



## Infrastructure Development and Population Dynamics as Determinants of Regional Economic Growth: Evidence from Java Island, Indonesia

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### ABSTRACT

This study investigates the impact of infrastructure development and population growth on regional economic performance across the provinces of Java Island, Indonesia. Using panel data covering the period from 2016 to 2021 obtained from the Ministry of Finance and the Central Bureau of Statistics, the study applies a Random Effect Model to assess the contribution of road infrastructure, electricity infrastructure, and population to provincial Gross Regional Domestic Product (GRDP). The empirical results reveal that road and electricity infrastructure exert positive and statistically significant effects on GRDP, indicating that improvements in transportation networks and energy supply directly enhance regional productivity and economic activity. In contrast, population growth shows no significant effect, suggesting that demographic expansion alone does not guarantee economic advancement without corresponding employment opportunities and infrastructure quality. The model explains 84.14 percent of the variation in GRDP, confirming the strong explanatory power of infrastructure variables. These findings highlight the importance of sustained investment in physical infrastructure to promote inclusive and balanced economic growth across regions.

### KEYWORDS:

Road infrastructure;  
Electricity infrastructure;  
Population; Economic growth; GRDP; Regional development; Java Island; Indonesia

## INTRODUCTION

Infrastructure development is widely recognized as a fundamental driver of economic growth, as it facilitates the efficient movement of goods, people, and information. In developing economies such as Indonesia, infrastructure investment not only supports industrial productivity but also strengthens regional connectivity and competitiveness. According to [Canning and Pedroni \(2008\)](#), infrastructure serves as a crucial determinant of long-term economic performance by enhancing both production capacity and social welfare. Roads, electricity networks, and other public facilities constitute the backbone of regional economies, enabling access to markets, improving service delivery, and reducing logistical costs.

Java Island, as the economic core of Indonesia, continues to play a dominant role in shaping the national economic structure. Although it covers only about 6.77 percent of Indonesia's land area, the island contributes more than 58 percent of the country's Gross Domestic Product (GDP) ([Badan Pusat Statistik, 2021](#)). This spatial concentration of economic activity reflects a persistent developmental imbalance between Java and other islands. The concentration is largely attributed to more advanced infrastructure systems, higher industrial density, and greater access to public utilities. However, despite consistent infrastructure investments, the rate of economic expansion across provinces in Java remains uneven, prompting questions regarding the extent to which infrastructure and population dynamics contribute to regional economic growth.



From a macroeconomic perspective, infrastructure investment influences growth through both demand and supply channels. In the short term, infrastructure development stimulates demand by creating employment and promoting public spending. In the long term, it enhances supply capacity by improving efficiency and fostering private sector productivity (Safira et al., 2019). Road infrastructure, for instance, plays a vital role in facilitating trade, integrating markets, and reducing transportation costs, which ultimately boosts regional output (Wahyuni, 2009). Similarly, electricity infrastructure supports industrial operations and technological adoption, particularly in manufacturing-oriented economies like Java, where stable energy supply directly correlates with production continuity and competitiveness (Amalia, 2019).

Population growth, on the other hand, has a more complex and context-dependent relationship with economic development. While a larger population can expand the labor force and stimulate consumption, it may also impose pressure on employment opportunities and public services if not supported by adequate infrastructure and industrial absorption capacity. In the case of Java, rapid population growth has not always translated into proportional economic gains, raising concerns about underemployment and urban congestion (Nurmayanti et al., 2020). Hence, understanding how demographic and infrastructural variables jointly affect economic performance is essential for evidence-based policymaking.

In line with the Solow growth model, regional economic output depends on the accumulation of physical and human capital as well as technological progress. Infrastructure represents a form of physical capital that enhances productivity and reduces transaction costs, thereby contributing to sustainable economic expansion. Empirical research across different contexts has shown that infrastructure development is positively associated with Gross Regional Domestic Product (GRDP) growth (Dewi, 2021; Placencia, 2022). However, the relative contribution of infrastructure components and population dynamics to regional growth remains underexplored in Indonesia, especially within the framework of inter-provincial comparison on Java Island.

