The Dynamic Nexus Among Energy Consumption, Economic Growth, and Green Finance on Environmental Quality

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Abstract
This study investigates the relationship among energy consumption, economic growth, and green finance on environmental degradation. The Panel Dynamic ARDL-PMG was used to analyze the model in 33 provinces in Indonesia from 2010 to 2022. The result shows that GRDP per capita, Motor Vehicle Volume, and Green Finance significantly positively affect the Environmental Quality Index in the long run. In the short run, GRDP per capita significantly negatively affects the EQI. The findings of this study emphasize that the implementation of Indonesia's energy transition policy must be completed, including a comprehensive transition from upstream to downstream. The transition to a non-fossil fuel energy system must begin by converting fossil fuel power plants to non-fossil fuel power plants. Meanwhile, the government must expand public transportation and encourage electric vehicles through fiscal incentive schemes.

Keywords: GRDP Per Capita, Environmental Quality Index, Green Finance, Pooled Mean Group, Motor Vehicle Volume

Hubungan Dinamis Antara Konsumsi Energi, Pertumbuhan Ekonomi, dan Keuangan Hijau Terhadap Kualitas Lingkungan

Abstrak
Studi ini menganalisis hubungan antara konsumsi energi, pertumbuhan ekonomi, dan *green finance* terhadap degradasi lingkungan. Panel dinamis ARDL-PMG digunakan untuk menganalisis model di 33 provinsi di Indonesia dari 2010 hingga 2022. Hasilnya menunjukkan bahwa PDRB per kapita, volume kendaraan bermotor, dan *green finance* secara signifikan mempengaruhi indeks kualitas lingkungan dalam jangka panjang. Dalam jangka pendek, PDRB per kapita secara signifikan mempengaruhi Indeks Kualitas Lingkungan. Temuan penelitian ini menekankan bahwa implementasi kebijakan transisi energi Indonesia harus diselesaikan, termasuk transisi komprehensif dari hulu ke hilir. Transisi ke sistem energi bahan bakar non-fosil harus dimulai dengan mengubah pembangkit listrik bahan bakar fosil menjadi pembangkit listrik bahan bakar non-fosil. Sementara itu, pemerintah harus memperluas transportasi umum dan mendorong kendaraan listrik melalui skema insentif fiskal.

Kata Kunci: PDRB Per Kapita, Indeks Kualitas Lingkungan, *Green Finance*, *Pooled Mean Group,* Volume Kendaraan Bermotor

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INTRODUCTION

Since the conclusion of World War II, the pursuit of economic growth has taken center stage in national agendas across the globe (Chen & Xu, 2022). However, this relentless drive for expansion has come at a steep environmental cost, manifesting in widespread degradation (Bilgili et al., 2021). The specters of climate change and global warming loom large, fueled by the industrialization and technological advancements underpinning economic growth (Chandio et al., 2019). Activities like industrial expansion and economic scale-up contribute significantly to rising CO_2 emissions (Aslam et al., 2021; Guo & Jiang, 2011). This phenomenon can be largely attributed to prioritizing short-term economic gains over sustainable practices, particularly in developing nations (Yingfei et al., 2022).

The landmark Paris Agreement established a global objective to curb greenhouse gas emissions, aiming to prevent catastrophic temperature increases. It sets a crucial target of limiting the average global temperature rise to no more than 2°C above pre-industrial levels (Jernnäs & Linnér, 2019). Further emphasizing the urgency of action, the 26th Conference of the Parties (COP26) underscored the necessity of bolstering resource efficiency, accelerating green growth transitions, and driving robust scientific and technological innovations to achieve the more ambitious goal of keeping temperature rise below 1.5°C. Faced with severe resource depletion and ecological crises, economies worldwide are increasingly embracing green growth strategies as a means to achieve the Sustainable Development Goals (SDGs), particularly SDG 7 (affordable and clean energy), SDG 12 (*sustainable consumption and production*), and SDG 13 (climate action). Green growth advocates decoupling economic prosperity from environmental degradation by promoting resource efficiency (Razzaq et al., 2023; Su et al., 2022). In light of this paradigm shift, understanding the key drivers of green growth, of which sustainable natural resource management is critical, becomes paramount.

