential to affect the country's Gross Domestic Product (GDP) over the long run and exacerbate climate change (Dellink et al., 2014). Each sector of national/regional economic development requires policies that promote environmental resilience in order to achieve environmentally friendly, sustainable economic growth (Adejumo, 2020). The rise in greenhouse gas emissions in Indonesia is due to forest and land fires. According to statistics from the Ministry of Environment and Forestry of Indonesia (MEFI), Indonesia's carbon emissions would reach 41.4 million tons of CO2 in 2020. The forest and land fires that occurred in Indonesia during 2019 increased carbon emissions by 2.7% compared to the previous year. In 2019, forest and land fires in Indonesia emitted as much as 40,2 million tons of carbon dioxide into the atmosphere (MEFI, 2020). In emerging nations, economic expansion continues to have a significant impact on environmental quality. The transition from the traditional agricultural sector to the industrial sector has an impact on the quality of the existing environment, waste, and smoke from industrial goods, which in turn affects economic growth and contributes to a reduction in environmental quality (Bella et al., 2021). According to a study from the United Nations (2015), environmental quality and quality of life have a direct link and correlation, therefore as environmental quality improves, so will quality of life. Concerning the environment, carbon dioxide emissions have climbed by fifty percent since 1990 and are anticipated to continue to rise annually (Wysokińska, 2017). Figure 1 demonstrates that the Environmental Quality Index from 2016 to 2019 has dropped compared to the national QEI in 2018 of 73.01 percent and the national QEI in 2019 of 66.83 percent.

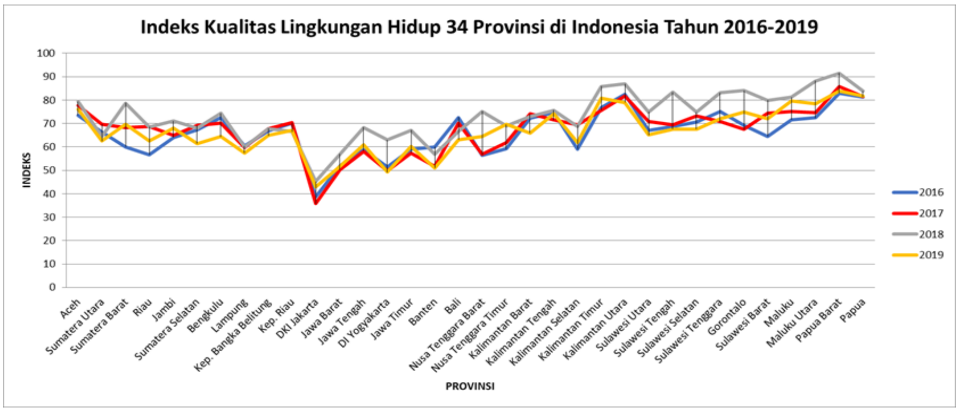

Figure 1. The Quality Environment Index of Indonesia 2016-2019

In the process of national income measurement, there are various crucial areas, including the mining sector, the agricultural sector, and the industrial sector, which will be examined in environmental degradation study. In the mining industry, these activities can cause harm to the surrounding community and environmental conditions, including changes in the topography of the soil and the condition of the land surface, the release of toxic substances that can pollute the air, water, and soil, and geological conditions that can cause landslides, floods, and earthquakes. (Listiyani, 2017). The agricultural industry may harm the environment if it is not managed correctly, but the government and farmers are taking tangible efforts to ensure that agricultural land is properly processed in accordance with sustainable development principles (Sudantoko & Mariyono, 2010). Increasing per capita national wealth may raise CO2 emissions. Increased usage of nonrenewable energy produces a rise in carbon dioxide emissions, which in turn increases air pollution (Cahyani & Aminata, 2020). Environmental quality with indicators of air pollution (CO_2 and SO_2) is an essential element affecting public health in both developed and developing nations; the poorer the air quality, the greater the amount of air pollutants (Drabo, 2011).

Due to the low level of education resulting from low community income and limited government participation, the community's lack of awareness and information about sustainable natural resource management may have a negative effect on the quality of the environment (F. A. Cahyani, 2020). Continual education may raise public awareness till the community comprehends the development process of a region while sustaining environmental resilience (Rizki & Saleh, 2007). The rising quantity of air contaminants has the potential to diminish public health. There must be a government program to lower air pollution levels if it is not predicted that it would shorten life expectancy (Kumar et al., 2016). Air pollution is a severe issue encountered by all nations (Ghosh et al., 2020).

