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Research Paper

Exploring Sustainable Economic Growth: Promoting Green Development Productivity through Decentralized Environmental Policy and Regional Competitiveness

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Abstract

The freedom of regions in regulating territories is now being promoted with the decentralization of environmental policies. This policy serves as the forerunner in empowering regions to function autonomously, thereby playing a role in practical politics. Therefore, this research aimed to analyze the role of decentralization of environmental policy and local government competition in navigating green development productivity in Indonesia. The slack base model and dynamic panel regression were used to generalize the method of the moment. The results showed that the decentralization of environmental policies and local government competition negatively affected the productivity of green development. Meanwhile, budget allocations for research and development, along with strategic initiatives in economic sectors such as agriculture and mining, showed a substantial positive effect.

Keywords: Environmental Policy Decentralization; Green Development; Local Government Competition.

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1. Introduction

Environmental policy decentralization is important in increasing decision-making and implementing actions aimed at preserving and safeguarding the environment. Local authorities, often have a better understanding of the unique environmental challenges and requirements of the respective regions, which are better equipped to make well-informed decisions. Decentralization empowers the local authorities to make quicker decisions on local conditions, thereby leading to more timely and effective measures against environmental issues. Local authorities can also consider cultural, social, economic, and geographic factors influencing environmental dynamics, which increases the possibilities of policies being successful and sustainable over the long term. Additionally, environmental decentralization policies include granting regions the freedom to actualize development. In this approach, decisions and responsibilities are distributed among various levels of government, non-governmental organizations, and communities, making it easier to understand specific environmental problems and respond quickly to environmental changes (Udeagha & Breitenbach, 2023). The decentralization of environmental policies contributes to achieving environmental stability and fosters regional innovations, thereby promoting ecologically based and sustainable inclusive economic growth (Fredriksson & Wollscheid, 2014; Wu et al., 2020).

Modern production activities can cause significant environmental harm, specifically when conducted without a commitment to sustainability and responsibility. Production activities that produce liquid waste cause threaten water quality, putting aquatic life at risk and disrupting the balance of aquatic ecosystems (Khalish et al., 2022). Moreover, gas emissions due to excess production also have the potential to pollute the air and disrupt human and animal health. Activities such as agriculture and plantations, which are associated with production, contribute to deforestation and excessive logging, decreasing wildlife habitats and increasing the possibility of natural disasters such as landslides and floods (Sarkodie & Strezov, 2018). Other production-related activities, including mining, infrastructure development, and industrial operations, have the potential to damage the soil in the form of erosion, decrease soil quality, and loss of biodiversity (Worlanyo & Jiangfeng, 2021). Production activities that use natural resources such as water, wood, and minerals can lead to over-exploitation, thereby reducing the availability of these resources for future generations (Sarkodie, 2018).

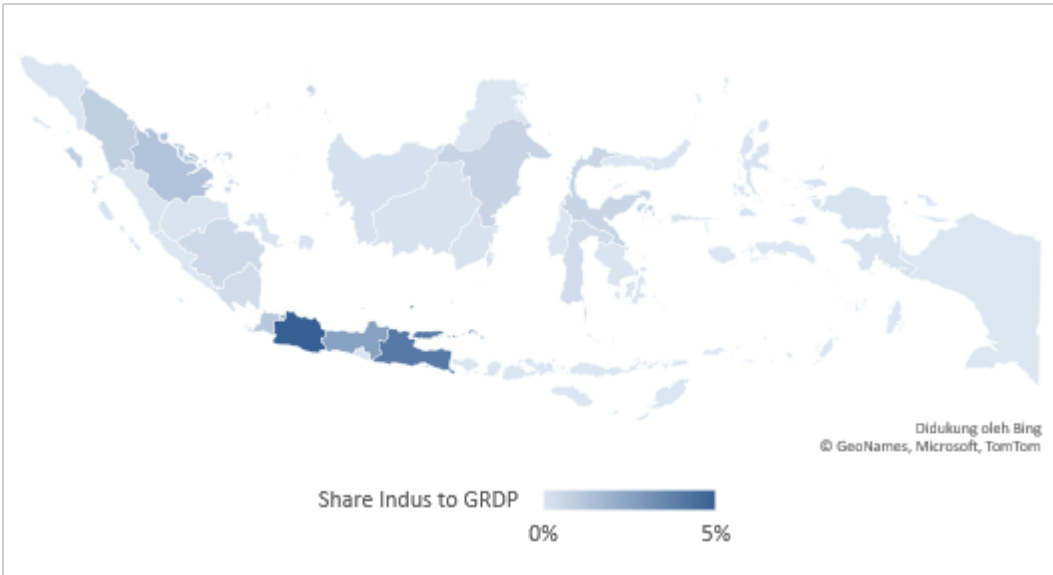

Figure 1. Distribution of Industrial Sector Orientation in Indonesia, from Research data, processed
Sources: (BPS, 2022)

Java Island is the most densely populated island in Indonesia with several big cities and witnessing the rapid expansion of industrial zones, including Jakarta, Surabaya, and Bandung. Industrialization on Java Island has played an important role in increasing economic growth to a current value of 56.6% (Buchori et al., 2017; BPS, 2022). However, the island has severe environmental challenges due to various human activities such as agriculture, industry, and urbanization. The compounded impact of these activities in addition to overpopulation, poses an ongoing challenge for Java to maintain ecological

balance. Figure 1 shows a massive industrial concentration on Java Island with the increasing potential for pollution accumulation due to the significant use of coal energy.

