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The influence of infrastructure on economic growth in indonesia 2016-2022

Muhammad Ibnu Aziz[1], Nur Hidayah[2]

[1,2]Department of Development Economics, Universitas Muhammadiyah Surakarta, Indonesia

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ABSTRACT

This study investigates the influence of infrastructure on economic growth in Indonesia from 2016 to 2022, offering a novel contribution by simultaneously analyzing multiple infrastructure dimensions road length, electricity distribution, clean water availability, and the number of educational institutions across all 34 provinces over seven years. The research addresses the ongoing issue of regional economic disparities despite sustained infrastructure investments. Using a quantitative approach, the study employs secondary data from the Central Bureau of Statistics (BPS) and applies panel data regression with the Fixed Effect Model (FEM) as the most suitable estimation method based on model selection criteria. The variables analyzed include road length (Km), electricity distributed (GWh), clean water distribution (L/sec), and the number of senior high schools (units), with Gross Regional Domestic Product (GRDP) at current market prices as the dependent variable. The empirical results indicate that electricity distribution, clean water access, and the number of senior high schools have a significant positive effect on GRDP, highlighting their role in enhancing productivity and economic performance. Conversely, road length exhibits a significant negative effect, suggesting a tested reverse hypothesis: that road expansion, in some regions, may not translate into economic gains due to inefficiencies in allocation or lack of alignment with local economic needs. These findings underscore the importance of strategic, need-based infrastructure planning to foster equitable and sustainable economic growth in Indonesia.

Corresponding Author:

Muhammad Ibnu Aziz,
Department of Development Economics,
Universitas Muhammadiyah Surakarta,
A. Yani, Pabelan, Kartasura, Sukoharjo, Central Java 57169 Indonesia.
Email: b300210076@student.ums.ac.id

1. INTRODUCTION

The neoclassical economic growth theory proposed by Solow emphasizes that capital accumulation, labor growth, and technological progress are the primary determinants of long-term economic growth (Solow 1956, as cited in Todaro and Smith 2020). Within this framework, physical infrastructure such as roads, electricity, clean water, and education serve as essential means to enhance efficiency and productivity in economic activities (Muara 2022; Gati 2023; Nugraha 2023). Adequate infrastructure reduces transaction costs and improves market access, ultimately accelerating sustainable economic growth (Husein and Aisyah 2022).

However, disparities in infrastructure development across regions in Indonesia remain a major challenge. Data from the Central Bureau of Statistics (BPS) reveal significant imbalances in the distribution of educational infrastructure in 2022, as shown in the following table.

Table 1. Educational Infrastructure Disparities in Indonesia in 2022

Region	Total (%)
Java Island	38%
Sumatra Island	29%
Sulawesi Island	11%
Kalimantan Island	8%
Nusa Tenggara and Bali Islands	8%
Maluku Islands	3%
Papua Island	3%

Source: Central Bureau of Statistics (BPS), processed.

The dominance of infrastructure in Java and Sumatra indicates unequal development that may result in variations in educational service quality and human capital development in other regions, such as Maluku and Papua (Rijal, 2023). These disparities risk widening regional economic gaps and hindering inclusive and equitable growth(Fitri 2024).

Previous studies have shown mixed results regarding the impact of infrastructure on economic growth. Manthofi & Aisyah (2024) found that in Pematangsiantar City, only water infrastructure had a significant effect, while roads and electricity did not. Rijal et al., (2023) revealed that infrastructure in roads, electricity, education, and health had no significant effect on economic growth in East Java. On the other hand, Irawanet al., 2012 in Joeliaty (2024) demonstrated that road infrastructure had a positive and significant contribution in Bali Province. These differences suggest that the impact of infrastructure is context-dependent and varies across regions (Romhadhoni 2019).

At the international level, Yuliadi (2023) found that electricity and transport infrastructure significantly increased economic growth in 46 African countries. Similarly, Bustomi (2022) reported positive results in Northern Malaysia. In contrast, Syahputra & Damanik (2021) identified long-term negative effects of infrastructure investment on economic growth in Bangladesh, although Foreign Direct Investment (FDI) still had a positive impact. In Indonesia, (Hutauruk (2021) found that telecommunications infrastructure positively influenced economic growth through reduced unemployment and inequality.