The high level of consumption in society results in the formation of negative externalities in the form of waste generation, unmanaged waste generation has the potential to harm the environment from both domestic and non-domestic waste, and increasing the added value of waste as a resource can be a part of a development strategy to increase the added value of waste (Zhan et al., 2012). Waste resources may be managed by avoiding the negative effects of waste destruction, boosting recycling capacity, processing waste kinds correctly, and enhancing resources by decreasing both purposeful and involuntary mishaps (Firmansyah et al., 2016). The rate of deforestation in developing countries acts as a gauge for changes in the environment that may have an effect on the consistency and productivity of the agricultural sector as well as natural resources (Evans et al., 2017). This occurs as a result of an increase in wind and water erosion, in addition to the loss of organic carbon that is necessary for agriculture, plantations, and human survival (Lim et al., 2017).

This study aims to examine and analyze the effect of GRDP growth in the industrial sector, the effect of GRDP growth in the mining sector, the effect of GRDP growth in the agricultural sector, poverty rates, average years of schooling, waste generation, and deforestation rates on air quality in order to prioritize variables. assist policyholders in addressing issues associated with the deteriorating air quality environment. Therefore, researchers are interested in unknown but essential information pertaining to successful strategies for enhancing the quality of the environment, particularly air quality. If environmental quality is not addressed throughout the development process, environmental deterioration happens, which may be detrimental to the society.

2. Literature Review

2.1 Environmental Economic Theory

Environmental economics is a vital aspect of examining human actions in exploiting the environment in such a manner that its function and purpose may be preserved or even improved through time. Externalities emerge when the production and consuming activity of one economic actor has an impact on the welfare of another economic actor and actual events occur outside of the market process (Karl & Fair, 2007). Externalities lead private choices made by consumers and producers in private marketplaces to generate nothing economically efficient. Externalities come in two varieties: negative externalities and positive externalities. Externalities come in two varieties: negative externalities and positive externalities. Negative externalities (external costs) are expenses to third parties other than consumers and sellers that are not reflected in market prices (Mankiw et al., 2012). Economic expansion results in negative externalities such as environmental harm to air, water, and land cover. This is due to a combination of reasons, including politicians and corporate leaders who don't care whether economic expansion harms the environment, and environmental campaigners who don't believe that economic growth can be sustained without harming the environment (Cohen, 2020). The formation of trash as a result of economic operations is one type of negative externality.

The creation of this garbage, if not effectively handled, will impact the environment and public health. Domestic waste and non-domestic trash are the two categories of garbage generated. Domestic trash is waste created directly by humans, such as home waste, market waste, rubbish from populated areas, hospital waste, and non-domestic waste produced indirectly by humans, such as industrial waste, agricultural waste, livestock waste, and construction waste (Setianingrum, 2018). Handling environmental pollution is an important aspect that needs to be done, so the design of policies that support in improving the quality of the environment is urgently needed (Adejumo, 2020).

2.2 Contribution of the Industry, Mining, and Agriculture Sectors to GRDP

The administration of the industrial sector is an issue that every country, whether developing and developed, faces. Although the severity of the problems differs, the discrepancies are impacted by a variety of factors, including the rate of economic growth, the technology utilized, and the government's wisdom. According to the macroeconomic viewpoint, industrial sector expansion may occur through economic growth, namely through the process of continuously expanding production output through time. As a result, the contribution of the industrial sector to increasing GRDP is critical; a rise in production from the industrial sector, of course, has a favorable influence on GRDP (Lumbanraja et al., 2019). To achieve optimal economic growth, the mining industry is an essential foreign exchange income in the Indonesian economy. Strategic sectors, particularly the mining industry, are intended to contribute to the economic growth of certain regions that are linked to other spatial sectors. The growth of strategic industries can have an influence, either directly or indirectly, on the quality of the environment, particularly if the mining industry is not managed efficiently and sustainably. Concerning environmental quality concerns caused by mining activities, policyholders should take immediate action by overseeing Environmental Impact Analysis and taking into account the implications for the community and the environment (Hidayat et al., 2014).

Increasing global demand for food and natural resource has driven the capitalization of the agricultural sector development. If the agricultural sector is not effectively managed, which might harm the environment; nevertheless, the government and farmers are taking tangible efforts to cultivate agricultural land correctly based on sustainable development. This is done to limit the amount of environmental deterioration; rising environmental degradation will have a negative influence on agricultural land production in the long run (Sudantoko & Mariyono, 2010)**.** The agriculture industry is one of industries that contribute to and drive the Indonesian economy. The agricultural sector, as a source of livelihood for the people, may act as a job creator, enhance people's income, generate foreign exchange, and shape the Gross Domestic Product. A well-managed agricultural industry that incorporates environmental factors can help the community's economy. However, low agricultural production is caused by a lack of improvement in the agricultural sector (Faiziah, 2014). However, Yani (2020) found that the benefits of environmental services from forests in the long term are still higher than the benefits from land conversion from forests to oil palm plantation areas in The Province of West Kalimantan, Indonesia. According to Mediana and Maryunani (2021), the quality of the environment will be better maintained if the agricultural sector uses an organic system.