The development of physical infrastructure aimed at improving connectivity also plays an important role in improving the sustainability of environmental ecosystem resilience. In addition, the potential for land clearing is also increasingly massive outside Java Island, leading to a decrease in the availability of an adequate environment. As a result of this phenomenon, the development of private vehicles in various regions is increasing with an imbalance in public transport. This condition led to environmental issues that pose a threat to the future sustainability of the economy with a high number of private vehicles experienced in some regions. Figure 2 shows that the concentration of motorized vehicle growth is increasing in Java due to the rise in the number of private cars and motorbikes by 19,508,454 and 131,134,878 units, respectively. Meanwhile, other public vehicles such as buses have experienced relatively stagnant growth at around 6% (POLRI Traffic Corps, 2023). Uncontrolled vehicle growth has caused environmental degradation in densely populated regions, disrupting economic activity in general.

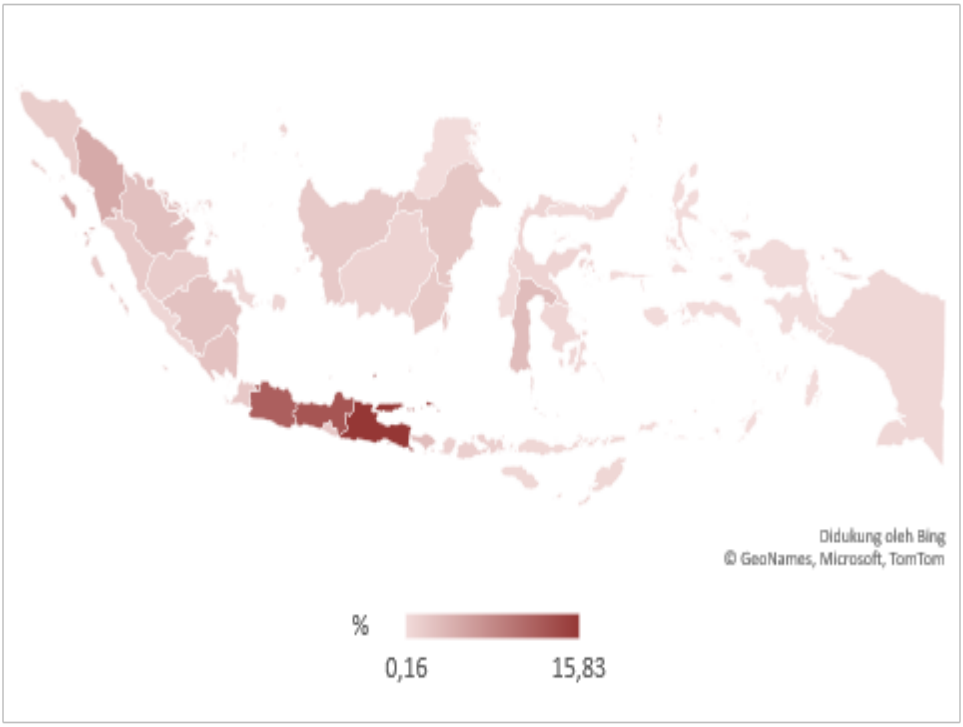

Figure 2. Distribution of Vehicle Growth in Indonesia, processed
Sources: POLRI Traffic Corps (2023)

Environmental protection in Indonesia is relatively similar, showing that land cover remains adequate. This is presented in Figure 3, showing that most of the greatest environmental protection is supported by regions with the highest land cover. Land cover comprises information on the types of land present in regions, comprising features such as forests, agricultural land, urban regions, water bodies, etc. Changes in land cover produce significant impacts on the environment, contributing to habitat degradation, ecosystem damage, and deterioration in water and air quality, as well as other environmental issues. Some regions with tropical and monsoon rainforest land cover are still scattered in Kalimantan and Papua. Meanwhile, others such as Java, Sumatra, and Sulawesi are supported by natural forests and adequate water quality.

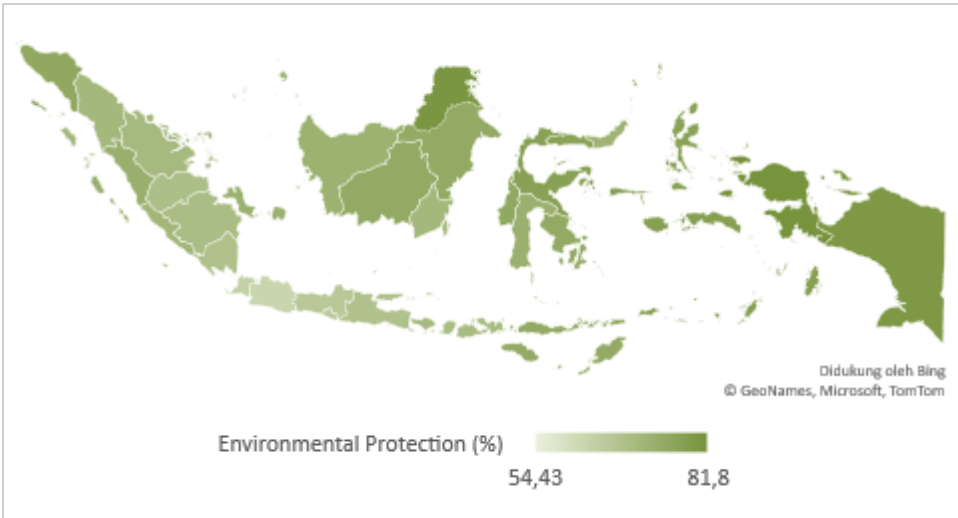

Figure 3. Distribution of Environmental Protection in Indonesia, processed
Sources: The Minister for Environment and Forestry (2021)

