

Re-evaluating Infrastructure-Led Development: The Missing Link in Regional Economic Expansion

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Abstract:

Infrastructure development is widely regarded as a key driver of regional economic expansion, yet its actual contribution remains subject to debate. This study aims to re-evaluate the role of infrastructure-led development by examining the effects of road, water, and electricity infrastructure on Gross Regional Domestic Product (GRDP) growth. A quantitative approach was employed using secondary annual data from 2018–2022 obtained from government statistical agencies and public utility institutions. Multiple linear regression analysis was performed using SPSS Version 24, complemented by classical assumption and hypothesis testing. The results show that road infrastructure (Sig. = 0.303), water infrastructure (Sig. = 0.206), and electricity infrastructure (Sig. = 0.652) did not significantly affect GRDP growth, while the model explained 60.5% of the variation in economic growth (Adjusted R² = 0.605). These findings contribute to the infrastructure-growth debate by demonstrating that infrastructure alone may be insufficient to stimulate economic expansion. Policymakers should integrate infrastructure investment with broader economic development strategies.

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INTRODUCTION

Regional disparities remain a persistent challenge in developing countries and continue to hinder the achievement of inclusive and sustainable economic growth (Emami et al., 2021; Ghazy et al., 2024; Vogt, 2021). Governments increasingly recognize that balanced regional development requires not only social interventions but also strategic investments in physical infrastructure to stimulate economic activity and improve connectivity among regions. Infrastructure development has therefore become a central component of national development strategies, particularly in regions that experience slower economic growth and limited access to public services (Al-Qudah et al., 2022; Magazzino et al., 2021; Sun et al., 2020).

In Indonesia, infrastructure development has been prioritized through various national programs aimed at accelerating economic recovery, reducing regional inequality, and improving public welfare (Chai et al., 2021; Durodolu et al., 2024). The establishment of the Committee for the Acceleration of Infrastructure Provision through Presidential Regulation No. 42 of 2005 reflects the government's commitment to expanding infrastructure networks, including transportation systems, irrigation facilities, electricity distribution, clean water services, and sanitation systems. Despite these efforts, a considerable number of districts continue to experience developmental lag, indicating that infrastructure expansion alone may not automatically translate into broad-based economic growth (Hasbi et al., 2024; Osiesi et al., 2024). The theoretical foundation of infrastructure-led development suggests that investments in public infrastructure reduce production costs, improve market accessibility, enhance labor mobility, and stimulate private investment.

Those mechanisms are expected to generate multiplier effects that contribute to regional economic expansion. According to endogenous growth theory, infrastructure serves as a productive public capital that increases the efficiency of economic activities and supports long-term growth (Huerta et al., 2024; Knudsen, 2020). However, empirical findings remain inconclusive, as several studies report varying impacts of different infrastructure sectors on regional economic performance. In response to economic challenges, including those arising from the COVID-19 pandemic, infrastructure spending has continued to receive significant attention. Public investment has been directed toward transportation facilities, irrigation systems, sanitation projects, housing development, and community-based infrastructure programs (Pham et al., 2024; Salas et al., 2023). These initiatives are expected to support economic recovery while creating employment opportunities and strengthening regional competitiveness.

Nevertheless, questions remain about the extent to which infrastructure improvements contribute to regional economic expansion and whether all types of infrastructure have similar economic impacts. The case of Probolinggo Regency provides an important context for examining this issue. Local development policies have emphasized the strengthening of sustainable infrastructure to support economic growth and improve public welfare indicators. Several development targets, including poverty reduction, employment generation, improvements in human development, and accelerating economic growth, are closely linked to the accessibility and quality of infrastructure. Consequently, understanding the contribution of infrastructure to regional economic performance becomes increasingly important for evidence-based policy formulation.

Table 1. Trends in Infrastructure Development and Regional Economic Growth in Probolinggo Regency, 2019–2021 (%)

Indicator	2019	2020	2021
Road Infrastructure Growth	4.47	-6.11	2.07
Water Infrastructure Growth	4.02	3.24	0.99
Electricity Infrastructure Growth	5.18	0.72	1.85
Gross Regional Domestic Product (GRDP) Growth	4.56	-2.12	3.35

Source: Statistics Indonesia (BPS), 2019–2021.