Most previous studies tend to be partial, focusing on one or two types of infrastructure in local contexts without accounting for inter-regional variation on a national scale. This research addresses that gap by adopting a comprehensive approach that combines four key infrastructure sectors: roads, electricity, water, and education. Unlike prior studies, this study presents a quantitative regional-based analysis to examine the simultaneous and specific influence of each infrastructure type on economic growth. Theoretically, this research extends the application of the Solow growth model in a multi-sector infrastructure context in developing countries. Empirically, the findings are expected to provide evidence-based insights for formulating more inclusive infrastructure development policies.

2. RESEARCH METHOD

This study employs a quantitative approach utilizing secondary panel data obtained from the official publications and digital databases of the Central Bureau of Statistics (BPS). The dataset includes Gross Regional Domestic Product (GRDP) at current market prices, total road length, electricity distribution, clean water access, and the number of senior high schools (SMA) across 34 Indonesian provinces over the period 2016–2022. The selected timeframe ensures data completeness and comparability across provinces.

To prepare the data for analysis, all independent variables underwent a linear transformation aimed at addressing potential issues of non-normality and heteroskedasticity, while also facilitating more meaningful interpretation of regression coefficients. This transformation supports elasticity-based interpretation in line with (Sawitri 2023).

Model specification and estimation were conducted through panel data regression analysis using EViews software. Three estimation methods were tested: Pooled Ordinary Least Squares (Pooled OLS), Fixed Effects Model (FEM), and Random Effects Model (REM). Model selection was determined based on the results of the Chow and Hausman tests. To ensure the robustness of the chosen model, diagnostic tests were performed, including assessments for multicollinearity via correlation matrix, which revealed strong intercorrelations among infrastructure variables such as electricity distribution, clean water access, and education. Consequently, interpretation was carried out with caution. Heteroskedasticity was evaluated through residual plot inspection, which indicated homoskedastic variance as residuals displayed random fluctuations without systematic patterns (Suprapto et al. 2024). Due to the nature of the data, autocorrelation testing was not conducted.

The regression results were subsequently interpreted in the context of regional disparities in Indonesia, focusing on how differences in infrastructure and public service provision affect regional economic performance as measured by GRDP. These insights informed the formulation of policy recommendations aimed at promoting more equitable regional growth.

Table 2. Operational Definition of Variables

Variable	Data Type	Unit	Source
GRDP	Gross Regional Domestic Product at Current Prices by Province	billion IDR	Central Bureau of Statistics (BPS)
Road Length	Road Length by Province	Km	Central Bureau of Statistics (BPS)
Electricity	Electricity Distribution by Province in Indonesia	GWh	Central Bureau of Statistics (BPS)
Clean Water	Clean Water Distribution by Province in Indonesia	L/sec	Central Bureau of Statistics (BPS)
Education	Number of Senior High Schools (SMA) by Province in Indonesia	Units	Central Bureau of Statistics (BPS)

Each variable reflects a key infrastructure or service that supports regional economic activity. The selection of variables is grounded in endogenous growth theory, which posits that infrastructure and human capital (proxied by schools) stimulate productivity and output growth (Barro & Sala-i-Martin, 2004). Unlike previous studies that may focus on labor, investment, or exports, this study emphasizes public infrastructure and services as key regional growth drivers.

The equation in this research model can be written as follows (Solihatun, 2024):

$$GRDP_{it}{=}\beta_0 + \beta_1 \text{in}RL_{it} + \beta_2 \text{in}Elec_{it} + \beta_3 \text{in}W_{it} + \beta_4 \text{in}EDUC_{it} + e_{it}$$

Information:

GRDP	= Gross Regional Domestic Product at current market prices (billion Rupiah)
In RL	= Total road length (Km)
In Elec	= Electricity distributed per province (GWh)
In W	= Water distribution per province (L/second)
In EDUC	= Number of senior high schools (or equivalent) (Units)
i	= Number of provinces in Indonesia
t	= Time period from 2016 to 2022
e_{it}	= *error term*

3. RESULTS AND DISCUSSIONS

This research presents an analysis and discussion of the determinants affecting the Gross Regional Domestic Product (GRDP) through the application of panel data regression. The results derived from processing the data using this regression technique revealed the following key findings.