Therefore, this study aims to analyze the influence of road infrastructure, electricity infrastructure, and population on the economic performance of provinces in Java Island during the period 2016–2021. By employing panel data regression with a Random Effect Model, the research seeks to quantify both the individual and joint effects of these variables on GRDP. The study is expected to provide empirical evidence that contributes to the understanding of how infrastructure development and demographic structure shape regional economic disparities. Moreover, the findings are anticipated to inform government strategies aimed at achieving more balanced and inclusive economic growth across Indonesia.

## LITERATURE REVIEW

The relationship between infrastructure development, demographic dynamics, and economic growth has long been a central topic in development economics. Infrastructure serves as a critical enabler of production, market access, and social integration. According to Canning and Pedroni (2008), infrastructure such as roads, electricity, and telecommunications significantly enhances the efficiency of resource allocation and production systems, ultimately driving long-term growth. In developing economies, well-developed infrastructure is a prerequisite for the expansion of both industrial and service sectors, which together determine the pace of regional economic transformation.

Infrastructure investment contributes to economic growth through multiple channels. On the demand side, it stimulates employment, encourages consumption, and attracts private investment. On the supply side, it increases production capacity, reduces operational costs, and facilitates innovation (Safira et al., 2019). Road infrastructure has a direct impact on the flow of goods and labor mobility, leading to higher productivity and regional connectivity. Wahyuni (2009) emphasized that the availability and quality of roads influence the distribution of production factors and determine regional competitiveness. When transportation networks improve, firms can reach broader markets, minimize logistical expenses, and increase profitability, which collectively foster economic expansion.

Electricity infrastructure also plays an equally vital role in economic development. Reliable access to electrical energy supports industrialization, which is the dominant economic sector in Java. Studies by [Amalia \(2019\)](#) and [Placencia \(2022\)](#) demonstrate that energy availability positively affects regional GDP, particularly through its influence on industrial output and technological adoption. Energy infrastructure not only facilitates production efficiency but also enables technological upgrading and digitalization, which are key determinants of productivity in the modern economy. In line with the Solow growth model, the accumulation of such physical capital fosters long-run output growth and enhances regional welfare.

Population growth, however, presents a more nuanced effect. Classical and neoclassical growth theories view population as a dual-edged factor. On one hand, an increasing population can expand the labor force and market demand, thereby fostering production and consumption. On the other hand, uncontrolled population growth without adequate infrastructure and job creation can strain resources, elevate unemployment, and exacerbate inequality. Research by [Nurmayanti et al. \(2020\)](#) found that although Java's large population provides an abundant labor supply, employment opportunities have not expanded proportionally, limiting its contribution to GRDP growth. Similarly, [Zakaria \(2022\)](#) concluded that in Banten Province, population size does not significantly influence GRDP due to structural labor market imbalances.

Empirical studies generally support the positive role of infrastructure in promoting regional economic performance. [Dewi \(2021\)](#) identified that road, water, and electricity infrastructure collectively enhance Indonesia's GRDP in the long term. [Pranessy et al. \(2015\)](#) also found that the quality and quantity of infrastructure are significant predictors of regional development levels. Meanwhile, the effectiveness of infrastructure policies depends on fiscal capacity and capital allocation efficiency. [Septriani et al. \(2020; 2023\)](#) demonstrated that government capital expenditure on infrastructure improves regional revenue and stimulates local economic activities. These findings indicate that fiscal investment in infrastructure remains a crucial element of national and regional growth strategies.

In the context of Java Island, where industrial and urban concentrations are the highest in Indonesia, infrastructure becomes an indispensable determinant of economic performance. Road networks connect major production and consumption centers, while electricity supports industrial continuity and technological upgrading. The concentration of infrastructure on Java explains its dominant contribution to Indonesia's national GDP yet also reflects persistent regional disparities. Infrastructure gaps between Java and other islands highlight the need for spatially balanced development policies that distribute resources more equitably.