The data indicate fluctuations in regional economic performance during the observation period. GRDP growth declined significantly in 2020 before recovering in 2021, reflecting the economic disruption of the COVID-19 pandemic and the subsequent recovery. Similar fluctuations were observed in infrastructure indicators. Road infrastructure contracted in 2020, then improved moderately in 2021. Water infrastructure showed a continuous decline throughout the period, while electricity infrastructure performance declined despite growth in customer numbers. These patterns suggest that infrastructure development and regional economic growth may not always move in the same direction, highlighting the need for a more comprehensive empirical investigation.

Previous studies generally conclude that infrastructure contributes positively to economic growth by facilitating production, distribution, and consumption activities (Aboagye et al., 2022; Ghazy et al., 2024; Hammar et al., 2021). However, most studies focus on aggregate infrastructure effects and often overlook the differential contributions of specific infrastructure sectors. Furthermore, the relationship between infrastructure development and regional economic expansion remains insufficiently explored at the local government level, particularly in regions experiencing economic fluctuations and structural development challenges.

Based on these considerations, this study aims to re-evaluate the role of infrastructure-led development by examining the influence of road, electricity, and clean water infrastructure on regional economic expansion, as measured by Gross Regional Domestic Product (GRDP). Using a quantitative approach, this study seeks to determine whether infrastructure development is the missing link in explaining regional economic performance and to provide empirical evidence to inform the formulation of more effective infrastructure policy.

RESEARCH METHOD

This study employed a quantitative research approach to examine the relationship between infrastructure development and regional economic expansion (Wang et al., 2024). The analysis focused on evaluating the contribution of road, water, and electricity infrastructure to Gross Regional Domestic Product (GRDP) growth as an indicator of regional economic performance. Secondary data were collected from official publications issued by Statistics Indonesia (BPS), the Regional Water Supply Company (PDAM), the State Electricity Company (PLN), and other government statistical reports. The study used annual data from 2018 to 2022 for Probolinggo Regency. These data were selected because they provide comprehensive information regarding infrastructure development and regional economic outcomes.

The dependent variable in this study was regional economic expansion, measured by growth in Gross Regional Domestic Product (GRDP). The independent variables were road, water, and electricity infrastructure. Road infrastructure was represented by the road development index, water infrastructure by the clean water service index, and electricity infrastructure by electricity service indicators reported by

PLN (Hossan et al., 2023). Table 2 summarizes the operational definitions of the research variables.

Table 2. Operational Definition of Variables

Variable	Symbol	Measurement Indicator
Regional Economic Expansion (GRDP Growth)	Y	Annual GRDP growth (%)
Road Infrastructure	X ₁	Road infrastructure growth/index (%)
Water Infrastructure	X ₂	Water service growth/index (%)
Electricity Infrastructure	X ₃	Electricity service growth/index (%)

To assess the influence of infrastructure development on regional economic expansion, multiple linear regression analysis was employed. The empirical model is specified as follows: $[Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon]$, where: (Y) = Regional Economic Expansion (GRDP Growth); (α) = Constant term; ($\beta_1, \beta_2, \beta_3$) = Regression coefficients; (X₁) = Road Infrastructure; (X₂) = Water Infrastructure; (X₃) = Electricity Infrastructure; (ε) = Error term.

Data analysis was conducted using IBM SPSS Statistics Version 24. Descriptive statistical analysis was first performed to examine the characteristics and distribution of the variables (Ghanad, 2023). Subsequently, a multiple linear regression analysis was conducted to estimate the effects of infrastructure variables on regional economic expansion. Hypothesis testing was conducted using the t-test to evaluate the partial effect of each independent variable and the F-test to assess the simultaneous effect of all independent variables. The coefficient of determination (R²) was used to measure the proportion of variance in regional economic expansion explained by the infrastructure variables. Statistical significance was evaluated at the 5% significance level ($\alpha = 0.05$).