Target-oriented economic development often ignores environmental considerations, leading to serious environmental problems, such as air pollution and natural destruction in regions focused on physical development and trade dominance. To address these challenges, it is important to navigate various aspects and create environmentally friendly economic development. One important future orientation for maintaining environmental and global economic sustainability is green economic sustainability (Khanra et al., 2022). The concept of green development comprises sustainable economic progress based on renewable resources, aimed at minimizing negative impacts on the environment while improving the quality of human life (Feng & Chen, 2018; Zhu et al., 2019). In this process, natural resources are processed efficiently and developed sustainably to increase the availability for future generations. This approach promotes the use of renewable resources and clean technologies that reduce carbon emissions, contributing to the fight against climate change and improvements in air quality (Shao et al., 2016; Yang et al., 2019). Green development promotes innovation and investment in environmentally friendly technology and infrastructure, increases competitiveness, and promotes sustainable economic growth (Qiu et al., 2021).

According to Liu et al. (2022), the impact of environmental decentralization is determined by tax incentives. The collection of environmental protection tax provides economic incentives for local governments, which also increases government utilities and promotes regional green development. Zhang & Li (2022) stated that environmental decentralization promoted green technology innovation. Zou et al. (2019), stated that environmental decentralization promotes development in neighboring regions. Meanwhile, Luo et al. (2023) and Fang & Cao (2022) reported that environmental decentralization hinders the productivity of green economy development and reduces the quality of information disclosure.

Several research provided insights into the issue of unfair competition among governments impacting the productivity of green development. Particularly in cases of "bottom-to-bottom" competition among local governments, the pursuit of high-quality resources dominates environmental control efforts, thereby leading to environmental degradation (Kuai et al., 2019; van der Kamp et al., 2017). Additionally, the process of urbanization, which led to industrial agglomeration also affects the environmental quality of region (Zhang et al., 2020). The swift agglomeration of urban populations and the expansion of distorted urban spaces contribute to a decrease in the productivity of green development. Guild (2020) analyzed the allocation of research funds as measured from green finance toward sustainable development. The results showed that the allocation of these funds positively influences the productivity of green development, thereby making development more environmentally friendly.

The concept of green development is frequently associated with fiscal decentralization (Li & Xu, 2023; Liu et al., 2022; Wang et al., 2022; Wang et al., 2022; Zhu et al., 2022). These discussions

predominantly center on the efforts of local governments in allocating fiscal resources specifically for environmental purposes. Meanwhile, other research established connections between green development and regional innovation, exploring how regions could anticipate innovation and examine aspects of innovation financing through various models (Li et al., 2020; Yuan & Xiang, 2018). Research on green development related to policy decentralization in Indonesia remains limited. In Indonesian context, research on green economic development have primarily focused on conceptual aspects and have yet to delve into the practical role in fostering sustainable economic growth (Martawardaya et al., 2022; Masdar et al., 2022). The relationship of this development to local government competition has not been discussed to promote better innovations. Therefore, this research examined the impact of the decentralization of environmental policies and local government competition on green development in Indonesia.

This research provides theoretical insights into the measurement of green development efficiency in Indonesia. Furthermore, it also implicatively evaluates the efforts used to decentralize environmental policies and navigates local government competition towards achieving stability.

2. Methods

2.1 Data

Secondary data were collected from 34 provinces in Indonesia from 2016 to 2021. These provinces include Aceh, North Sumatra, West Sumatra, Riau, Riau Islands, Jambi, South Sumatra, Bengkulu, Lampung, Bangka Belitung Islands, DKI Jakarta, Banten, West Java, Central Java, DI Yogyakarta, East Java, Bali, West Nusa Tenggara, East Nusa Tenggara, West Kalimantan, Central Kalimantan, South Kalimantan, East Kalimantan, North Kalimantan, South Sulawesi, West Sulawesi, Southeast Sulawesi, Central Sulawesi, North Sulawesi, Gorontalo, Maluku, North Maluku, Papua, and West Papua.

Table 1. Definition of Research Variables

Variable	Definition	Period	Unit of Measurement	Source
pgd	Productivity of Green Development	2016-2022	Percent	Author Estimation
ed	Environmental Decentralization Score	2016-2022	Probability Score	Author Estimation
fc	Regional Competition Indeks	2016-2022	Probability Score	Author Estimation
Ln fdi	Natural logarithm of foreign investment	2016-2022	Percent	BPS
Ln rnd	Natural logarithm of research and development	2017-2022 (2016 backast using inflation)	Percent	Bappenas
Ln eb	Natural logarithm of environmental financing	2018-2021 (2016-2017 and 2022 backast & forecast using inflation)	Percent	The Ministry of Environment and Forestry
Ln urb	Natural logarithm of urban dwellers	2016-2022 (chow lin using population)	Percent	BPS
Ind	The share of the industrial sector to GRDP	2016-2022	Percent	BPS
Agri	The share of the agricultural sector to GRDP	2016-2022	Percent	BPS
Mining	The share of the mining sector to GRDP	2016-2022	Percent	BPS

The start of this data from 2016 is relevant to the updating of the research after the change in nomenclature of Presidential Decree No. 16 of 2015 came into effect. In addition, environmental issues have been dominant over the past five years and the use of the data is important for interpreting green development productivity. The analysis includes measuring green development productivity using output-based slack modeling, considering air quality and gross regional domestic product. Meanwhile, on the input side, factors such as investment, labor, and electricity consumption are considered.