A substantial body of scientific evidence confirms the reality of climate change, manifested in an unabated rise in global temperatures (Meinshausen et al., 2009). Mounting concerns over climate change underscore the threats and challenges posed by energy consumption, carbon emissions, and economic growth. To effectively address the consequences of climate change, it is crucial to strike a delicate balance between climate mitigation goals and economic growth. Greenhouse gas (GHG) emissions are widely recognized as the principal cause of climate change, posing a formidable challenge to nations worldwide in their efforts to combat environmental degradation. Ecologists and economists concur that CO_2 emissions are the primary culprit behind global warming (Andreoni & Galmarini, 2016; Fodha & Zaghdoud, 2010). This assertion is substantiated by the average annual growth rate of global CO_2 emissions, which is a staggering 1.8 percent. Consequently, CO_2 emissions have skyrocketed from 21.57 million metric tons (MMT) in 1990 to 33.47 MMT in 2014 (Dance, 2019).

The deterioration of the environment is fundamentally associated with the escalating use of non-renewable energy resources. The surge in greenhouse gas emissions carries grave implications, expediting the annually observed global warming trend (Wang, 2022). The employment of non-renewable energy resources, such as fossil fuels, and the emission of greenhouse gases negatively impact the economy and potentially harm the Earth's atmosphere (Shaheen et al., 2020). Brock & Taylor (2005) posited that sustainable economic growth is tied explicitly to both economic expansion and environmental sustainability. The growing reliance on non-renewable energy resources has resulted in adverse environmental effects, thereby complicating the attainment of future sustainable economic objectives. However, during the Covid-19 pandemic, the consumption of non-renewable fuels witnessed a decline. This reduction in non-renewable energy consumption is attributed to decreased community activities and the implementation of mobility restriction policies aimed at curtailing the spread of the virus, consequently leading to an economic downturn in various countries.

The economic decline triggered a 66 percent global drop in crude oil prices (Bi, 2023). The global demand for crude oil has diminished due to mobility restrictions, including lockdowns and business shutdowns, experienced by many countries. This has resulted in a worldwide economic contraction, affecting the demand for energy, including non-renewable energy. As a consequence of the Covid-19 pandemic, global carbon emissions have seen a decrease (Mohsin et al., 2022). This can be comprehended in light of the economic contraction that affected various countries, including Indonesia. The reduction in industrial activities, transportation, and other sectors has led to a decrease in carbon emissions.

The environmental quality in developing countries has suffered a decline, leading to critical situations such as air pollution, depletion of natural resources, water scarcity, disposal of industrial waste, and adverse effects on human health (Lin & Wang, 2019). Developing countries, including Indonesia, are frequently confronted with a range of severe environmental issues, such as climate change (Masron & Subramaniam, 2019). Aswicahyono et al. (2010) elucidated that Indonesia, a developing country with the largest economy in the Southeast Asia region, has a strong connection with the influence of the industrial sector. Governments in developing countries, including Indonesia, have undertaken objective measures to enhance economic impact by reducing unemployment and poverty levels. However, environmental concerns should be addressed or given more attention in the process.

Climate change is a tangible manifestation of environmental degradation in Indonesia. It is a multifaceted issue encompassing various aspects, including development related. It extends beyond being a mere environmental concern, exerting wide-ranging impacts on diverse development sectors such as the economy, society, and human well-being (Ma & Jiang, 2019). An observable consequence of climate change is the average increase in air temperature, attributable to the heightened concentration of greenhouse gases in the atmosphere. Despite not experiencing the heatwave phenomenon that South Asia underwent in 2023, Indonesia records an annual increase in air temperature. This has been confirmed by the Meteorology, Climatology, and Geophysics Agency (BMKG) of Indonesia, which reports an upward trend in average air temperature over the past two decades.