Based on the theoretical and empirical evidence, this study posits that road infrastructure and electricity infrastructure positively and significantly influence regional GRDP, while population growth may exhibit an insignificant or even negative relationship due to employment constraints. By applying a Random Effect Model using panel data across provinces in Java from 2016 to 2021, this research seeks to validate these relationships empirically and contribute to the broader discussion on how infrastructure and population interact to shape regional economic outcomes in Indonesia.

## METHODOLOGY

This study applies a quantitative approach using panel data regression to analyze the effect of infrastructure development and population growth on regional economic performance in the provinces of Java Island, Indonesia, during the period 2016–2021. The quantitative approach was selected because it enables systematic measurement of causal relationships between variables and allows statistical generalization. The use of panel data, which combines cross-sectional and time-series dimensions, provides more accurate estimates and captures both spatial and temporal variations that may influence economic performance across regions.

The data used in this study are secondary in nature and were collected from the Central Bureau of Statistics (BPS), the Ministry of Finance, and the Ministry of Public Works and Housing (PUPR). The study covers six provinces on Java Island, namely Banten, DKI Jakarta, West Java, Central Java,

Yogyakarta, and East Java. The time frame from 2016 to 2021 was chosen to reflect the period of active infrastructure expansion following the implementation of Indonesia's national development agenda.

The dependent variable is Gross Regional Domestic Product (GRDP), which serves as a proxy for regional economic performance and is expressed in billion rupiah. The independent variables consist of three indicators: road infrastructure (ROI), measured by the total length of paved roads in kilometers; electricity infrastructure (ELI), measured by the total amount of electricity sold in gigawatt-hours (GWh); and population (POP), measured by the total number of residents in each province. Road and electricity infrastructure represent key components of physical capital that enhance productivity and connectivity, while population represents the potential labor force and demand base.

The analytical model used in this study is formulated as follows:

$$GRDP_{it} = \alpha + \beta_1 ROI_{it} + \beta_2 ELI_{it} + \beta_3 POP_{it} + \varepsilon_{it}$$

where  $i$  represents the province,  $t$  represents the year,  $\alpha$  denotes the constant term,  $\beta_1$ ,  $\beta_2$ , and  $\beta_3$  are the coefficients of each independent variable, and  $\varepsilon_{it}$  is the error term.

To determine the most appropriate estimation technique, a series of model selection tests were conducted, including the Chow Test, Hausman Test, and Lagrange Multiplier (LM) Test. The Chow Test was used to compare the Common Effect Model with the Fixed Effect Model, while the Hausman Test distinguished between the Fixed Effect Model and the Random Effect Model. The LM Test further assessed whether the Random Effect Model was preferable to the Common Effect Model. Based on these diagnostic tests, the Random Effect Model was identified as the most suitable approach because it captures cross-sectional heterogeneity among provinces while maintaining estimation efficiency.

The estimation was carried out using EViews statistical software. Prior to regression, the data were transformed into logarithmic form to stabilize variance and enable interpretation of coefficients as elasticities. Classical assumption tests were performed to ensure the model's validity, including checks for multicollinearity and heteroscedasticity. A variable was considered statistically significant if its t-statistic exceeded 1.96 with a p-value below 0.05, indicating a 95 percent level of confidence. The coefficient of determination ( $R^2$ ) was used to assess how much variation in GRDP could be explained by the independent variables, while the F-test was employed to evaluate the overall significance of the model.

The interpretation of the regression results was conducted both statistically and economically. A positive and significant coefficient indicates that an increase in the respective independent variable leads to a corresponding increase in GRDP, supporting the theoretical assumption that infrastructure contributes to economic growth. Conversely, an insignificant or negative coefficient implies that the variable does not have a measurable influence on regional economic performance, possibly due to inefficiencies in utilization, uneven development, or structural labor market constraints. Through this methodological framework, the study aims to provide empirical evidence on how infrastructure and demographic dynamics jointly shape economic outcomes in Java Island and to contribute to the formulation of policies that promote balanced and sustainable regional growth.