Environmental policy decentralization is calculated through environmental protection shift share, using the provincial environmental quality index compared to the national index. Regional competition is estimated using fiscal budget information on regional revenues and expenditures. Additional data includes foreign direct investment (FDI), budget for research and development, budget for environmental mitigation, urban population, and the share of industry, agriculture, and mining to GDP. These data help understand how internal factors such as population growth, government efforts for the environment, and the performance of key economic sectors influence green development. These data are then adapted as controls to actualize green development efficiency properly.

2.2 Empirical Models

Environmental Policy Decentralization Model

Decentralization of environmental policies is determined using shift-share proxies for water, air, and land cover quality indices. The construction is associated with a particular form of management delegated to the regions by the central government for handling natural and non-natural damage (Zhang & Li, 2022). The main objective is to effectively supply public goods to protect the environment, including the effectiveness in terms of regulations and conditions in the field. In addition to the increasingly complex diversification of regional governments, establishing more precise measurement validations is possible. The measurement process for environmental policy decentralization is formulated as follows:

$$ed_{it} = \left[\frac{\frac{leqi_{it}}{lpop_{it}}}{\frac{neqi_{it}}{npop_{it}}}\right] \times \left[1 - \left(\frac{GRDP_{it}}{GDP_t}\right)\right] \quad (1)$$

Where i and t denote province and year, respectively, ed_{it} represents the decentralization of environmental policy, and $leqi_{it}$ is the local environmental quality index. The local quality can be changed by exchanging the local water, air, and land cover quality index. Furthermore, $neqi_{it}$ is the national environmental quality index, $lpop$, and $npop$ denote the total population at the province and national levels. Finally, $GRDP_{it}$ and GDP_t are local and national gross regional domestic products, respectively.

Based on the measurements above, a higher ed value indicates better protection and vice versa (Ran et al., 2020). According to Botta & Koźluk (2014), the environmental quality index is equivalent to the performance index that represents policies in each country. The comparison results showed that the higher the value of the environmental performance index, the stronger the environmental care policies and vice versa. Meanwhile, Indonesia has implemented this index to describe the navigation movement of regional environmental indicators as a means to control and follow up regulations. The process of supporting information including water quality, air, and land cover is achieved as follows:

$$ed_{it} = [0.3 \times edW_{it} + 0.3 \times edA_{it} + 0.4 \times edLC_{it}] \times \left[1 - \left(\frac{GRDP_{it}}{GDP_t}\right)\right] \quad (2)$$

$$ed_{it} = \left[0.3 \times \frac{\frac{leqw_{it}}{lpop_{it}}}{\frac{neqw_{it}}{npop_{it}}} + 0.3 \times \frac{\frac{leqa_{it}}{lpop_{it}}}{\frac{neqa_{it}}{npop_{it}}} + 0.4 \times \frac{\frac{leqlc_{it}}{lpop_{it}}}{\frac{neqlc_{it}}{npop_{it}}}\right] \times \left[1 - \left(\frac{GRDP_{it}}{GDP_t}\right)\right] \quad (3)$$

Where ed is determined through fixed proportions of edW, edA, and $edCL$, which are decentralized moderation of water, air, and land cover, respectively. This fixed weighting portion refers to the pattern of determining the environmental quality index set by the Ministry of Environment and Forestry through the formulation of the quality standard for environmental statistics. These are 0.3 for water and air quality, and 0.4 for land cover, which are then implemented in the weighting of environmental decentralization to prevent the equalization process from changing. Therefore, from this information, the decentralization of environmental policies is examined based on more minor indicators, as shown in Table 2.

Table 2. Decomposition of Environmental Decentralization Policy Score

Label	Definition	Unit of Measurement	Source
leq	Provincial Environmental Quality index	Percent	Kemen LHK
leqw	Provincial water quality index	Percent	Kemen LHK
Lequ	Provincial air quality index	Percent	Kemen LHK
Leqlc	Provincial land cover quality index	Percent	Kemen LHK
Neq	National environmental quality index	Percent	Kemen LHK
Neqw	National water quality index	Percent	Kemen LHK
Neqa	National air quality index	Percent	Kemen LHK
Neqlc	National land cover quality index	Percent	Kemen LHK
Lpop	Province population	Person	BPS
Npop	National population	Person	BPS
GRDPit	Gross Regional Domestic Product	Billion Rp	BPS
GDPt	Gross domestic product	Billion Rp	BPS

Regional Government Competition

Local government competition shows that the higher the competition for fiscal decentralization, the more monopoly the region has in accommodating the various policies. The local government competition model was formulated as follows:

$$fc_{it} = \frac{pfr_{it} - fe_{it}}{pfr_{it}}; pfr_{it} \neq 0 \quad (4)$$

Where fc_{it}, pfr_{it}, and fe_{it} denote fiscal, regional income, and total regional expenditure, respectively. When the competitive value is relatively large, the regional pressure to use the budget is higher, which enables it to delegate policies through budget independence (Ran et al., 2020).