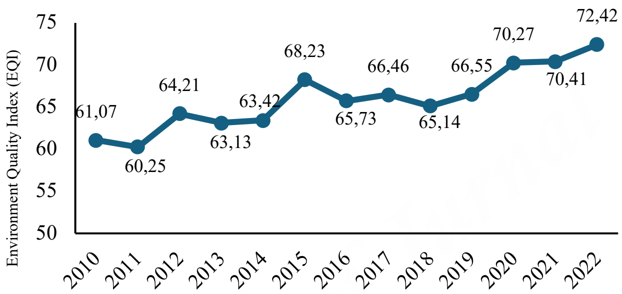

Figure 1. Environmental Quality Index of Indonesia 2010-2022
Source: Indonesian Ministry of Environment and Forestry, 2023

The Environmental Quality Index (EQI) serves as an indicator reflecting the status of national environmental management across the provinces of a country. The Ministry of Environment and Forestry of the Republic of Indonesia has introduced the EQI as a measure of environmental quality throughout Indonesia. The EQI comprises several sub-indicators: the Water Quality Index, Soil Quality Index, and Land Cover Quality Index. In 2022, Indonesia's EQI saw an improvement compared to its 2010 levels. However, this upward trend was not consistent over the thirteen years from 2010 to 2022, indicating that while progress has been made, the EQI has yet to reach its target, and challenges persist in enhancing the EQI in Indonesia. Moreover, the environmental quality across various provinces in Indonesia needs to be more balanced. Some provinces in the western part of Indonesia are marked by high warning levels and poor environmental quality, while regions in the eastern part of Indonesia exhibit good environmental quality (Sumargo & Haida, 2020). This disparity is also evident in the EQI indicators, namely the Water Quality Index, Air Quality Index, and Land Cover Quality Index, which have also seen fluctuations in their development from 2010 to 2022.

The advancement of renewable energy can serve as a key catalyst for sustainable economic growth (Wang & Jia, 2022). Over the past two decades, societal focus has been directed towards environmental issues stemming from the consumption of fossil fuels. The transportation sector, by its interconnections with various economic sectors, assumes a pivotal role in economic development. Contributing to 10 percent of carbon emissions, the transportation sector ranks third among emission contributors (*CO2 Emissions from Fuel Combustion 2019*, 2019; Xu et al., 2022). Predominantly reliant on fossil fuels, the transportation sector is a significant source of carbon emissions (Zhang et al., 2023). As per a report from the International Energy Agency (2020), transportation has emerged as a sector contributing to 25 percent of carbon gas emissions. Avotra & Nawaz (2023) and Zhang et al. (2023) elucidate that with the progression of urbanization activities, the transportation system assumes an increasingly significant role in national development and positively impacts industrial performance. The migration of the rural population to urban areas triggers significant changes in production, social dynamics, and lifestyle. This results in a shift in energy consumption patterns and structures, leading to increased carbon emissions and the evolution of overall energy consumption and energy consumption structure energy (Fan et al., 2023; Ma et al., 2017). Hence, curbing carbon emissions in the transportation sector is imperative to accomplish the task of carbon emission reduction.

The correlation between economic growth and environmental quality continues to be a debate among economists, owing to inconsistent research findings and differing arguments among researchers. While some studies suggest that economic growth influences the decline in environmental quality (Koengkan et al., 2020; Osobajo et al., 2020; Raheem et al., 2020), others posit that environmental quality will enhance as economic growth escalates (Dogan & Aslan, 2017). Besides a linear relationship, the correlation between economic growth and environmental quality also forms an inverted U-shaped non-linear relationship, as explained by the Environmental Kuznets Curve (EKC) Hypothesis. The EKC Hypothesis posits that at the onset of a country's development, environmental degradation will escalate as economic growth increases. Still, upon reaching a certain income level, environmental degradation will diminish as economic growth escalates (Al-Mulali et al., 2016; Juliani et al., 2021; Rahmayani et al., 2023; Sasana & Aminata, 2019). Although EKC has become a dominant approach in environmental and economic performance modeling, most EKC model estimates lack robust statistical strength (Stern, 2018), and several studies on the Environmental Kuznet Curve (EKC) have been questioned and found to be inconsistent. Consequently, the relationship between economic growth and environmental quality has not yet been definitively established. These inconsistent research findings render the study of environmental quality and economic growth an intriguing area for further exploration.

The discourse surrounding the interplay between economic growth and environmental preservation in Indonesia is continually evolving. Notably, (Nafngiyana et al., 2019) employed the Generalized Method of Moment (GMM) approach. They discerned that economic growth exerts an indirect yet statistically significant positive impact on CO_2 emissions, mediated through per capita health expenditure. This finding aligns with the conclusions drawn by Sukono et al. (2019), who asserted that escalating economic growth correlates with increased CO_2 emissions. Furthermore, the investigation conducted by (Muhammad Fajar & Hariyanto, 2021) provided empirical substantiation for the Environmental Kuznets Curve (EKC) using the Ordinary Least Squares (OLS) regression method. Conversely, (Saboori et al., 2012) contradicted the EKC hypothesis by applying the Autoregressive Distributed Lag (ADRL) approach. Despite these advancements, gaps, and incongruities persist in the extant body of research. Consequently, exploring the nexus between economic growth and environmental dynamics in Indonesia remains a pertinent subject necessitating further scrutiny.