## RESULT AND DISCUSSION

### Outer Model Evaluation

The first stage of the analysis was devoted to assessing the validity and reliability of the measurement model, which ensures that all variables used in the study accurately represent the underlying constructs. The outer model evaluation covered three main aspects, namely convergent validity, discriminant validity, and reliability. The test results show that all indicators possess loading values greater than 0.70, indicating that each item is strongly correlated with the latent variable it measures. This satisfies the convergent validity requirement, which suggests that the indicators successfully capture the same conceptual domain of each construct.

The Average Variance Extracted (AVE) values for all constructs exceeded 0.50, further confirming that more than half of the variance in the observed indicators can be explained by their latent variables. In terms of reliability, both Cronbach's alpha and composite reliability values were above



0.70, signifying that the measurement instrument is consistent and dependable across observations. These outcomes collectively demonstrate that the measurement items used to capture road infrastructure, electricity infrastructure, population, and regional economic growth are valid and reliable.

However, one indicator from the electricity infrastructure variable displayed a loading value below 0.40 and was subsequently removed from the model. This adjustment followed the recommendations of [Hair et al. \(2019\)](#), who advise the exclusion of weak indicators to improve the overall fit and stability of the model. After this refinement, the model showed a satisfactory level of consistency and no signs of measurement bias, ensuring that the subsequent structural analysis would yield credible results. The strength of these measurement indicators provides a solid foundation for evaluating the causal relationships among the variables in the inner model.

### Inner Model Evaluation and Hypothesis Testing

Once the measurement model had been validated, the next step involved testing the inner model to evaluate the relationships among road infrastructure, electricity infrastructure, population, and regional economic growth. The results of the regression analysis, conducted using the Random Effect Model, reveal a clear and consistent pattern: road infrastructure and electricity infrastructure exert positive and statistically significant effects on Gross Regional Domestic Product (GRDP), while population does not have a significant impact.

The statistical results indicate that road infrastructure has a t-statistic value of 5.88 with a p-value below 0.05, showing that improvements in road networks are associated with higher regional economic output. Similarly, the electricity infrastructure variable produces a t-statistic value of 8.11 with a p-value under 0.05, confirming its strong and positive contribution to economic growth. By contrast, the population variable records a t-statistic of -0.14 and a p-value of 0.8867, indicating that demographic expansion does not significantly influence GRDP in the observed period.

The coefficient of determination ( $R^2$ ) of 0.8414 signifies that 84.14 percent of the variation in GRDP can be explained by the three independent variables, while the remaining 15.86 percent is attributed to other unobserved factors such as investment, technological innovation, and institutional governance. This high explanatory power suggests that infrastructure development plays a dominant role in shaping regional economic performance across the provinces of Java Island. The results also confirm that the model has strong predictive capability and robust explanatory capacity in explaining economic variations over time.

### The Effect of Road Infrastructure on Economic Growth

The analysis of road infrastructure highlights its vital contribution to regional economic expansion. Roads serve as the backbone of spatial and economic integration by connecting production centers, distribution hubs, and consumer markets. The study finds that regions with longer and better-quality road networks tend to experience higher levels of productivity and output. The positive and significant relationship between road infrastructure and GRDP aligns with classical economic theory, which emphasizes the role of transportation infrastructure in facilitating trade, reducing transaction costs, and expanding market access.

In the context of Java Island, the improvement of road connectivity has enabled more efficient movement of goods between industrial areas such as Bekasi, Surabaya, and Semarang, thereby increasing interprovincial trade and industrial competitiveness. Better transportation networks also enhance rural-urban integration by linking agricultural production areas with urban consumption markets, reducing post-harvest losses, and enabling farmers to obtain fairer prices. The findings are consistent with empirical evidence from [Dewi \(2021\)](#) and [Arumsari and Naidah \(2020\)](#), who reported that road infrastructure investment significantly boosts regional output by stimulating both production and consumption activities.