Table 3. Decomposition of Regional Competition using Fiscal Decentralization Measurement

Label	Definition	Unit of Measurement	Source
pfr	The amount of regional original income, general-specific allocation funds, and profit-sharing funds also known as regional income	Milliard Rp	The Ministry of Finance
fe	The amount of regional expenditure of the province	Milliard Rp	

Green Development Productivity

Green development productivity (PGD) is measured through a slack-based model to determine the optimal output from the increasingly massive economic development results (Yang et al., 2018b). This productivity follows the deterministic modeling that *K (k=1,2,…, K)* uses *N(n=1,2,.., N)* inputs, with expected and unexpected outputs as *M (m=1,2,.. , M)* and *I(i=1,2,.., I)*. s is the slack of each of the input, output, and unexpected output indicators. Meanwhile, x,y, and b are the coefficients for input, output, and unexpected output, respectively. Lastly, z is weighted vector of coefficient that respectively to the equation. The measurement process can be calculated as follows:

$$pgd_{it} = min\left[\frac{1 - \frac{1}{N}\sum_{n=1}^{N}\frac{s_{nt}^{x}}{x_{nt}^{j}}}{1 - \frac{1}{M+1}\left(\sum_{m=1}^{M}\frac{s_{mt}^{y}}{x_{mt}^{j}} + \sum_{i=1}^{I}\frac{s_{it}^{b}}{x_{it}^{j}}\right)}\right] \quad (5)$$

$$\text{s.t} \sum_{k=1}^{K} z_k s_{nt}^{m} + s_{nt}^{x} = x_{nt}^{j}, \text{ where } n = 1, 2, \dots, N \quad (6)$$

$$\sum_{k=1}^{K} z_k s_{mt}^{k} - s_{mt}^{y} = y_{mt}^{j} \text{ where } m = 1, 2, \dots, M \quad (7)$$

$$\sum_{k=1}^{K} z_k s_{it}^k - s_{it}^b = b_{it}^j \text{ where } i = 1, 2, \ldots, I \quad (8)$$

$$\sum_{k=1}^{K} z_k = 1 \quad (9)$$

$$z_k \geq 0, s_{nt}^x \geq 0, s_{mt}^y \geq 0, \text{and } s_{it}^b \geq 0 \quad (10)$$

Based on the estimation results, pgd has a maximum value of 1, which means using renewable energy transmission is more productive in achieving green development. When the value is less than one, it can be ascertained that the increase in production inputs has implications for environmental pollution and vice versa.

Table 4. Decomposition of Slack Base Productivity of Green Development Measurement

Indicator	Label	Definition	Unit of Measurement	Sources
Input	M_1	Gross Fixed Capital Formation	Billion Rp	BPS
	M_2	The amount of labor	Person	
	M_3	Electricity Consumption	GwH	
Desirable Output	N_1	Gross Domestic Product	Billion Rp	PLN
Undesirable Output	I_1	Air Pollution	Index	Global Change Data Lab (GC)

2.3 Empirical Models

Effect of Decentralization of Environmental Policy and Local Government Competition on Green Development Productivity

Previous research stated that foreign investment, urbanization, and mining share negatively affected the productivity of green development (Li et al., 2022). Meanwhile, it was positively affected by the budget allocated for research and development, and environmental considerations, including industry and agriculture shares of GRDP (Feng et al., 2017). Foreign investment was perceived as a potential driver of massive economic growth, opening up possibilities for new value-oriented industries. Meanwhile, higher rates of urbanization were associated to concentrated populations and the potential formation of slum regions, contributing to reduced green development productivity (Shang & Liu, 2021). Rapid urbanization was associated with deforestation, habitat destruction, and increased pollution, negatively impacting the environment and overall green development efficiency. The mining share was also suspected of hindering productivity due to basins and land clearing, creating environmental challenges (Gao et al., 2019). Budgets allocated for research and development purposes, along with environmental interests, were perceived as critical in establishing a more ecologically sound policy climate at the regional level (Feng & Chen, 2018). The share of the industrial sector played a crucial role by supporting the adoption of the latest technology and new renewable energy, with the potential to increase economic productivity (Guo & Liu, 2022). Finally, the agricultural sector is also an essential promoter of creating green development productivity (Yu et al., 2020).

To evaluate the effect of decentralization on environmental policies and local government competition in the productivity of green development, a dynamic panel regression known as Generalized Method of Moments (GMM) was used. The choice of GMM over VAR panel regression was motivated by the need for a model that accommodates short periods, specifically in the context of a limited number of provinces. GMM panel regression, designed for changes in time series, adopted variable lag terms in this research. The model aims to analyze the impulse response of changes in the overall unit decentralization of environmental policy, water, air, and land cover qualities. It also examined the influence of these decentralized aspects, alongside green development in the preceding and recent years. To obtain accurate results and address classic issues of autocorrelation and heteroscedasticity, Arrelano-bond and Sargan post-estimator tests, were conducted (Arellano & Bond,

1991; Arellano & Bover, 1995). This approach aims to enhance the reliability and accessibility of the research findings.

$$pgd_{it} = \alpha_0 + \beta ed_{kit} + \alpha_1 fc_{it} + ln\, fdi_{it} + ln\, rnd_{it} + ln\, eb_{it} + ln\, urb_{it} + ind_{it} + agri_{it} + mining_{it} + u_{it} \quad (11)$$

Where pgd_{it} is green development productivity, ed_{kit} is an indicator of environmental policy decentralization, $\ln fdi_{it}$ is the natural logarithm of foreign investment, $\ln rnd_{it}$ is the natural logarithm of expenditure for research and development purposes, $\ln eb_{it}$ is the natural logarithm of spending on environmental needs, $\ln urb_{it}$ is the natural logarithm of urbanization, ind_{it} is the share of the industrial sector (% of GDP), $agri_{it}$ is the share of the agricultural sector (% of GDP), $mining_{it}$ is the share of the mining sector (% of GDP), u is another factor, i and t are province and year, respectively.

3. Results and Discussion

3.1 Descriptive Statistics

The following descriptive statistics present measures of concentration, distribution, and location.