Table 3. Panel Data Regression Results

Variable	CEM		FEM		REM	
	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C	-14422,9	0,0000	-43034,6	0,0054	-11798,5	0,0375
In RL	152,4029	0,0000	-163,8185	0,0007	76,1476	0,0030
In Elec	33,4337	0,0000	13,0626	0,0006	22,2615	0,0000
In W	25,3360	0,0000	33,5853	0,0000	36,7485	0,0000
In EDUC	-182,192	0,0033	2039,60	0,0000	96,4269	0,4199
R-Square	0,921338		0,989224		0,652753	
F-statistic	682,2572		496,2014		109,4981	
Prob. F-statistic	0,0000		0,0000		0,0000	
DW-Stat	0,16615		0,78491		0,68376	

Source: Eviews output, processed

Based on the Fixed Effect Model (FEM) regression results, all independent variables show statistically significant effects on the Gross Regional Domestic Product (GRDP), with p-values below 0.01. The variable representing road length (In RL) has a negative coefficient of -163.8185, suggesting that a 1% increase in road length is associated with a decrease in GRDP by approximately 163.82 billion Rupiah, holding other factors constant. This counterintuitive result may indicate inefficiencies in infrastructure development or expansion occurring in less productive regions. In contrast, variables such as electricity distribution (In Elec), water distribution (In W), and the number of senior high schools (In EDUC) all show positive and significant coefficients, highlighting their contribution to regional economic growth.

Specifically, electricity distribution has a coefficient of 13.0626, meaning a 1% increase in electricity usage is associated with a rise in GRDP by approximately 13.06 billion Rupiah. Water distribution has an even greater impact, with a coefficient of 33.5853, suggesting its vital role in supporting both households and industries. The most substantial effect comes from the number of senior high schools, with a coefficient of 2039.60, indicating that education plays a critical role in enhancing human capital, which in turn boosts regional economic productivity.

These findings imply that improvements in basic infrastructure particularly access to electricity, clean water, and quality education are key drivers of GRDP growth at the provincial level. Policymakers should prioritize investments in these sectors to foster inclusive and sustainable economic development. Additionally, the negative impact of road length on GRDP warrants further investigation, as it may reflect underlying issues such as misallocation of infrastructure funds or inadequate utilization of transport networks.

To further contextualize the findings, the following matrix compares this study's results with previous literature:

Table 4. Comparison of Empirical Findings with Prior Studies

Variable	This Study (FEM)	Expected Theory	Prior Studies	Alignment
Road Length (In RL)	Negative, significant	Positive	Aschauer (1989); Calderón & Servén (2010)	✕□
Electricity (In Elec)	Positive, significant	Positive	Sahoo et al. (2012)	✓□
Water distribution (In W)	Positive, significant	Positive	Duflo & Pande (2007)	✓□
Senior High Schools (In EDUC)	Positive, significant	Positive	López et al. (2008)	✓□

The discrepancy observed in road infrastructure calls for more nuanced policy recommendations. Investment in infrastructure should not only focus on quantity (e.g., total road length) but also consider quality, connectivity, and actual economic utilization. Monitoring mechanisms, performance audits, and better integration of infrastructure planning with local industrial priorities are essential.

3.1 Selection of the Best Estimation Model

Based on the results in the table above, testing is needed to determine the best estimation model. The following are the results of the model testing that has been carried out.

a. Chow Test

Table 5. Chow Test

Effect Test	Statistic	d.f	Prob.
Cross-section F	38. 179672	(32,200)	0.0000
Cross-section Chi-Square	473. 102552	33	0.0000

Source: Eviews Output

The Chow test is used to determine whether the Fixed Effect Model (FEM) is more suitable than the Common Effect Model (CEM). The null hypothesis in this test assumes that the CEM is sufficient, implying that individual heterogeneity across cross-sections (provinces) is not significant. However, if the null is rejected, it suggests that cross-sectional effects are present and that FEM should be preferred.