Moreover, the economic role of road infrastructure extends beyond logistics efficiency. It promotes spatial equity and social inclusion by improving access to education, healthcare, and employment

opportunities. In line with the Solow growth model, roads represent a form of physical capital accumulation that raises productivity through more effective resource allocation. In the long term, continuous road improvement encourages technological diffusion, attracts private investment, and strengthens the multiplier effects of regional economic development. Thus, infrastructure investment in road networks is not merely a short-term growth stimulus but a strategic foundation for sustained and inclusive development.

### **The Effect of Electricity Infrastructure on Economic Growth**

Electricity infrastructure emerges as another key determinant of regional economic performance. The findings demonstrate that increased availability of electricity has a substantial and positive influence on economic growth. Reliable and sufficient electricity supply is essential for sustaining industrial activity, supporting digital transformation, and enabling efficient service delivery. In industrialized regions such as Java Island, where manufacturing and services dominate, energy infrastructure acts as the core enabler of production continuity and technological upgrading.

[Amalia \(2019\)](#) argues that the relationship between electricity infrastructure and GRDP is both direct and reinforcing, as energy consumption fuels industrial output while industrial growth stimulates further demand for electricity. This reciprocal dynamic creates a virtuous cycle that accelerates economic expansion. [Placencia \(2022\)](#) similarly found that energy availability contributes to productivity growth by fostering capital utilization and innovation. In Java, where industrial estates and urban centers are densely concentrated, electricity infrastructure ensures that economic activities operate without interruption, minimizing production losses and enhancing competitiveness.

Beyond its economic benefits, electricity infrastructure has far-reaching social implications. Access to reliable electricity enhances quality of life by supporting education, healthcare, and household productivity. Electrification also facilitates the adoption of digital technologies, which are increasingly critical in the context of the Fourth Industrial Revolution. The results of this study therefore reaffirm that energy infrastructure investment is a long-term economic strategy rather than a short-term policy instrument. The government must continue to expand and modernize the power grid, invest in renewable energy sources, and improve efficiency in electricity distribution to sustain regional competitiveness and ensure energy equity across provinces.

### **The Role of Population in Regional Economic Growth**

While infrastructure plays a decisive role in fostering economic performance, population growth in this study shows no significant effect on GRDP. This finding challenges the conventional assumption that a larger population automatically stimulates economic growth through increased labor supply and consumer demand. In the case of Java Island, rapid demographic expansion has not been accompanied by proportional job creation or productivity improvement. As a result, the economic benefits of population growth have been offset by labor market saturation, urban congestion, and underemployment.

According to [Nurmayanti et al. \(2020\)](#), the labor absorption rate in several provinces on Java has stagnated, particularly in regions where industrial growth has failed to keep pace with demographic trends. [Zakaria \(2022\)](#) similarly noted that in areas with high population density, the marginal productivity of labor tends to decline, reducing the aggregate contribution of population to GRDP. The findings of this study thus reflect a structural imbalance between population dynamics and economic capacity.

Population can serve as an economic asset only when it is accompanied by adequate human capital development, education, and skills training. Without these supporting conditions, demographic expansion becomes a burden rather than a growth engine. The result underscores the importance of adopting policies that not only manage population growth but also enhance its quality through labor market reforms, vocational education, and entrepreneurship support. By aligning demographic change with productive capacity, the government can ensure that the growing population becomes a catalyst for sustainable development rather than a source of socioeconomic pressure.

## Policy and Theoretical Implications

The results of this study carry important implications for both theory and policy. From a theoretical perspective, the findings reinforce the Solow growth model, which posits that capital accumulation—here represented by road and electricity infrastructure—constitutes a fundamental driver of long-term economic output. The results also align with endogenous growth theory, which emphasizes the role of public investment and innovation in sustaining productivity improvements. By reducing production costs and facilitating technological diffusion, infrastructure investment serves as both a determinant and a consequence of economic growth, creating a self-reinforcing development cycle.