2.3 The Relationship of Poverty Rate to Environmental Quality

The interaction between poverty and the environment has a dynamic and complicated set of challenges that need a thorough examination of location and actual situations. In El Salvador, rural poverty and land degradation create the scenario in which small - scale farmers are squeezed by two variables that cause wellbeing to diminish, namely getting relatively little incomes while living in terrible environmental conditions. This makes it difficult for small farmers to overcome their challenges since a lousy environment leads to low yield. Lower earnings result from low productivity (Southgate et al., 2001). One of the reasons of environmental deterioration caused by poverty is population pressure in terms of behavior patterns and care for the surrounding environment. The same thing is true for contamination of water, air, and soil. In general, impoverished people in major cities choose to reside on the margins of rivers. This can place a significant strain on the quality of water and soil in these residential areas (Lubis et al., 2015). Poverty is one of the most serious problems that emerging countries encounter. This phenomenon is typically accompanied by an increase in the rate of environmental degradation; this occurs as a result of a unique causal correlation between poverty and environmental degradation, which has a unidirectional relationship in which as poverty increases, so does the rate of environmental degradation. So it is vital to investigate the subject matter by incorporating the community, as well as how environmental repercussions would influence the quality of life in the form of environmentally conscious programs that are sustainable (Rany, et.al, 2020).

2.4 The Relationship of Education Level to Environmental Quality

The linkage between educational level and environmental quality is unidirectional; inadequate grasp of environmental management knowledge causes people's conduct to gain from environmental resilience to quality of life is low. This lack of understanding makes individuals less sensitive to long-term consequences and is deemed less favorable to personal interests. The community's condition and socioeconomic level are particularly affected, with a poor level of education on information and awareness about the necessity of clean environmental management. According to Maslow's hierarchy of requirements, this group of people is typically only able to fulfill fundamental needs, with no ability to meet higher-level wants such as health care (Saputro et al., 2016). The quality of education influences community behavior in terms of environmental management, including land, water, and air. This suggests that education plays a significant role in environmental conservation and the necessity for comprehensive policies that take into account the aspects and linkages between education and proper environmental management. This may be accomplished by internalizing environmental consequences from an early age and continuing through college (Suwarno et al., 2014). The degrade the quality of life in the community is caused by a lack of public education, as seen by the low literacy rate in society. One of the techniques for improving educational equality and quality across all paths, kinds, and levels, particularly in the context of implementation. The absence of implementation of environmentally sensitive policies causes environmental conditions to remain unchanged; this is characterized by poor community participation in environmental protection (Christiani & Masalah, 2014)**.**

3. Methodology Research

This study employs a quantitative technique based on the idea of positivism to evaluate a population or sample; statistical data analysis research tools are employed for data collecting. The kind of data used is secondary data in the form of panel data, which is a mix of time series data with a time period of 2016-2019 and cross section data of 34 Indonesian provinces. The panel data for Indonesia comprises GRDP growth in the industrial sector, GRDP growth in the mining sector, GRDP growth in the agricultural sector, education level, poverty rate, quantity of waste creation, deforestation rate, and the Air Quality Index. Following is an illustration of the form of functions and equations:

- Function form:

$$KPI = f\,(Inds, Minn, Agri, Rubb, Mys, Pov, For).\ Cp$$

- Mathematical Equation form:

$$IKU_{it} = \alpha_0 + \alpha_1 Inds_{it} + \alpha_2\, Minn_{it} + \alpha_3\, Agri_{it} + \alpha_4\, Rubb_{it} + \alpha_5\, Mys_{it} + \alpha_6\, Pov_{it} + \alpha_7\, Fort_{it} + e_{it}$$

Where:

IKU = Air Quality Index

Inds = Industrial Sector (Percentage)

Minn = Mining Sector (Percentage)

Agri = Agriculture Sector (Percentage)

Mys = Average Length of Schooling (Life/year)

Pov = Poverty Rate (Life/year)

Rubb = Waste Generation Rate (Kg/year)

Forst = Land Cover Area (Ha/year)

e_t = Error term

i = Cross Section

t = time series

The first stage in panel data regression is the selection of an estimating model, which may be accomplished in a number of ways, including:

1. Common Effect Model equations are as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots\ldots + \beta_k X_{kit} + \varepsilon_{it}$$

Where I represents the topic (cross section) and t represents the time period. This model posits that the behavior of data between independent variables remains constant across time.