This study stands out from previous research with two approaches; first, unlike the available literature, which mostly uses carbon emissions, we use EQI, a more comprehensive measure that is important in providing a comprehensive environmental evaluation. Second, this study examines the linkages to the conventional transportation sector and economic structure, estimates short-term and long-term impacts, and offers policy recommendations. These insights are critical to Indonesia's efforts to promote environmental quality and environmental sustainability. Policymakers can strategically allocate resources to reduce pollution and promote sustainable development by identifying the key sectors driving these emissions.

This study seeks to elucidate the repercussions of energy consumption in transportation, economic growth, and green investment on environmental degradation. The authors employ linear relationship estimation to scrutinize the intricate interplay between economic advancement and environmental quality. The investigation delves into long-term and short-term relationships between economic growth and environmental quality, employing the Panel Dynamic Autoregressive Distributed Lag (DADRL) methodology. Consequently, the study endeavors to comprehensively dissect the relationship between economic development and environmental quality across the 33 provinces of Indonesia from 2010 to 2022.

METHOD

Data and Measurement

This study utilizes secondary data published by the Ministry of Environment and Forestry (KLHK) and the Central Bureau of Statistics (BPS). The research employs panel data from 34 provinces from 2010 to 2022, discussing the Environmental Quality Index (IKLH). The data for this study is processed using STATA MP-17 software. Table 1 summarizes the list of variables along with their descriptions and sources.

Empirical Model

This research explores the correlation between the Environmental Quality Index (EQI) and economic development. The empirical model for this study is as follows:

$$\ln \boldsymbol{EQI}_{it} = \boldsymbol{\alpha}_i + \boldsymbol{\beta}_1 \ln \boldsymbol{GDRPC}_{it} + \boldsymbol{\gamma}.\boldsymbol{X}_{it} + +\boldsymbol{e}_{it} \qquad (1)$$

Where: **EQI** is Environmental Quality Index, **GDRPC** is Gross Domestic Regional Product per Capita, **X** is vector of control variables, **ln** is the natural logarithm, α_i is province-fixed effects, $\boldsymbol{\beta}_1$, $\boldsymbol{\beta}_2$, $\boldsymbol{\beta}_3$, and $\boldsymbol{\gamma}$ are the coefficients of elasticity of each variable, $\mathbf{e}_{it}$ is error term, and subscript **i** indicates province index, **t** indicates time index. The previous equation could be modified by adding other control variables:

$$\ln \boldsymbol{EQI}_{it} = \boldsymbol{\alpha}_i + \boldsymbol{\beta}_1 \ln \boldsymbol{GDRPC}_{it} + \boldsymbol{\beta}_2 \ln \boldsymbol{VHC}_{it} + \boldsymbol{\beta}_3 \boldsymbol{PEF}_{it} + \boldsymbol{e}_{it} \qquad (2)$$

Table 1. *Description of Variables*

Variable	Description	Source
Environmental Quality Index **(lnEQI)**	Indicator encompassing various environmental aspects such as air, water, soil, biodiversity, and human impact on the environment.	Indonesian Ministry of Environment and Forestry
Motor Vehicle Volume **(lnVHC)**	Quantity of motor vehicles (cars, buses, trucks, motorcycles). Data presented in unit measurement.	Statistics Indonesia
Government Expenditure for Green Environment **(PEF)**	Percentage of local government expenditure allocated to the green environment. Data is presented in percentage units.	Statistics Indonesia
Economic Growth Per Capita **(lnGRDPC)**	Gross Regional Domestic Product Per Capita based on constant prices	Statistics Indonesia