In Table 3, the F-statistic value is 38.179672 with a p-value of 0.0000, which is well below the 5% significance threshold ($\alpha = 0.05$). This strongly indicates that the cross-sectional units have significantly different intercepts, meaning each province in the panel dataset has unique characteristics that affect GRDP, and treating them as identical (as in CEM) would result in biased estimates.

Therefore, the results of the Chow test lead us to reject the null hypothesis. It can be concluded that the Fixed Effect Model (FEM) provides a better fit than the Common Effect Model, as it captures unobserved heterogeneity across provinces that might otherwise distort the model's validity. Hence, proceeding with FEM is statistically justified.

b. Hausman Test

Table 6. Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	70. 180373	4	0.0000

Source: Eviews Output

The Hausman test is employed to choose between the Fixed Effect Model (FEM) and the Random Effect Model (REM). The null hypothesis assumes that the REM is appropriate, under the condition that the regressors are uncorrelated with the individual effects. If the null is rejected, it implies that there is correlation between the regressors and the individual effects, and the FEM should be preferred for more consistent estimates.

In Table 6, the test result shows a Chi-square statistic of 70.180373 with 4 degrees of freedom and a p-value of 0.0000, which is far below the significance level of $\alpha = 0.05$. This indicates strong evidence to reject the null hypothesis and confirms that the unique errors (individual effects) are indeed correlated with the regressors in the model.

Consequently, the Fixed Effect Model (FEM) is deemed more appropriate than the Random Effect Model (REM). The FEM accounts for the correlation between independent variables and province-specific effects, ensuring unbiased and consistent parameter estimates. With both the

Chow and Hausman tests pointing toward FEM, it becomes the most statistically sound model to use in this study.

Table 7. Fixed Effect Model (FEM)

$$GRDP_t = -430348{,}6 - 163{,}81\ InRL_t + 13{,}06\ InElec_t + 33{,}58 InW_t + 2039{,}60 InEDUC_t$$

(0,0007) (0,0006) (0,0000) (0,0000)

R2 =0,9892; DW = 0,7849; F = 496,2014 Prob. F = 0,0000

Source: Table 2. Description: significance at α = 0.05

The Fixed Effect Model (FEM) regression output presents the final estimated equation for Gross Regional Domestic Product (GRDP) as influenced by infrastructure and education-related variables. All variables are expressed in natural logarithm form. The model includes the total road length (InRL), electricity distribution (InElec), water distribution (InW), and the number of senior high schools (InEDUC).

The estimation results show that InRL has a negative and significant coefficient of -163.81 (p = 0.0007), indicating that a 1% increase in road length is associated with a decrease in GRDP by approximately 163.81 billion Rupiah, holding other variables constant. This counterintuitive finding might reflect inefficient infrastructure expansion or allocation in economically weaker regions. Meanwhile, the other three variables InElec (13.06), InW (33.58), and InEDUC (2039.60)—all exhibit positive and statistically significant coefficients, suggesting that increases in electricity distribution, water availability, and educational facilities significantly contribute to GRDP growth.

These results underline the importance of basic infrastructure and education in driving regional economic development. The especially large coefficient on InEDUC suggests that investment in secondary education has a substantial impact on economic output, possibly by enhancing workforce skills and productivity. This highlights the role of human capital in economic planning. On the other hand, the negative impact of road length deserves further investigation possibly into regional utilization patterns or project efficiency.