2. Fixed Effect Model with the equation:

$$Y_{it} = \beta_0 + \sum \beta_j X_{ji} t + u_{it}$$

$$u_{it} = e + \sum^{N-1} D_i V_i + \sum^{T-1} D_t w_t$$

$$Y_{it} = \beta_0 + \sum \beta_j X_{jit} + \sum^{N-1} D_i^c V_i + \sum^{T-1} D_t^{\,T} W_t + e$$

Where D_{ic} and D_t T are dummy variables in the same way as N-1 and T-1 are when determining the constant residual components of cross section and time series. To avoid the dummy variable trap, which is a circumstance where complete collinearity arises, the number of dummy variables employed in a research with 10 cross sections is reduced to nine (Basuki, 2017). The intercept β_0 represents the value of the intercept for the first subject, and the coefficient β_j reflects the significant difference between the intercepts of other subjects and the intercept for the first subject.

3. Random Effect Model: The REM equation analyzes panel data in which residual variables are assumed to have a temporal and intersubject connection. REM is used to overcome the limitation of FEM's usage of dummy variables. The number of cross-sections must be larger than the number of study variables for the REM panel data analysis technique to satisfy the criteria. According to Gujarati (2012), the REM equation is as follows:

$$Y_{it} = \beta 0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \ldots\ldots + \beta_k X_{kit} + \varepsilon_{it}$$

REM is based on describing the constant in the following equation:

$$Y_{it} = \beta i + X\,Tit\,\beta + eit$$

$$\beta i = \beta + ui$$

$$Y_{it} = \beta i + X\,T_{it}\,\beta + e_{it} + u_i \quad = \beta i + X\,T_{it}\,\beta + w_{it}$$

$$w_{it} = e_{it} + u_i$$

Where wit is composed of two parts, eit (residual cross section) and u_i (residual combination of time series and cross section). This approach is also known as the Error Components Model (ECM) due to the fact that the residual is composed of two components.

In the meanwhile, a number of tests, including the following, were used to determine the right approach for this research.

1) Chow test: Determination of a satisfactory model after the Chi-Square or F-test by comparing the probability (p-value) to alpha (). If p-value is greater than (0.05), H0 is accepted and the model follows Common or Pooled. If the p-value is less than 0.05, Ho is rejected and the model is adjusted to reflect the Fixed Effect.

2) Hausman test: Determination of a decent model based on Chi-Square or Cross-Section Random statistics by comparing the probability (p-value) to alpha () 0.05 or 5%. If p-value is greater than (0.05), the Ho hypothesis is accepted and the model follows the Random Effect. If the p-value is less than 0.05, Ho is rejected and the model is adjusted to reflect the Fixed Effect.

3) Lagrange Multiplier Test: A good model is determined using the Breush-Pagan Probability by determining if the probability (p-value) exceeds or falls below alpha (α). If p-value is greater than (0.05), H0 is accepted and the model follows the Random Effect. If the p-value is less than 0.05, Ho is rejected and the model is adjusted to match the Common Effect.

The last part of this study is to evaluate the hypothesis using the Classical Assumption Tests, namely the Normality test, Multicollinearity test, Heteroscedasticity test, and Autocorrelation test, while the Statistical Tests (T-Test and F-Test) and R2 are also used (R-Squared).

4. Results

Selection Based On Regression Of Panel Data For Air Quality

Chow Test In this test, the model selection between the common effect and fixed effect estimation models will be used.

Table 1. Result of Chow Test estimation

Redundant Fixed Effects Tests			
Test cross-section fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	3.174232	(33,95)	0.0000
Cross-section Chi-square	101.073566	33	0.0000

Source: secondary data, processing by eviews (2022)

The chance of the redundant fixed effect or likelihood ratio for this model is less than 0.05, hence H0 is rejected and H1 is accepted. The suitable model from this result is the fixed effect (since the probability is 0.0000 0.05).

Hausman Test

Fixed-effect and random-effect models were used for panel data regression. The Hausman test is used to choose between fixed-effect and random-effect research models.

Table 2. Hausman Test Estimation Result

Correlated Random Effects - Hausman Test			
Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	0.000000	7	1.0000

Source: secondary data, processing by eviews (2022)

The Hausman test findings are compared to a Chi Square table with the same number of independent variables. $H\chi^2df$ is the threshold limit for rejecting Ho based on the chi-square significance level and degree of freedom. At 5% significance and k-1 = 7-1 = 6, the critical limit is 12,591. Table below shows all comparison findings.

Table 3. Hausman test comparasion result

Chi Square Hitung (Hausman Test)	**Sign**	**Chi-Square Tabel**	**Conclusion**
0.000000	<	12.591	H0 is rejected and the model chosen is Random Effect

Source: secondary data, processing (2022)

Based on Hausman's statistical test, the Random Effect method is the best model for panel data in this research.

Lagrange Multiplier Test

This LM test determines which model to utilize based on conflicting fixed and random test results. The Lagrange Multiplier Test or Lagrangian Multiplier Test determines whether to utilize common effects or random effects in panel data regression.