Table 5. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Pgd	204	0.86	0.061	0.753	1
Ed	204	99.756	99.548	3.578	477.811
Fc	204	-0.202	0.414	-2.18	1
Fdi	204	874.901	1201.61	5.9	5881
Rnd	204	48.116	65.498	7.731	379.516
Eb	204	45.549	56.587	-6.023	356.769
Urb	204	4348.428	7444.541	131.46	39837.293
Ind	204	0.751	1.381	0.008	6.735
Agri	204	0.411	0.46	0.015	2.06
Mining	204	0.234	0.403	0.003	2.296

Source: Author Estimation Result

The results of statistical measurements show that the productivity of green development is currently static and inefficient, as presented by a gap level of 0.14 in absolute productivity (absolute productivity=1). The decentralization of environmental policies is moderately low, depicting that it has not been completely adopted by most local governments. Table 2 shows the inefficiency in green development productivity, which tends to remain static at 0.86. This simply means that to enhance the efficiency, the input productivity gap should be reduced by a scale of 0.16. In terms of environmental policy decentralization, the score is relatively small at approximately 99.75, signifying that many local governments are yet to fully implement these policies. This was shown by the environmental policy decentralization score that reached a maximum value of 477.81. However, local government competition had a relatively low value of -0.202, showing a competitive regional setting, where each region competes to enhance the developmental capacity. Based on the calculation, the average FDI was 874,901, showing a continuous influx of new capital. This condition also implied that foreign financing sentiment was still relatively good. The budget allocated for research and development, including environmental purposes is relatively minimal, with magnitudes of 48.1 and 45.54, respectively, in addition to the maximum value which tends to be greater. Urbanization, represented by the urban population, remains substantial at 4348 individuals. Meanwhile, certain provinces show a shift toward the industrial sector in the economic structure, surpassing concentrations in agriculture and mining. When further analyzed, it was discovered that all research variables were free from data outlier problems, allowing for estimation in the subsequent stages.

3.2 Correlation coefficient

The following represents the estimated correlation coefficient for the research variables:

Table 6. Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) pgd	1.000									
(2) edm	-0.071	1.000								
(3) fc	-0.070	0.100	1.000							
(4) fdi	0.378*	0.369*	0.108	1.000						
(5) rnd	0.433*	0.395*	0.103	0.729*	1.000					
(6) eb	0.434*	0.392*	-0.107	0.713*	0.967*	1.000				
(7) urb	0.220*	0.429*	0.122*	0.764*	0.655*	0.649*	1.000			
(8) ind	0.352*	0.410*	0.150*	0.760*	0.711*	0.694*	0.966*	1.000		
(9) agri	0.248*	0.493*	0.132*	0.352*	0.357*	0.349*	0.693*	0.754*	1.000	
(10) mining	0.527*	0.172*	0.001	0.093	0.064	0.065	0.060	0.195*	0.332*	1.000

** shows significance at p<0.1*

Source: The results of the author's estimation

Table 6 showed an overall moderate relationship which does not correlate with the decentralization of environmental policies and green development productivity. On the contrary, foreign investment, budget for research and development, including the environment, urbanization rate, industrial, agricultural, and mining sectors showed positive correlations at a significance level of 10%. The regression estimation stage enabled a smooth continuation due to the unavailability of autocorrelation.

3.3 Estimation Results

Table 7. The results of the estimation of the effect of decentralization of environmental policies and local government competition on the productivity of green development

	GMM Difference				GMM System			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	PGD	PGD	PGD	PGD	PGD	PGD	PGD	PGD
_cons	1.067***	1.322***	1.54***	1.529***	0.805***	0.954***	1.269***	1.23***
	(0.12)	(0.215)	(0.26)	(0.291)	(0.062)	(0.131)	(0.171)	(0.188)
L.pgd	0.231***	0.218***	0.223***	0.223***	0.261***	0.173***	0.245***	0.252***
	(0.03)	(0.035)	(0.038)	(0.038)	(0.027)	(0.026)	(0.035)	(0.031)
Ed	-0.001***	-0.001***	-0.001***	-0.001***	0***	0**	-0.001***	-0.001***
	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Fc	-0.006	-0.009	-0.004	-0.017*	-0.025	-0.037***	-0.021	-0.023***
	(0.011)	(0.011)	(0.011)	(0.01)	(0.017)	(0.014)	(0.017)	(0.009)
Lnfdi	0.001	0	0	0	0	0	0	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
Lnrnd	0.021	0.026	0.016	0.044**	0.052**	0.07***	0.039	0.052***
	(0.023)	(0.023)	(0.024)	(0.022)	(0.022)	(0.016)	(0.029)	(0.02)
Lneb	0.016	0.012	0.015	0.007	0.011	-0.007	0.005	0
	(0.013)	(0.012)	(0.013)	(0.013)	(0.017)	(0.015)	(0.019)	(0.014)
Lnurb	-0.062***	-0.099***	-0.127***	-0.137***	-0.051***	-0.063***	-0.107***	-0.105***
	(0.015)	(0.025)	(0.034)	(0.037)	(0.009)	(0.015)	(0.023)	(0.024)
Ind		0.046**	0.031*	0.021		0.035*	0.028*	0.018
		(0.02)	(0.018)	(0.015)		(0.019)	(0.016)	(0.014)
Agri			0.081	0.072			0.124***	0.112**
			(0.071)	(0.066)			(0.043)	(0.044)
Mining				0.04*				0.049**
				(0.021)				(0.024)
F-Test	80.52***	77.31***	99.73***	94.59***	405.08***	581.21***	231.51***	200.31***
P(AR(2))	0.8506	0.8559	0.9357	0.9554	0.5895	0.3189	0.7418	0.8449
P (Sargan)	0.2828	0.2933	0.3574	0.3057	0.1921	0.1714	0.5044	0.5463
Observations	134	134	134	134	169	169	169	169