3.2 Classical Assumption Testing

a. Multicollinearity Test

Table 8. Multicollinearity Test Results

	In RL	In Elec	In W	In EDUC
In RL	1.000000	0.461769	0.398740	0.353159
In Elec	0.461769	1.000000	0.849514	0.824173
In W	0.398740	0.849514	1.000000	0.803346
In EDUC	0.353159	0.824173	0.803346	1.000000

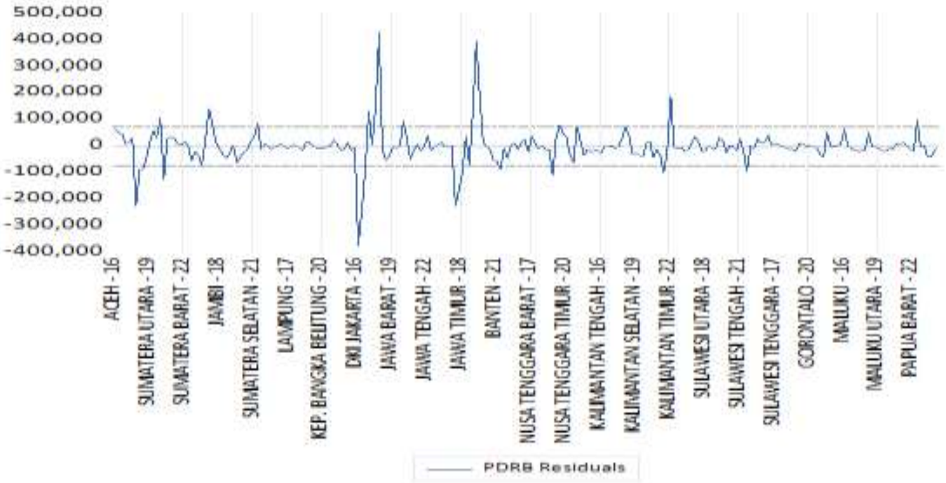
Source: Eviews Output

The multicollinearity test aims to assess whether there is a strong correlation between the independent variables used in the regression model. Multicollinearity occurs when two or more independent variables are highly correlated, which can distort the estimated coefficients and undermine the reliability of the regression analysis. A commonly used threshold is a correlation coefficient of 0.85 or above values exceeding this threshold suggest potential multicollinearity problems.

In Table 6, all correlation coefficients among the independent variables (In RL, In Elec, In W, and In EDUC) are below the critical value of 0.85, indicating that there is no strong linear relationship between any pair of variables. Specifically, the highest correlation value observed is between In Elec and In W (0.849514), which, although close to the threshold, still remains within an acceptable range. The other coefficients, such as between In RL and In Elec (0.461769) or between In RL and In EDUC (0.353159), are much lower, further confirming that multicollinearity is not a concern in this model.

Therefore, it can be concluded that the independent variables in this regression model are free from multicollinearity, and the model passes the multicollinearity test. This ensures that the regression coefficients can be interpreted with confidence, as they are not inflated or biased due to overlapping information between predictors. As a result, the Fixed Effect Model's estimations remain statistically robust and reliable for inference.

b. Heteroscedasticity Test



Graph 1. Results of Heteroscedasticity test

From the residual graph (blue color) it can be seen that it does not cross the limit (500 and -500), meaning that the residual variance is the same. Therefore, there is no symptom of heteroscedasticity or it passes the heteroscedasticity test (Napitupulu et al., 2021: 143.

c. Partial Significance Test (t-Test)

The t-statistic test is employed to determine whether the relationship between the independent and dependent variables is statistically significant. The outcomes of the partial t-test in this research are described as follows:

Table 9. Results of the t-Test

Variable	Sig. t	Criteria	Conclusion
In RL	0,0007	< 0,05	Significantly Influential
In Elec	0,0006	< 0,05	Significantly Influential
In W	0,0000	< 0,05	Significantly Influential
In EDUC	0,0000	< 0,05	Significantly Influential

Source: Eviews output, processed

The t-test results in Table 9 provide strong empirical evidence regarding the influence of infrastructure variables on Gross Regional Domestic Product (GRDP) in Indonesia. All four independent variables road length (In RL), electricity distribution (In Elec), water distribution (In W), and the number of senior high schools (In EDUC) exhibit significance values below the 0.05 threshold. This confirms that each variable individually and significantly contributes to regional economic output, thereby directly supporting the research objective of identifying key infrastructure determinants of GRDP.