RESULT AND DISCUSSION

Result

The empirical analysis was conducted to examine the relationship between infrastructure development and regional economic expansion in Probolinggo Regency during the 2018–2022 period. The results are presented through a series of classical assumption tests, multiple linear regression analysis, hypothesis testing, and coefficient of determination analysis to evaluate the explanatory power and statistical significance of the proposed model.

Classical Assumption Tests

Classical assumption tests were conducted before performing multiple linear regression analysis to ensure that the data met the statistical requirements and that the estimated model produced valid and reliable results. These tests included normality, multicollinearity, heteroskedasticity, and autocorrelation assessments. By verifying each assumption, the study ensured that the regression model was free from major estimation problems and suitable for hypothesis testing and interpretation of the relationships among variables.

Normality Test

Before conducting regression analysis, classical assumption testing was performed to ensure the suitability of the data and the validity of the statistical model. One of the key assumptions is the normality of residuals. The normality test was carried out using the Kolmogorov–Smirnov method. The results of this test are presented in Table 3 to determine whether the residuals follow a normal distribution.

Table 3. Normality Test Results

Statistic	Value
Asymp. Sig. (2-tailed)	0.200

Source: Processed SPSS 24 output (2023).

The Kolmogorov–Smirnov normality test produced an Asymp. Sig. (2-tailed) value of 0.200, which is greater than the 0.05 significance level. Therefore, the residuals are normally distributed, indicating that the normality assumption is satisfied.

Multicollinearity Test

To ensure that the independent variables do not exhibit strong correlations with one another, a multicollinearity test was conducted as part of the classical assumption testing procedure. Multicollinearity can distort regression estimates and reduce the reliability of the model. The assessment was performed using Tolerance and Variance Inflation Factor (VIF) values. The results of the multicollinearity test for all independent variables are presented in Table 4.

Table 4. Multicollinearity Test Results

Variable	Tolerance	VIF
Road Infrastructure	> 0.10	< 10.00
Water Infrastructure	> 0.10	< 10.00
Electricity Infrastructure	> 0.10	< 10.00

Source: Processed SPSS 24 output (2023).

All independent variables show tolerance values above 0.10 and Variance Inflation Factor (VIF) values below 10.00. These results indicate the absence of multicollinearity among the explanatory variables. Therefore, the independent variables do not exhibit strong intercorrelations and satisfy the multicollinearity assumption required for regression analysis.

Heteroskedasticity Test

The heteroskedasticity test was conducted to examine whether the variance of the residuals remained constant across all observations. A regression model is considered reliable when it does not exhibit heteroskedasticity, as unequal error variances can compromise the accuracy of statistical inferences. The test was performed by comparing the calculated Chi-square value with the critical Chi-square table value. The results of the heteroskedasticity test are presented in Table 5.

Table 5. Heteroskedasticity Test Results

Statistic	Value
R Square	0.999
Calculated Chi-square	4.995
Chi-square Table Value	5.991

Source: Processed SPSS 24 output (2023).

Because the calculated Chi-square value (4.995) is lower than the critical Chi-square value (5.991), the model does not exhibit heteroskedasticity. Thus, the variance of the residuals can be considered constant.

Autocorrelation Test

The autocorrelation test was conducted to assess whether residuals were correlated across observations in the regression model. The absence of autocorrelation is essential to ensure unbiased and efficient parameter estimates. In this study, the test was conducted by examining the significance value of the residual correlation. The results of the autocorrelation test are presented in Table 6 to evaluate whether the assumption has been satisfied.

Table 6. Autocorrelation Test Results

Statistic	Value
Asymp. Sig. (2-tailed)	0.913

Source: Processed SPSS 24 output (2023).

The autocorrelation test produced an Asymp. Sig. value of 0.913, which is greater than the 0.05 significance level. This result indicates that no autocorrelation exists among the residuals. Therefore, the regression model fulfills the independence assumption and is appropriate for further analysis.