Table 4. Lagrange Multiplier (LM) test

Lagrange Multiplier Tests for Random Effects			
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives			
	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	11.61603	1.599162	13.21520
	(0.0007)	(0.2060)	(0.0003)
Honda	3.408230	-1.264580	1.515790
	(0.0003)	--	(0.0648)
King-Wu	3.408230	-1.264580	-0.226872
	(0.0003)	--	--
Standardized Honda	3.667427	-1.050789	-2.804526
	(0.0001)	--	--
Standardized King-Wu	3.667427	-1.050789	-3.010553
	(0.0001)	--	--
Gourieroux, et al.*	--	--	11.61603
			(< 0.01)
*Asymptotic critical values:			
1%	7.289		
5%	4.231		
10%	2.952		

Source: secondary data, processing (2022)

The result shows that Prob. Breusch-Pagan (BP) is 0.0003. (In the third column is "Both"). Prob BP (0.0003 0.05) rejects H0, hence random effect is the appropriate model. Because a random effect model is acceptable, this research uses one.

Classic Assumtion Test For Air Quality Index (KPI)

This study employs a panel data regression model to examine the relationship between the Industrial Sector (Inds), Mining Sector (Minn), and Agricultural Sector (Agri), Waste Generation Rate (Rubb), Average Years of Schooling (Mys), Poverty Level (Pov), and Deforestation Rate (Forst) and the Air Quality Index (AQI) (IKU). Panel data regression analysis necessitates the satisfaction of a number of classical assumptions so that the model may be utilized for accurate prediction or analysis, or has satisfied the Best Linear Unbiased Estimator (BLUE). Normality, multicollinearity, heteroscedasticity, and autocorrelation are the fundamental assumptions. If these conditions are not satisfied, the parameter value will not be BLUE. Examining the traditional assumptions of the panel data regression model using Eviews software in this research.

Normality test

The purpose of the normality test is to determine if the confounding or residual variables in the regression model have a normal distribution. A good regression model has residual values with a normal distribution. Ajija et al. (2011) discuss the normality test utilizing the Jarque-Bera Test to assess if the residuals have a normal distribution (JB Test). The following are the findings of the JB Test normalcy test:

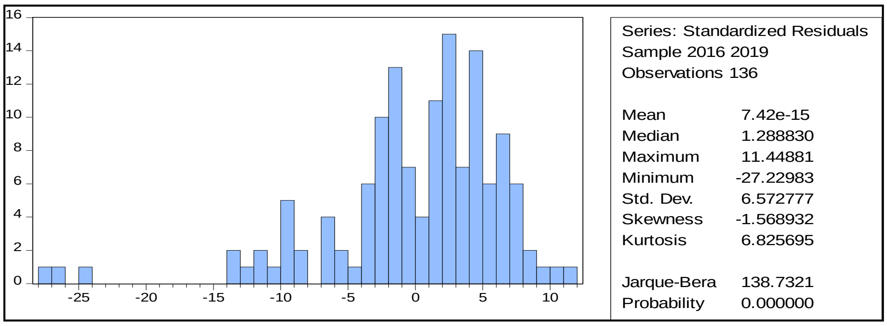

Figure 2. Normality Test result of Jarque-Bera (JB *Test*)

If the JB Test normality test yields a p-value of 0.000000 0.05, H0 is rejected or the residual value is not normally distributed. Outlier data must be cleaned since it's not usual. After removing outliers, here are the JB Test normalcy test results.

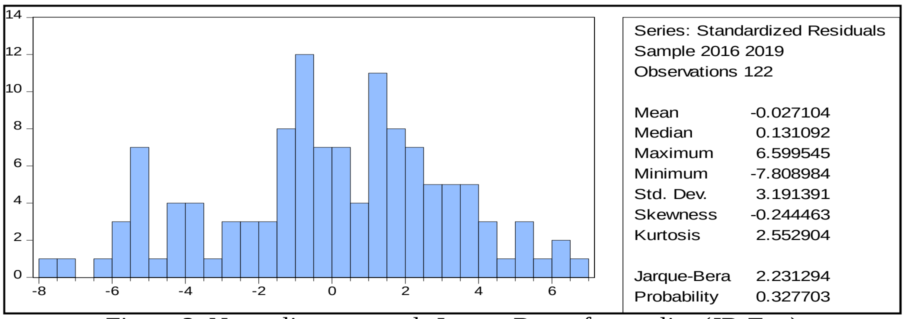

Figure 3. Normality test result Jarque-Bera after outlier (JB *Test*)

After cleaning outlier data, if the JB Test normality test p-value is > 0.05, H0 is approved or the residual value is normally distributed. Error term or residual value is regularly distributed with 95% confidence.