Additional control variables in Equation (2) encompass motor vehicle volume **(VHC)** and the proportion of government expenditure for the green environment **(PEF)**. In the case of cross-section dependence, the Im-Pesaran-Shin test is used to check for unit roots since it assumes the existence of this dependence between provinces. For non-stationary data, the cointegration is checked using the Pedroni test to check for potential long-run relationships between variables in the model. The panel Autoregressive Distributed Lag model (panel ARDL) can be used in case of no cointegration. Specific estimators like pooled mean group (PMG) and two-way fixed effect (DFE) could be computed.

$$\Delta \ln \boldsymbol{EQI}_{it} = \boldsymbol{\alpha}_i + \boldsymbol{\beta}_1 \ln \boldsymbol{EQI}_{it-l} + \boldsymbol{\beta}_2 \ln \boldsymbol{GDRPC}_{it-l} + +\boldsymbol{\beta}_3 \ln \boldsymbol{VHC}_{it-l} + \boldsymbol{\beta}_4 \boldsymbol{PEF}_{it-l} + \sum_{j=1}^{p1} \boldsymbol{\varphi}_j \Delta \ln \boldsymbol{EQI}_{it-j} + \sum_{k=1}^{p2} \boldsymbol{\varphi}_k \Delta \ln \boldsymbol{GDRPC}_{it-k} + \sum_{n=1}^{p3} \boldsymbol{\varphi}_n \Delta \ln \boldsymbol{VHC}_{it-n} + \sum_{l=1}^{p4} \boldsymbol{\varphi}_o \Delta \boldsymbol{PEF}_{it-o} + \boldsymbol{e}_{it} \quad (3)$$

This study formulates four models, comprising (i) the Two-way Dynamic Fixed Effects (DFE) model, (ii) the Pooled Mean Group (PMG) model, and (iii) COP 21. Models (i) and (ii) employ a dynamic panel ARDL approach to evaluate the impact of alterations in environmental quality before and after the 21st Conference of the Parties (COP 21) to the United Nations Framework Convention on Climate Change (UNFCCC) held from November 30 to December 12, 2015. Dummy codes (0) are applied for 2010-2015, while dummy codes (1) are used for 2015-2022.

FINDING AND DISCUSSION

This research utilizes the panel dynamic ARDL methodology to scrutinize the interrelationships among the variables under study and evaluate their short- and long-term impacts. The study's objective is to examine the linkage between economic development and environmental quality at the provincial level in Indonesia from 2010 to 2022. The findings are encapsulated in the subsequent section for a more holistic understanding. Table 2 provides descriptive statistical data about various factors that influence and contribute to environmental quality in Indonesia. The Environmental Quality Index serves as the dependent variable to measure environmental quality. The independent variables encompass the economic level represented by GDP per capita, the volume of motor vehicles (including cars, buses, trucks, and motorcycles), and the proportion of local government expenditure allocated for the green environment.

Initially, the green environmental quality exhibits an average of 4.20 percent, with a standard deviation of 0.16 percent. The maximum value of environmental quality is 4.60 percent, while the minimum stands at 3.46 percent. Secondly, the economic level, proxied by GDP per capita, has an average value of 10.35 percent, with a standard deviation of 0.55 percent. The GDP per capita peaks at a maximum value of 12.11 percent and dips to a minimum value of 9.13 percent. Thirdly, motor vehicle volume averages 14.42 percent, with a standard deviation of 1.15 percent. The maximum and minimum values are 16.97 percent and 10.59 percent, respectively. Lastly, the proportion of local government expenditure for the green environment averages 0.97 percent, with a standard deviation of 1.75 percent. The highest and lowest values are 19.43 percent and 0.01 percent, respectively.

Table 2. *Descriptive Statistics*

Variable	Obs.	Mean	Std. dev	Min	Max
ln EQI	429	4.202	0.168	3.464	4.601
ln GDRPC	429	10.351	0.554	9.139	12.116
ln VHC	429	14.421	1.153	10.590	16.976
PEF	429	0.975	1.759	0.01	19.430

The correlation test results, as shown in Table 3, reveal the interrelationships among the variables under consideration. As demonstrated in Table 1, the logarithmic growth in the number of motor vehicles (ln VHC) and the Environmental Quality Index (ln EQI) exhibit a moderate negative correlation, with a correlation coefficient of -0.52. Moreover, the GDP per capita also manifests a weak negative correlation with the Environmental Quality Index, possessing a correlation coefficient of -0.26. This suggests that an escalation in the growth of motor vehicle numbers and GDP per capita is concomitant with a declining trend in the Environmental Quality Index, albeit with a relatively weak to moderate degree of trend similarity. Furthermore, the green financing indicator, quantified by the percentage of government expenditure for the green environment (PEF), displays a weak negative correlation with the Environmental Quality Index, with a correlation coefficient of -0.18.