Standard errors are in parentheses; *** p<.01, ** p<.05, * p<.1

Source: The results of the author's estimation

The results of the estimation are shown in Table 7, with each process including the addition and subtraction of sectoral variables. In general equations (1) to (4) were estimated using GMM difference, whereas (5) to (8) were calculated by applying GMM system. The results of the estimation shows that environmental policy decentralization, local government competition, and urban population consistently had a significant negative effect on green development productivity. Meanwhile, the budget for research and development, agricultural, and mining sectors had a positive impact. This pattern remained consistent across sectors, showing the stability of results in absolute terms. The influential factors are attributed to the budget allocated for research and development, as well as the economic contributions of the agricultural and mining sectors. Meanwhile, a hindering factor was identified in the form of a higher urban population. Finally, this model proved to be the best fit due to the absence of autocorrelation AR(2), and the sargan probabilities in line with the GMM. Therefore, this model is suitable for describing the actual conditions.

3.4 Ranking of Environmental Policy Decentralization Indicators, Local Government Competition, and Green Development Productivity

The provided details offer an overview of the distribution of indicators for environmental policy decentralization, local government competition, and green development productivity across 34 provinces from 2016 to 2021.

Table 8. Rating of Environmental Policy Decentralization Indicators

Province	Green Development Productivity	Rank	Environmental Policy Decentralization	Rank	Regional Government Competition	Rank
Aceh	0.805672	30	55.3436	21	-1.51212	35
Bali	0.808735	28	60.85166	18	-0.18475	29
Banten	0.84121	22	16.79549	31	-0.12353	22
Bengkulu	0.807568	29	138.4204	8	-0.1049	18
Yogyakarta Special Region	0.779257	35	57.23369	20	-0.37787	32
Jakarta Special Capital City	0.978379	3	13.65203	32	-0.02059	4
Gorontalo	0.782254	34	245.8418	3	-0.00171	3
Jambi	0.890114	8	73.10355	17	-0.0887	15
West Java	0.885368	10	3.805037	35	-0.11674	20
Central Java	0.875469	13	6.485574	33	-0.06505	13
East Java	0.906397	6	5.244279	34	-0.06065	11
West Kalimantan	0.846927	18	54.36467	22	-0.04823	8
South Kalimantan	0.825629	25	60.57962	19	0.065022	2
Central Kalimantan	0.853642	16	107.8222	12	-0.03812	7
East Kalimantan	0.984492	2	80.91905	16	-0.15976	26
North Kalimantan	0.889892	9	450.1822	1	-0.184	28
Bangka Belitung Islands	0.819448	27	183.6427	6	-0.15056	24
Riau Islands	0.990338	1	120.173	9	-0.03231	6
Lampung	0.842352	21	27.92873	29	-0.05331	10
Maluku	0.786556	33	168.7156	7	-0.07998	14
North Maluku	0.836178	23	243.9581	4	-0.1207	21
West Nusa Tenggara	0.794959	32	49.07444	24	-0.05002	9
East Nusa Tenggara	0.796755	31	48.30886	25	-0.22706	31
Papua	0.945593	4	93.57935	15	-1.50372	34
West Papua	0.904837	7	340.4289	2	-0.84706	33
Riau	0.929263	5	35.77019	26	-0.15541	25
West Sulawesi	0.846188	19	209.4706	5	-0.12945	23
South Sulawesi	0.882227	12	30.5754	27	-0.06475	12
Central Sulawesi	0.854943	15	96.2628	14	-0.02679	5
Southeast Sulawesi	0.833511	24	108.6236	10	-0.17177	27

Province	Green Development Productivity	Rank	Environmental Policy Decentralization	Rank	Regional Government Competition	Rank
North Sulawesi	0.822189	26	108.2969	11	-0.10051	17
West Sumatera	0.846188	19	49.19864	23	-0.1059	19
South Sumatera	0.852536	17	30.06466	28	0.084215	1
North Sumatera	0.884124	11	16.9964	30	-0.09557	16

Source: The results of the author's estimation

Based on the ranking calculations, the top five regions with the highest green development productivity are Riau Islands Province, East Kalimantan, DKI Jakarta, Papua, and Riau. This achievement was influenced by diverse factors, and provinces such as Riau Islands, Papua, and Riau had favorable environmental quality indicators. Meanwhile, DKI Jakarta and East Kalimantan attributed high productivity to the proactive government approach in formulating environmental policies. The decentralization of environmental policies is significant in provinces characterized by relatively good ecological quality, such as North Kalimantan, West Papua, Gorontalo, North Maluku, and West Sulawesi. The ecological excellence in these regions was supported by favorable land cover and water quality. Finally, from the aspect of local government competition, South Sumatra, Kalimantan, Sulawesi, Gorontalo, and DKI Jakarta were perceived as the major players. The varying levels of competition are primarily dominated by the fiscal dynamics and deficits in the respective provinces.

3. 5 Discussion

The act of decentralizing environmental policies was associated with a decrease in green development productivity. The results of this research are in line with Fang & Cao (2022), and Luo et al. (2023), that environmental decentralization has a negative effect on the productivity of green development. However, the absence of environmental policies in certain regions does not always correlate with a decline in green development quality. The environmental policies were also affected by several other factors, including unfavorable geographical conditions, such as barren soil or low rainfall, which required assistance in building parks or green open spaces. Less economically developed regions may face budget constraints for green environmental initiatives, while densely populated regions tend to encounter challenges in finding space for parks or green open spaces.