Multicollinearity

Multicollinearity means independent variables are linearly related. Multicollinearity in a regression may be identified by examining each variable's Tolerance or VIF. Multicollinearity in regression may shift the sign of the regression coefficient from positive to negative or vice versa. If Tolerance > 0.1 and VIF 10, there is no multicollinearity for each variable.

Table 5. Result of The Multicolinearity Test

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	13.55532	155.4823	NA
INDS	6.93E-10	3.574663	2.462647
MINN	6.20E-11	1.740784	1.277692
AGRI	1.64E-10	3.973897	2.335711
RUBB	2.40E-12	2.034413	1.345583
MYS	0.157688	140.1459	1.276577
POV	0.003377	6.449717	1.305571
FORST	1.64E-10	2.057633	1.629811

Source: data processing by statistic (2022)

All independent variables have a VIF less than 10, hence there is no multicollinearity and the regression model may be employed.

Heteroskedastic

The test compares residual variance across different time periods. Heteroskedastic is used to determine if a regression model's residuals differ from one another. Variation from one genotype to another is called homoskedastic, and heteroskedastisic. Good regression model is non-heteroskedastic.

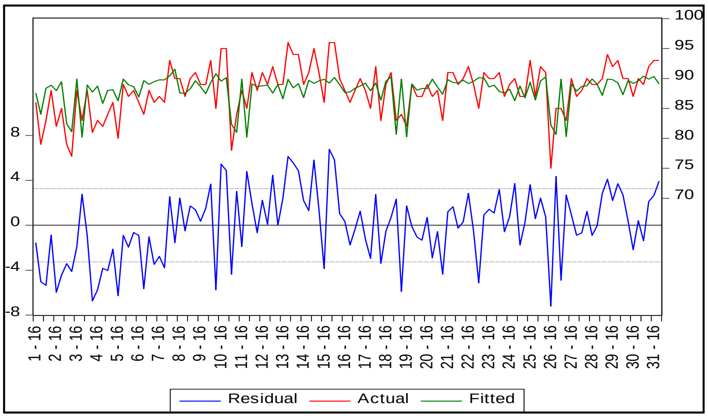

Figure 4. The Result of Heteroskesdasticity Test

The heteroscedasticity test shows that the residual value does not create a pattern, hence it is satisfied.

Autocorelation

Autocorrelation tests whether one observation's residuals are related to others'. Autocorrelation is more common in time series data since current data influences past data (Winarno, 2011). Autocorrelation illustrates the correlation between time- or space-ordered data, according to Ajija et al. The Durbin Watson (DW) statistic may identify autocorrelation. DW value or d coefficient ranges from 0 to 4. The regression model's DW test results give a d coefficient of 2.061924. Then, with a significance level of 0.05, these results were compared to the results from the Durbin-Watson statistical table. Number of data N=122. if there are three independent variables (K-3), then the outer limit (dL) will be 1.5 and the inner limit (dU) will be 1.8. means that 4 – dL = 2.58 and 4 – dU = 2.2. Since the DW value is between dU and 4dU, or 1.8 2.061924 2.2, it can be said that there is no correlation between the data in the regression model. Based on the DW test matrix, we can say that the regression equation doesn't have any problems with autocorrelation.

Air quality panel regression

The panel data regression model's findings are devoid of normality, multicollinearity, heteroscedasticity, and autocorrelation. Using Eviews 9 to test the panel data regression model. The Random Effect model estimation equations are:

Estimating Panel Data Regression

The panel data regression model's findings are devoid of normality, multicollinearity, heteroscedasticity, and autocorrelation. Using Eviews 9 to test the panel data regression model. Table 6 shows Random Effect model estimate results.

Table 6. Result for Equation Data Panel Model Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	89.67951	3.953382	22.68425	0.0000
INDS	9.64E-05	2.97E-05	3.248779	0.0015
MINN	-9.83E-06	6.88E-06	-1.429262	0.1557
AGRI	-8.45E-05	1.52E-05	-5.557392	0.0000
RUBB	3.24E-07	1.23E-06	0.263336	0.7928
MYS	0.043223	0.434566	0.099462	0.9209
POV	-0.009332	0.050709	-0.184020	0.8543
FORST	-1.74E-05	1.26E-05	-1.373274	0.1724
	Effects Specification			
			S.D.	Rho
Cross-section random			1.743949	0.2936
Idiosyncratic random			2.705336	0.7064
	Weighted Statistics			
R-squared	0.358306	Mean dependent var		54.19147
Adjusted R-squared	0.318904	S.D. dependent var		3.795426
S.E. of regression	2.746229	Sum squared resid		859.7621
F-statistic	9.093558	Durbin-Watson stat		2.061924
Prob(F-statistic)	0.000000			
	Unweighted Statistics			
R-squared	0.378047	Mean dependent var		88.10656
Sum squared resid	1232.472	Durbin-Watson stat		1.438381