According to the Im-Pesaran-Shin test, the panel data for EQI and VHC demonstrate stationarity at the level, while the remaining panel data is stationary in the first difference (Table 4). All panel data is transformed into natural logarithms, with the exception of the PFE data. This transformation is employed to facilitate interpretation in terms of the elasticities of each independent variable.

Table 3. *Correlation Coefficients*

	ln EQI	Ln VHC	PEF	ln GDRPC
ln EQI	1.0000			
ln VHC	-0.5196	1.0000		
PEF	-0.1846	0.1729	1.0000	
ln GDRPC	-0.2579	0.3099	0.1760	1.0000

The outcomes of the cointegration test are presented in Table 5. Based on the Pedroni and Kao tests, it is apparent that there is cointegration between the logarithm of EQI and all variables: ln GDRPC, ln VHC, and PEF at a significance level of 1%

for the Pedroni test and 5% for the Kao test. Conversely, the Westerlund test indicates no cointegration between the dependent and independent variables. Thus, the variables under observation are cointegrated or have long-term relationships (Widarjono, 2009).

Table 4. *The Results of The Im-Pesaran-Shin Test for Checking The Presence of Unit Roots In Panel Data (2010-2022)*

Variable	(1)	(2)	(3)	(4)
ln (EQI)	-5.7509***	-8.9607***	-9.2909***	-5.5421***
	(0,0000)	(0.0000)	(0.0000)	(0.0000)
ln (GFRPC)	2.0405	3.5672	-6.6147***	-3.4678***
	(0.9793)	(0.9998)	(0.0000)	(0.0003)
ln (VHC)	-6.3827***	0.3727	-8.0200***	-1.6277*
	(0.0000)	(0.6453)	(0.0000)	(0.0518)
PFE	14.1516	0.7524	-9.0043***	-3.1141***
	(1.0000)	(0.7741)	(0.0000)	(0.0009)

Notes: (1) Statistic (Constant and Trend) (No Lag) Data in Level, (2) Statistic (Constant and Trend) (One Lag) Data in Level, (3) Statistic (Constant and Trend) (No Lag) Data in the First Difference, (4) Statistic (Constant and Trend) (One Lag) Data in the First Difference. The numbers in parentheses are the p-values.

Table 5. *Cointegration Test Results*

Pedroni Test	**Statistic**	***p*-value**
Modified Phillips-Perron	4.7437	0.0000
Phillips-Perron	-3.9726	0.0000
Augmented Dickey-Fuller	-5.3614	0.0000
Westerlund test		
Variance ratio	-0.2586	
Kao test		
Modified Dickey-Fuller	-5.1688	0.0000
Dickey-Fuller	-10.1473	0.0000
Augmented Dickey-Fuller	-2.0224	0.0216
Unadjusted modified Dickey-Fuller	-9.0053	0.0000
Unadjusted Dickey-Fuller	-11.5014	0.0000

Table 6 presents the results of the Hausman test, aiming to select the most suitable model between the Two-way Dynamic Fixed Effects (DFE) Model and the Pooled Mean Group (PMG) Model. The Hausman test outcome indicates that the probability value is greater than alpha (1.00 > 0.05), meaning H_0 is not rejected. This implies that the Pooled Mean Group (PMG) Model outperforms the Two-way Dynamic Fixed Effects (DFE) Model. A concise summary of the PMG and DFE model comparisons can be found in Table 7. Additionally, Table 7 introduces a third model, incorporating the dummy effect variables from COP 21 in 2015 and Covid-19 in 2019.