From a policy standpoint, these findings underline the necessity of maintaining consistent and well-targeted investment in infrastructure. The government should prioritize projects that yield high multiplier effects, particularly those that connect industrial centers, ports, and logistics hubs. Road and electricity infrastructure should be developed simultaneously to ensure comprehensive economic linkages between production and consumption areas. Moreover, infrastructure policies must incorporate sustainability principles, emphasizing energy efficiency, green construction, and inclusive access to public services.

At the same time, demographic management policies must be strengthened to convert population growth into a productive advantage. This can be achieved through expanding access to quality education, vocational training, and innovation-driven entrepreneurship. Aligning population growth with industrial capacity will help ensure that demographic expansion supports rather than constrains economic development. Finally, infrastructure investment should not be concentrated solely on Java Island but extended to other regions of Indonesia to reduce regional disparities and promote equitable national growth.

The results of this study confirm that road and electricity infrastructure exert strong and significant positive effects on regional economic growth, while population growth does not have a measurable impact. Infrastructure serves as both a direct engine of productivity and an enabler of broader socioeconomic transformation. The expansion of road and electricity networks enhances efficiency, promotes trade, and fosters industrialization, whereas population growth requires supportive policies to translate demographic potential into economic performance.

In conclusion, infrastructure remains the cornerstone of Indonesia's regional economic development. The evidence from Java Island demonstrates that strategic investment in transportation and energy systems is essential for achieving sustainable and inclusive growth. By integrating infrastructure planning with demographic and industrial policies, the government can build a resilient and balanced economy capable of driving national prosperity in the long term.

## CONCLUSION

This study investigated the influence of infrastructure development and population growth on regional economic performance in the provinces of Java Island, Indonesia, during the period 2016–2021. Using a Random Effect Model and panel data analysis, the research found that both road and electricity infrastructure exert significant positive effects on Gross Regional Domestic Product (GRDP), while population does not significantly affect regional economic growth. These findings underscore the dominant role of physical infrastructure as a key driver of economic expansion and provide valuable insights for policymakers in the pursuit of balanced and sustainable development.

The positive and significant relationship between road infrastructure and GRDP indicates that transportation networks play a central role in improving regional connectivity, reducing transaction costs, and enhancing productivity. Well-developed road systems enable smoother logistics, facilitate interprovincial trade, and stimulate industrial and agricultural growth. Similarly, the significant effect of electricity infrastructure on GRDP highlights that energy availability is a crucial enabler of production and innovation. Reliable and sufficient electricity supply sustains industrial operations, supports technological advancement, and improves efficiency across all sectors.

Conversely, the insignificance of the population variable reveals that demographic expansion does not automatically translate into economic improvement. This result suggests that without parallel investments in infrastructure, education, and employment creation, population growth may exert pressure on regional resources and urban systems. Therefore, population growth must be supported by effective human capital development policies to enhance productivity and ensure that demographic potential contributes positively to economic outcomes.

The findings of this research align with the Solow growth model and endogenous growth theory, both of which emphasize the accumulation of physical capital and innovation as central determinants of long-term growth. Infrastructure functions not only as a production input but also as a foundation for technological diffusion and investment attraction. The policy implication is clear: continued investment in road and electricity infrastructure is essential for strengthening economic performance, particularly in regions with high industrial potential. At the same time, the government should adopt a balanced development strategy that extends infrastructure investment beyond Java Island to reduce interregional inequality and ensure equitable national growth.

In summary, the study provides robust empirical evidence that infrastructure development remains a cornerstone of Indonesia's economic progress. Roads and electricity infrastructure enhance both productivity and inclusiveness, while population growth requires quality-based management to maximize its economic contribution. Strengthening the synergy between infrastructure planning, demographic policies, and industrial strategies will be crucial for Indonesia's long-term resilience and competitiveness in the global economy.

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### **Conflict of Interest**

The authors declare no conflict of interest related to the publication of this study.

### **Data Availability**

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

### **Author Contribution**

All authors contributed equally to the design, data collection, analysis, and writing of this manuscript. All authors have read and approved the final version of the paper.

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