Source: secondary data, processed by Eviews 9 (2022)

Linear regression equation model from panel data in this research, the following equation was derived:

$$IKU_{it} = \alpha_0 + \alpha_1 Inds_{it} - \alpha_2 Minn_{it} - \alpha_3 Agri_{it} + \alpha_4 Mys_{it} - \alpha_5 Pov_{it} + \alpha_6 Rubb_{it} - \alpha_7 Forst_{it} + e_{it}$$

$$IKU_{it} = 89.67951 + 9.64E\text{-}05\ Inds_{it} - 9.83E\text{-}06\ Minn_{it} - 8.45E\text{-}05\ Agri_{it} + 0.043223\ Mys_{it} - 0.009332\ Pov_{it} + 3.24E\text{-}07\ Rubb_{it} - 1.74E\text{-}05\ Forst_{it} + e_t$$

Coeffisien of Determinent (R^2)

R^2 measures how well a model explains the dependent variable. Close to one R square suggests the independent variable offers virtually all the information required to predict the dependent variable. Here are the findings of calculating the coefficient of determination:

The adjusted R-squared value of 0.318904 or 31.8904% shows the influence of the independent variable on the Air Quality Index (KPI). This means that 31.8904% of the Air Quality Index (KPI) may be explained by the Industrial Sector (Inds), Mining Sector (Minn), and Agricultural Sector (Agri), Waste Generation Rate (Rubb), Average Level -Mean Length of Schooling (Mys), Poverty Rate (Pov), and Deforestation Rate (Forst). Other independent factors explain the remaining 100% - 31.8904% = 68.1096%.

F-Test (Simultaneous Test)

The F Statistical Test examines if the model independent factors affect the dependent variable. F-Test results:

Table 7. F-test result

F-Statistic	9.093558
Prob(F-Statistic)	0.000000

Source: secondary data, processing by Eviews (2022)

Table 7 shows F-Statistic = 9.093558 with a probability of 0.000000 0.05. So the model can explain the effect of the Industrial, Mining, Agricultural, Waste Generation Rate, Average Years of Schooling, Poverty, and Deforestation Rates on air quality factors.

t-Test (Partial Test)

The t-test reveals how one independent variable influences the model's dependent variable. t-test results:

Table 8. t-Test Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	89.67951	3.953382	22.68425	0.0000
INDS	9.64E-05	2.97E-05	3.248779	0.0015
MINN	-9.83E-06	6.88E-06	-1.429262	0.1557
AGRI	-8.45E-05	1.52E-05	-5.557392	0.0000
RUBB	3.24E-07	1.23E-06	0.263336	0.7928
MYS	0.043223	0.434566	0.099462	0.0009
POV	-0.009332	0.050709	-0.184020	0.8543
FORST	-1.74E-05	1.26E-05	-1.373274	0.0017

Souce: data processing by Eviews 9

From the model's estimation results, hypothesis testing was done to determine the effect of GRDP growth in the industrial sector, GRDP growth in the mining sector, GRDP growth in the agricultural sector, waste generated, average schooling, poverty levels, and deforestation rates on partial air quality (individually). The t-test compared t-value to t-table. If tcount > t table, the impact is considerable; else, it's trivial. Hypothesis testing results:

H1: Industrial sector GDP growth has a favorable and considerable influence on Air Quality in Indonesia.

Based on the t-test at a significance level of 5% in table 10, the probability value of the Industrial Sector variable is 0.0015 or less than 0.05, hence it can be inferred that the industrial sector has a positive and statistically significant impact on air quality. Thus, it can be inferred that the industrial sector's GDP development has a positive and considerable influence on Indonesia's air quality. This demonstrates that the Indonesian industrial sector is gradually using environmentally friendly technologies with a closed-loop system to decrease waste disposal by creating a circular economy in waste management (Winans et al., 2017).

H2: The mining sector's GDP growth has a detrimental and severe influence on Indonesia's air quality.

Based on the t-test at a significance level of 5% in table 10, where the probability value of the Mining Sector variable is higher than or equal to 0.05, it can be inferred that the Mining Sector has a positive but not statistically significant influence on air quality. Thus, it can be inferred that the Mining Sector GDP Growth has a negative but insignificant influence on Indonesia's Air Quality Index. Due to the transformation of land into mining land, an expansion in the mining sector may contribute to a decline in air quality. However, this mining site is limited to areas with a small population (Fauzi et al., 2019).

H3: Gross Domestic Product (GDP) growth Indonesia's Air Quality is negatively and significantly affected by the agriculture industry.