Table 6. *Hausman Test Result*

	Coefficients			
	(b) PMG	(B) DFE	(b-B) Difference	sqrt (diag(V_b-V_B) Std. err.
In_VHC	0.02947	0.05052	-0.0210	0.4827
PEF	0.02031	0.01877	0.0015	0.1587
In_GDRPC	0.24423	0.24941	-0.0051	1.536.572

b=Consistent under H0 and Ha; obtained from xtpmg

B= Inconsistent under Ha, efficient under H0; obtained from xtpmg

Test of H0: Difference in coefficients not systematic

chi2(3) = (b-B)' [(V_b-V_B)^(-1)](b-B)

= 0.00

Prob > chi2 = 1.000

Initially, we present estimations utilizing models with primary variables, followed by a robustness check incorporating additional variables into the models. The outcomes derived from the Pooled Mean Group (PMG) model can be interpreted as follows: in the long term, all independent variables exhibit a significant relationship with the Environmental Quality Index.

Economic growth, represented by the logarithm of Gross Regional Domestic Product per Capita (ln GDRPC), demonstrates a distinct relationship with the logarithm of the Environmental Quality Index (ln EQI) in both the long and short term. In the long term, ln GDRPC exhibits a significant positive association with ln EQI, indicating that economic growth exerts a significant positive impact on environmental quality at the inter-provincial level in Indonesia over the long term. Statistical results reveal that a 1 percent increase in GDP per Capita can enhance the Environmental Quality Index by 24.4 percent.

Similarly, in the long term, the variables representing the number of motor vehicles (comprising cars, buses, trucks, and motorcycles) and the percentage of local government expenditure for the green environment display significant positive relationships. This suggests that a 1 percent increase in the number of motor vehicles and a 1 percent increase in local government expenditure for the green environment can augment the Environmental Quality Index by 0.29 percent and 0.20 percent, respectively.

In the short term, there is a divergence in the phenomena of influence compared to the long term. In the short term, only the GDP per Capita variable is significantly related to the Environmental Quality Index. In the short term, GDP per Capita exhibits a relationship contrary to the long term, demonstrating a significant negative impact. Statistical results indicate that a 1 percent increase in GDP per Capita will decrease environmental quality by 79 percent. This suggests that economic growth is the predominant contributor to the decline in environmental quality.

According to the PMG model in Table 7, the models converge to a long-run relationship. The results solely reveal a long-term relationship among variables, with the highest speed of adjustment indicating a correction of 54 percent for this discrepancy in estimations. In the long run, the PMG model results show that Gross Regional Domestic Product per capita, motor vehicle volume, and Government Expenditure for Green Environment have a positive significant effect on the Environmental Quality Index. In the short run, the Gross Regional Domestic Product has a negative significance effect on the Environmental Quality Index (EQI). The others, Motor Vehicle Volume and Government Expenditure for Green Environment, have no significant effect on the EQI in the short run.

The COP-21 and Covid-19 models showed that all variables, Gross Regional Domestic Product, Motor Vehicle Volume, and Government Expenditure for Green Environment, have a positive significant effect on the EQI in the long run. Both dummy models, COP-21 and Covid-19, have positive significant effects on the raised EQI after COP-21 and Covid-19 happened in 2015 and 2019. In the short run, COP-21 showed that the period before COP-21 or before 2015 had a negative impact on the EQI; the other variables had no significant impact on the EQI. In the Covid-19 model, all variables have no effect on the EQI.

The interplay between the environment and the economy delineates distinct responsibilities for the government, which are regulated through policy measures. Governmental environmental policies may encompass investments and funding. The advent of green investments is anticipated to curtail environmental damage and foster efficiency in utilizing non-renewable energy sources (Aydin et al., 2023). Green investments play a pivotal role in environmental protection, resource conservation, and contribute to economic growth (Musah, 2022). Findings by Chen & Li (2023) elucidate that green funding (subsidies) for the industrial sector culminates in enhanced environmental quality through emission reduction. Furthermore, green investments exert a robust and significant positive impact on economic sustainability in Vietnam (Hung, 2023). However, research by (Koengkan et al., 2020; Osobajo et al., 2020; Raheem et al., 2020) posits that increasing green subsidies does not invariably engender a positive impact on the environment.