Effective environmental policy implementation plays an important role in enhancing the quality of green development in region. However, through properly enacted environmental policies, the development and maintenance of parks and open spaces was facilitated, which significantly improved resident quality of life.

Promoting fair competition in the government can promote a decrease in the productivity of green development. This is in line with the research conducted by Kuai et al. (2019) and van der Kamp et al. (2017), that competition among local governments tends to reduce the monitoring of environmental pollution. However, this competition does not consistently result in high-quality green developments. A monopoly-like competition can promote local governments to actively engage in the development and maintenance of the environment. This engagement includes practices such as the use of environmental impact analysis, establishing public green facilities, and implementing various measures supporting environmental stability. However, unhealthy competition, such as vying for funds or projects from the central government, can hinder coordination among local governments. This lack of coordination poses a challenge to the implementation of environmental and pro-stability programs. Neglecting the development and maintenance of the environment including the creation of parks and green open spaces can also lead to a generally low quality of green development. This negligence arises from insufficient budget, limited human resources, or lack of awareness regarding the importance of a green environment. Consequently, local governments must prioritize environmental development and maintenance as integral components of regional development agendas. Achieving this requires increased budget allocations, and human resources, including heightened public awareness regarding the importance of fostering a green environment. In addition, fostering effective coordination between local governments is important for improving the quality of green development in a given region.

The growing concentration of urban residents was associated with a decrease in the productivity of green development. This is in line with the research conducted by Zhang et al. (2020), that the rapid

agglomeration of the urban population and the continuous expansion of its space, have led to a deviation from high-quality, and efficient sustainable development. The direct correlation between urban population growth and the low quality of the green environment is not universally applicable (Zhang et al., 2020). Meanwhile, controlled urban population growth can trigger the development of a better green environment, which ensures the growth is in line with ideal spatial planning, and capable of resulting in environmental damage as well as a decline in green quality. Rapid urban population growth can lead to uncontrolled land use, deforestation, and the depletion of natural habitats, all of which are detrimental to the environment. High population density in urban regions can complicate the allocation of land for parks and green open spaces, contributing to overcrowding, increased pollution, and reduced air and water quality, affecting human health.

In this context, strategic spatial planning and effective environmental policies help to reduce the negative impacts of urban population growth. The deliberate development of parks and green open spaces helps improve the quality of the environment. Simultaneously, the enforcement of environmental policies focused on reducing emissions and pollution plays a crucial role in preserving good air and water quality.

The productivity of green development receives a significant improvement through the allocation of funds for research and development (Feng & Chen 2018; Guild, 2020). The results focused on the essential role of research and development funds in promoting sustainable development. Allocating these financial resources in the field of green development led to the opportunity to stimulate increased productivity. This investment can to the creation of innovative and environmentally friendly technologies, thereby enhancing the efficiency and quality of green development. Furthermore, research and development efforts contribute to a deeper understanding of optimal practices for developing and maintaining a green environment, comprising eco-friendly water and waste management methods, effective greening methods, and environmentally sustainable architectural designs.

The allocation of funds for research and development also strengthens the capacity of institutions and professionals in green development. By increasing this capacity, there is a simultaneous enhancement in the effectiveness and efficiency of efforts focused on its development and maintenance. The government and private institutions need to allocate dedicated funds for research and development in green development in order to achieve success. Such allocation will increase the progress of green development productivity and also improve the quality of life and reinforcement of environmental sustainability.

The mining and agricultural sectors positively contributed to green development productivity, although this is contrary to the research conducted by Gao et al. (2019). This present research focused on the essential role of these sectors in green development, stating that the impacts depend on how these sectors are managed and regulated. Specifically, in agriculture, increased productivity can be achieved through sustainable practices. These include minimizing the use of pesticides and hazardous chemicals, adopting efficient irrigation systems, applying environmentally sound tillage methods, and promoting crop diversification and biodiversity. However, unsustainable agricultural practices, such as monoculture and excessive use of chemicals, can damage the environment and reduce the productivity of green development.

The mining sector can provide natural resources needed for green development, such as minerals and materials for eco-friendly technologies and infrastructure. However, the potential harm from unsustainable mining practices to the environment, human health, and biodiversity is a significant concern. To reduce these risks, there is a pressing need for well-structured arrangements and regulations. This entails promoting sustainable practices in both agriculture and mining, enforcing restrictions and controls to prevent adverse environmental impacts, and fostering the development of environmentally sound technologies and innovations.

Conclusions

In conclusion, the decentralization of environmental policies and competition among local governments had a significantly negative impact on the productivity of green development. It was followed by urbanization, particularly when the rates got higher, resulting in a gradual decline. Meanwhile, a positive relationship was identified between the research and development budget and the productivity of green development. Finally, economic sectors such as agriculture and mining were found to have significantly positive effects on the productivity of green development.

The increase in fiscal policy decentralization and local government competition was reported to require careful moderation, coupled with gradual assistance from the central government. Several implications were considered, including the need to reduce the impact of unilateral policymaking, meaning that the central government was informed about the diverse efforts made by local governments, while deciding on the implementation of specific initiatives. Additionally, the central government had to address the disbursement of funds for research and development to prevent a dilemma resulting in decreased productivity. Finally, arrangements for urban maturity and its development were carried out for prospective new growth centers to prevent population increases from interfering with the productivity of green development.

This research faced limitations due to the use of spatial aspect analysis, preventing the interpretation of spillover impacts between regions. To overcome this, future research was suggested to direct attention towards spatial aspects, allowing for the improvement and further investigation of potential information connections.

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