Based on the t test at a significance level of 5% in table 10, the probability value of the agricultural sector variable is 0.000 or less than 0.05, hence it can be inferred that the agricultural sector has a negative and statistically significant influence on air quality. In conclusion, the agriculture sector's GDP development has a negative and considerable impact on the Air Quality Index in Indonesia. Indonesia's air quality will deteriorate as the conventionally processed agricultural sector expands; this may be avoided by transitioning traditional agricultural land management into contemporary, environmentally friendly, and sustainable agricultural land management by processing organically (Mediana & Maryunani, 2021)

H4: The average number of years spent in education has a favorable impact on air quality in Indonesia.

Based on the t-test at = 5% in table 10, the variable's probability value is With a value of 0.0009 or less than 0.05, it may be stated that the average duration of education has a positive and substantial impact on air quality. Therefore, it can be stated that the average number of years spent in school has a positive and statistically significant influence on the Air Quality Index in Indonesia. This indicates that environmental knowledge and education level have an impact on environmental caring attitudes. People will find it simpler to preserve environmental purity if they have a deep understanding of and care for the environment (Saputro et al., 2016)

H5: The poverty rate has a detrimental impact on air quality in Indonesia.

According to the t-test at a significance level of 5% in table 10, the probability value of the variable poverty rate is 0.8543 or larger than 0.05, hence it can be inferred that the poverty rate has a negative but not statistically significant influence on air quality. Therefore, it can be inferred that the poverty rate has a negative but not statistically significant influence on the Air Quality Index in Indonesia. This is because urban poor are more prone than rural poor to harm the environment. Different conceptions of a decent level of life among the impoverished in urban and rural regions may be the source of the ensuing variations in environmental quality (Ridena, 2021).

H6: Waste generation negatively impacts Indonesia's air quality

Table 10's t-test at a significance level of 5% indicates that the probability value of the variable trash production is 0.7928 or more than 0.05, hence it can be inferred that waste generation has a positive but not statistically significant influence on air quality. Thus, it may be stated that garbage creation in Indonesia has a somewhat favorable impact on air quality. Garbage creation has a positive effect, meaning that the more the generation of rubbish in a community, the less the possible impact on air quality. Due to the fact that garbage output varies by region, the most uncontrolled waste is generated in densely populated metropolitan regions (Lakatos et al., 2018). On the one hand, according to the Environmental Quality Index (2019) and SIPSN (National Waste Management Information System), the level of waste management began to improve with the expansion of unit and main waste banks and the provision of TPS3R (Temporary Processing Sites for Reused-Reduced-Recycle) in each district/municipality. Utilizing the circular economy idea, i.e. transforming garbage into a resource with economic worth and advantages, increased waste management may contribute to national/regional revenue (Kristianto & Nadapdap, 2021).

H7: Indonesia's Air Quality is adversely affected by the Deforestation Rate

Based on the t-test at = 5% in table 10, the Deforestation Rate variable's probability value is 0.0017 or less than 0.05, hence it can be stated that the Deforestation Rate has a negative and significant influence on the Air Quality Index (KPI). H7 is approved given that the t table value at alpha 0.05 (two tails) is 1.979 and the t-count value is -1.373274 (negative). Thus, it can be stated that a growing deforestation rate would lead to a decline in air quality, as a result of the high level of CO_2 emissions, followed by an increase in population and the level of urbanization, which leads to an increase in consumption levels (Beck & Joshi, 2015).

5. Discussion

Since air pollution may have far-reaching consequences, it is important that all nations, but particularly developing ones, devote significant resources to studying the best policies and tactics for addressing the problem. There is a chance that Indonesia's air quality would continue to deteriorate as the country's GRDP grows. Indicators of education, poverty, waste production, and deforestation rate, to name a few, must be assessed on a regular basis, as must the industrial, mining, and agricultural sectors. Reducing air pollution is one of the goals of the industrial sector, which may assist achieve this goal via the use of a closed loop system and proper waste management. Because of the conversion of previously non-mineral land to mining use, the mining industry may be contributing to worsening air quality; however, this is only the case in a handful of remote areas; therefore, those involved in the mining industry should evaluate the effects on the local environment. Sustainable and organic contemporary farming practices in the agricultural industry have the potential to lessen environmental damage. All parties involved need to work together to help socialize environmentally aware societies in a sustainable way, particularly in metropolitan areas where low levels of education and high poverty may contribute to air pollution. Inadequate waste management will cause issues for the environment, but if the government and the private sector work together to create green investment opportunities in the field of waste management, especially recycling investment, the increased waste could actually boost national or regional income and absorption. labor. Reduce the amount of land cleared for plantations and wood-related businesses to slow deforestation. Because the quality of land cover impacts environmental quality as a whole by a factor of 40 percent, the government should carefully and constantly pay attention to the current carrying capacity.

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