Table 7. *Model Estimation Results: Dynamic Fixed Effects (DFE), Pooled Mean Group (PMG), and COP 21 (Robust)*

Dependent: ln EQI				
	DFE	PMG	COP 21	Covid-19
	b/se	b/se	b/se	b/se
ec				
ln_GDRPC	0.249***	0.244***	0.093**	0.294***
	(0.06)	(0.03)	(0.03)	(0.03)
ln_VHC	0.051*	0.029***	0.023***	0.058***
	(0.02)	(0.03)	(0.03)	(0.03)
PEF	0,019**	0,020***	0,024***	0,034***
	(0,01)	(0,00)	(0,00)	(0,00)
COP21			0.052***	
			(0.01)	
Covid				0.025*
				(0.01)
Short Run				
ECT	-0.540***	-0.581***	-0.603***	-0.568***
	(0.04)	(0.05)	(0.05)	(0.05)
D.ln_GDRPC	-0.442***	-0.790*	-0.606	-0.958
	(0.11)	(0.39)	(0.40)	(0.72)
D.ln_VHC	-0.023	-0.178	-0.203	-0.074
	(0.02)	(0.13)	(0.12)	(0.16)
D.PEF	-0.007*	-0.005	-0.026	-0.004
	(0.00)	(0.02)	(0.02)	(0.02)
D.COP21			-0.058**	
			(0.02)	
D.Covid				-0.003
				(0.04)
constant	0.486	0.771***	1.776***	0.199***
	(0.36)	(0.07)	(0.16)	(0.04)
N	**396**	**396**	**396**	**396**

Note: *the numbers in parentheses are p-values,* * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Economic growth plays an integral role as a contributor to environmental quality. Estimation results indicate that in the long term, economic growth can ameliorate environmental degradation, while in the short term, economic growth will adversely impact environmental quality. Raheem et al. (2020) present contrasting research results using the ARDL approach; in both the long and short term, economic growth contributes to a decline in quality through increased CO_2 emissions in G7 countries. The discrepancies in these results could be attributed to the varying conditions of countries and the proxies used for environmental quality. Moreover, research conducted by Ozturk et al. (2022) exhibits analogous results through the DMOLS and FMOLS approaches in Saudi Arabia, indicating that economic growth will mitigate environmental degradation in the long term.

Furthermore, the findings of this research affirm that the implementation of Indonesia's energy transition policy must be completed on time, considering the prevailing conditions. The type of energy transition undertaken encompasses a comprehensive transition from upstream to downstream. On the upstream side, the energy transition must commence by converting fossil power plants to non-fossil power plants. However, the transition to power plants will necessitate significant costs. Until 2022, most PLN's (the state-owned electricity distribution monopoly in Indonesia) power plants were dominated by coal-fired power plants. Thus, government involvement is imperative to commit to an energy transition towards renewable energy.

Meanwhile, in the downstream sector, it is crucial to advocate for energy transition in the transportation and household sectors. In the transportation sector, the government needs to expand public transportation and encourage the use of electric vehicles, both achievable through fiscal incentive schemes.

CONCLUSION

Economic development invariably entails a trade-off between economic growth and environmental repercussions. The attainment of economic development, as gauged by the Gross Domestic Product, engenders externalities in the form of environmental degradation. Utilizing the ARDL-PMG approach, the findings of this research affirm that Gross Regional Domestic Product per capita, Motor Vehicle Volume, and Green Finance proxied by Government Expenditure for Green Environment have a positive significant effect on the Environmental Quality Index in the long run. In the short run, the Gross Regional Domestic Product has a negative significance effect on the Environmental Quality Index (EQI).

Promoting energy transition through fiscal financing to augment environmentally friendly public and private transportation can be a viable option for the government. In addition to transportation, households should also be considered by advocating the adoption of environmentally friendly technology and energy use. In the energy sector, the government needs to champion the use of renewable energy to transition from environmentally unfriendly fossil energy. To achieve sustainable development goals, it is recommended that the government increase public spending in the research and development (R&D) sector to encourage innovation in environmentally friendly production technologies in the industrial and manufacturing sectors. Fiscal policy also needs to be adjusted to this goal, especially to encourage acceleration of green investment such as with tax incentives for green investment and to standardization of environmentally friendly companies. In addition, it is necessary to specifically target energy consumption by utilizing environmentally friendly (renewable) energy for households and industries in transportation.

This research has certain limitations due to the constraints of the authors. Therefore, for future research agendas, several avenues can be explored: firstly, analysis using company or sectoral data with carbon or non-carbon emission variables at the provincial level and expanding the observation time frame, and secondly, constructing environmental variables using new index data. Thirdly, the analytical units are narrowed down to the district level, focusing on Java Island, Indonesia districts.

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