Specifically, road infrastructure (In RL) with a p-value of 0.0007 highlights the importance of transportation networks in facilitating trade, labor movement, and access to markets, which collectively enhance economic performance. Similarly, electricity distribution (In Elec) with a p-value of 0.0006 underscores the critical role of energy availability in powering industrial activities, services, and household consumption. Water infrastructure (In W), with the most significant p-value of 0.0000, plays a vital role in supporting agriculture, manufacturing, and basic human needs all of which are essential for economic growth.

Furthermore, the number of senior high schools (In EDUC), which also shows a highly significant p-value (0.0000), reinforces the importance of human capital development in driving regional productivity. Education infrastructure prepares a skilled workforce, boosts innovation, and enhances competitiveness. Collectively, these findings address the core research problem by confirming that both physical and social infrastructure are critical levers for improving regional economic performance in Indonesia.

d. Simultaneous Significance Test (F-Test)

The F-test is conducted to evaluate whether the independent variables collectively influence the dependent variable. The results based on the table 3 show a Prob. F-stat value of 0.0000, which is lower than the significance level ($\alpha = 0.05$). This indicates that the variables Infrastructure RL (total road length in kilometers), Infrastructure Elec (electricity distributed per province in GWh), Infrastructure W (water distribution per province in liters per second), and Infrastructure EDUC (number of senior high schools or equivalent units) simultaneously have a significant effect on GRDP (Gross Regional Domestic Product at current market prices, in billion Rupiah) across 34 provinces in Indonesia.

e. Coefficient of Determination (R^2)

The R-squared value measures the proportion of the variation in the dependent variable that can be explained by the independent variables. The regression results based on table 3 show an R-squared of 0.989224, or 98.92%. This means that factors such as total road length, electricity distribution, water supply, and the number of senior high schools collectively explain 98.92% of the changes in the Gross Regional Domestic Product (GRDP) at current market prices across the provinces. The remaining 1.08% of the variation is attributed to other factors not included in the model.

3.3 The Relationship Between RL Infrastructure and Gross Regional Domestic Product

The total length of roads shows a regression coefficient of -163.8185 with a probability value of 0.0007, which is less than the significance level of 0.05. This indicates that the length of roads has a significant negative impact on the Gross Regional Domestic Product (GRDP) in Indonesia. Specifically, an increase of one kilometer in road length is associated with a decrease in GRDP by approximately 163.81 billion rupiah. This negative relationship suggests that expanding road infrastructure does not necessarily lead to economic growth and may even reduce regional economic output. One possible explanation is that road development may not be targeted toward regions with strong economic potential, thereby limiting its effectiveness in boosting local economic activities. To address this, improving road infrastructure should be paired with efforts to revitalize and stimulate the economies surrounding these roads to enhance economic circulation.

Providing road infrastructure not only lowers physical barriers by facilitating the movement of people, goods, and services but also enhances access to markets, social services, and employment by cutting down transportation time and costs. The development of high-mobility roads, such as toll roads, can accelerate transportation, improving both domestic and international trade efficiency by reducing travel time and expenses. Meanwhile, expanding accessible local roads encourages commercial and social activities at the community level by easing access to land (Nurlestari and Oktavilia 2023).

3.4 Relationship between Electricity Infrastructure and Gross Regional Domestic Product (GRDP)

Electricity infrastructure has a regression coefficient of 13.06 and a probability value of 0.0006, which is below the significance level of 0.05. This indicates that electricity infrastructure has a positive and statistically significant effect on the Gross Regional Domestic Product (GRDP) in Indonesia. Specifically, an increase of 1 gigawatt-hour (GWh) in electricity distribution corresponds to an increase of 13.06 billion rupiahs in GRDP. This strong relationship exists because electricity is a fundamental necessity for daily life, both for households and industrial activities. Electricity consumption is often directly linked to a country's economic growth. With global economic expansion and rising income per capita, the demand for electrical devices has surged. Even in rural areas, there is a strong desire for connection to the electrical grid, access to major transportation routes, and ownership of energy-powered goods like appliances and vehicles. These factors are also reflected in small to large manufacturing industries, which rely heavily on electrical energy and significantly contribute to the region's economic output.