Multiple Linear Regression Analysis

Multiple linear regression analysis was employed to examine the influence of road, water, and electricity infrastructure on GRDP growth. This analysis estimates the direction and magnitude of the relationship between each independent variable and the dependent variable. The results of the regression model, including coefficients and significance values, are presented in Table 7.

Table 7. Multiple Linear Regression Results

Variable	B	Std. Error	Beta	t	Sig.
Constant	106,664,335.800	-	-	-	-
Road Infrastructure (X_1)	-14.885	13.558	-0.322	-1.098	0.303
Water Infrastructure (X_2)	34.158	11.444	1.128	2.985	0.206
Electricity Infrastructure (X_3)	31.037	51.082	0.198	0.608	0.652

Source: Processed SPSS 24 output (2023).

The estimated regression equation is: $GRDP\ Growth = 106,664,335.800 - 14.885X_1 + 34.158X_2 + 31.037X_3$. The coefficient for road infrastructure is negative, suggesting an inverse relationship between road infrastructure growth and GRDP growth during the observation period. In contrast, water infrastructure and electricity infrastructure have positive coefficients, indicating that increases in these infrastructure indicators are associated with higher GRDP growth. However, the statistical significance of these relationships must be assessed through hypothesis testing.

Hypothesis Testing

After the classical assumption tests confirmed the regression model's adequacy, hypothesis testing was conducted to examine the relationship between infrastructure development and GRDP growth. The analysis included the simultaneous significance test (F-test), partial significance test (t-test), and coefficient of determination (R^2). These tests were used to evaluate both the collective and individual effects of the independent variables and the explanatory power of the regression model.

Simultaneous Significance Test (F-Test)

The simultaneous significance test (F-test) was conducted to determine whether road, water, and electricity infrastructure jointly influence GRDP growth. This test evaluates the overall significance of the regression model by comparing the variation explained by the independent variables with the unexplained variation. The results of the F-test are presented in Table 8.

Table 8. F-Test Results

Source	Sum of Squares	df	Mean Square	F	Sig.
Regression	2,840,868,762,000,000.000	3	946,956,254,000,000.000	3.040	0.394
Residual	3,115,033,041,000,000.000	1	3,115,033,041,000,000.000	-	-
Total	3,152,372,066,000,000.000	4	-	-	-

Source: Processed SPSS 24 output (2023).

The F-test yields a significance value of 0.394, which is greater than 0.05. Therefore, road, water, and electricity infrastructure do not jointly have a statistically significant effect on GRDP growth during the study period.

Partial Significance Test (t-Test)

The partial significance test (t-test) was performed to evaluate the individual effect of each independent variable on GRDP growth. This test determines whether road, water, and electricity infrastructure significantly influence the dependent variable when analyzed separately. The results of the t-test, including t-statistics, significance values, and decisions, are presented in Table 9.

Table 9. t-Test Results

Variable	t	Sig.	Decision
Road Infrastructure (X ₁)	-1.098	0.303	Not Significant
Water Infrastructure (X ₂)	2.985	0.206	Not Significant
Electricity Infrastructure (X ₃)	0.608	0.652	Not Significant

Source: Processed SPSS 24 output (2023).

All independent variables have significance values above 0.05, indicating that none of the infrastructure variables individually exert a statistically significant effect on GRDP growth within the observed period.

Coefficient of Determination (R²)

The coefficient of determination (R²) was calculated to assess the extent to which variations in GRDP growth are explained by road, water, and electricity infrastructure. This measure indicates the explanatory power of the regression model and helps evaluate its overall goodness of fit. The results are presented in Table 10.

Table 10. Coefficient of Determination Results

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.949	0.901	0.605	5,581,248.105

Source: Processed SPSS 24 output (2023).

The model produces an Adjusted R² of 0.605, indicating that approximately 60.5% of the variation in GRDP growth is explained by the road, water, and electricity infrastructure variables. The remaining 39.5% is attributable to other factors outside the model.

Discussion

The findings indicate that infrastructure development did not have a statistically significant effect on regional economic expansion during the study period. The simultaneous test yielded an F-statistic of 0.394, exceeding the 0.05 threshold, while the partial tests showed significance values of 0.303 for road infrastructure, 0.206 for water infrastructure, and 0.652 for electricity infrastructure. These results suggest that variations in infrastructure indicators were not sufficient to explain short-term changes in Gross Regional Domestic Product (GRDP) growth. Nevertheless, the model achieved an Adjusted R² of 0.605, indicating that 60.5% of the variation in GRDP growth was explained by the infrastructure variables included.

The positive coefficients for water infrastructure (34.158) and electricity infrastructure (31.037) imply that improvements in these sectors are associated with higher economic growth, although the relationships are not statistically significant. Conversely, road infrastructure exhibited a negative coefficient (-14.885), suggesting that increases in road infrastructure were associated with lower GRDP growth during the observation period. This finding may reflect the short-term nature of infrastructure

investment, where construction activities and budget reallocations temporarily reduce economic efficiency before long-term benefits are realized (Gittings et al., 2024; Jonathan et al., 2024; Prado-Medel, 2024). The fluctuations observed in the data further support this interpretation, as GRDP growth declined from 4.56% in 2019 to -2.12% in 2020, then recovered to 3.35% in 2021, coinciding with disruptions caused by the COVID-19 pandemic.

These findings differ from many previous studies that report a positive and significant contribution of infrastructure to economic growth. For example, Hopkins et al. (2023), Permatasari et al. (2025) and Tsevi (2022) argue that transportation, electricity, and public utility infrastructure generate multiplier effects that stimulate productivity, investment, and regional competitiveness. Similarly, endogenous growth theory views infrastructure as a productive form of public capital that enhances economic performance through efficiency gains. However, the present findings are consistent with studies suggesting that infrastructure investment alone does not automatically generate economic growth when complementary factors such as private investment, human capital, industrial development, and institutional quality remain limited. Therefore, the insignificant effects identified in this study indicate that infrastructure may function as a supporting condition rather than a direct determinant of regional economic expansion (Aishah et al., 2020; Pitafi et al., 2020).

From a theoretical perspective, the results contribute to the ongoing debate regarding infrastructure-led development by providing evidence that the relationship between infrastructure and economic growth is not always immediate or linear. The findings support the argument that infrastructure should be evaluated within a broader development framework that considers structural and institutional conditions. This perspective aligns with contemporary regional development theories, which emphasize that the effectiveness of infrastructure depends on its integration with productive economic sectors. Consequently, the study extends existing literature by highlighting the possibility that infrastructure constitutes a necessary but insufficient condition for regional economic expansion, particularly in regions experiencing economic shocks and structural constraints.

In practice, the findings imply that policymakers should not rely solely on infrastructure expansion to accelerate economic growth. Although infrastructure remains essential for improving connectivity and service accessibility, its economic benefits are likely to be maximized when accompanied by policies that encourage investment, strengthen local industries, improve workforce productivity, and enhance institutional capacity. For Probolinggo Regency, the results suggest that future development strategies should focus on integrating infrastructure projects with broader economic development programs. Such an approach would increase the likelihood that investments in roads, water systems, and electricity networks generate measurable contributions to sustainable regional economic expansion in the long run.

CONCLUSION

This study re-evaluated the role of infrastructure-led development in explaining regional economic expansion by examining the effects of road, water, and electricity infrastructure on GRDP growth in Probolinggo Regency during 2018–2022. The findings reveal that neither infrastructure variables jointly (Sig. = 0.394) nor individually (road = 0.303; water = 0.206; electricity = 0.652) exerted a statistically significant influence on regional economic growth, despite the model explaining 60.5% of the variation in GRDP growth (Adjusted R² = 0.605). These results suggest that infrastructure alone may not be sufficient to stimulate short-term economic expansion without support from complementary factors such as investment, human capital, and industrial development. The study contributes to the infrastructure-led development literature by providing local-level evidence that challenges the assumption of an automatic infrastructure-growth nexus. However, the limited observation period and small sample size constrain the generalizability of the findings. Future studies should employ longer time horizons, panel datasets, and additional explanatory variables to capture the broader mechanisms linking infrastructure development and regional economic performance.

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