Similarly, road infrastructure, water distribution, and the availability of senior high schools also play important roles in influencing GRDP. Road length facilitates transportation and connectivity, water supply supports both households and industries, and the number of educational institutions contributes to human capital development. Research by Haryanto (2021) and Nasir (2025) confirms that electricity infrastructure positively and significantly impacts regional economic performance. In today's modern era, reliable electricity supply is essential for sustaining economic growth across urban and rural areas, with increasing demand as social development progresses.

3.5 Relationship between Water Infrastructure and Gross Regional Domestic Product (GRDP)

Water infrastructure has a regression coefficient of 33.58 with a probability value of 0.0000, which is below the significance level of 0.05. This indicates that water infrastructure has a positive and statistically significant effect on the Gross Regional Domestic Product (GRDP) in Indonesia. Specifically, an increase of one liter per second in water distribution is associated with an increase of 33.58 billion rupiahs in GRDP.

Water infrastructure is essential for development, particularly in advancing human resources. Significant improvements in human resource development contribute to economic progress measured by GRDP. Access to adequate clean water and sanitation facilities supports better health and well-being, enabling communities to maximize their potential. This, in turn, fosters the growth of skilled and productive human capital. According to research by Sebayang (2020) and Kresna et al. (2022), water infrastructure positively influences economic growth because water is a fundamental requirement for daily human activities. The availability of quality water enhances overall human life and supports economic advancement.

3.6 The Relationship Between EDUC Infrastructure and Gross Regional Domestic Product

The education infrastructure variable shows a regression coefficient of 2039.601 with a probability value of 0.0000, which is below the significance level of 0.05. This indicates that education infrastructure has a positive and statistically significant impact on the Gross Regional Domestic Product (GRDP) in Indonesia. Specifically, an increase of one unit in education infrastructure measured by the number of senior high schools or equivalent facilities corresponds to an increase of approximately 2039 billion rupiah in GRDP.

Education infrastructure includes essential facilities that support the teaching and learning process, such as school buildings, libraries, laboratories, and access to educational resources. This infrastructure plays a vital role in boosting economic growth by enhancing the quality of human capital, which subsequently raises labor productivity and encourages innovation. Workers with higher education and better skills tend to be more efficient and capable of producing greater output in less time, contributing significantly to a region's economic advancement.

Supporting these findings, Afifah et al. (2024), Farza, (2018) and Pratama et al. (2025) also concluded that education infrastructure positively and significantly affects GRDP. This emphasizes the importance of developing educational facilities to cultivate a productive workforce with adequate competencies, knowledge, and skills. Such a well-educated and skilled labor force is a key driver in expanding production capacity, which ultimately leads to economic growth.

4. CONCLUSION

This study reveals that infrastructure variables road length, electricity distribution, water supply, and educational facilities significantly influence regional economic output, yet their impacts vary in direction and magnitude, reflecting complex spatial and temporal dynamics across Indonesia's diverse provinces. The negative coefficient on road length suggests that infrastructure development may have been unevenly distributed or inefficiently targeted, highlighting the need to consider regional economic potential and connectivity when planning road investments. Meanwhile, positive effects of electricity, water, and education underscore the critical role of both physical and human capital infrastructure in fostering sustainable economic growth, aligning with endogenous growth theories emphasizing productive capacity and knowledge accumulation. However, this research is limited by its focus on aggregate provincial-level data over a specific period, which may obscure localized temporal fluctuations and spatial spillovers among regions. Future studies should incorporate more granular spatial econometric methods and longer time horizons to capture interregional interdependencies and evolving infrastructure impacts, thereby providing richer insights for policymakers aiming to reduce regional disparities and promote inclusive development across Indonesia.

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