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RESEARCH ARTICLE

Infrastructure Development and Economic Growth in Java Island: A Random Effect Panel Data Analysis (2016–2021)

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ABSTRACT
This study aims to examine the impact of infrastructure development and population growth on regional economic growth across six provinces in Java Island from 2016 to 2021. Infrastructure serves as a critical determinant of productivity enhancement and interregional connectivity, while demographic dynamics influence regional production and consumption capacity. The study employs secondary data obtained from Statistics Indonesia (BPS), the Ministry of Finance, and the Ministry of Public Works and Housing (PUPR). A panel data regression approach is applied, comparing the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM). Model selection through Chow, Hausman, and Lagrange Multiplier tests identifies the Random Effect Model as the most appropriate specification. The results show that road and electricity infrastructures have a positive and significant effect on Gross Regional Domestic Product (GRDP), whereas population growth has no significant influence on regional economic performance. The coefficient of determination (R^2) of 0.8414 indicates that the independent variables collectively explain 84.14 percent of the variation in GRDP. These findings confirm that infrastructure development remains a vital engine of regional economic growth, while population growth must be supported by improvements in human capital and labor productivity to become an effective driver of economic progress. The study contributes to regional development literature and provides policy implications for sustainable and equitable growth planning in Indonesia.

KEYWORDS:
Infrastructure, GRDP, Population Growth, Economic Development, Panel Data, Java Island

INTRODUCTION

Infrastructure development is widely recognized as a fundamental engine of economic growth, productivity enhancement, and regional competitiveness. It serves as the backbone of economic systems by facilitating transportation, energy distribution, communication, and public services that enable the efficient functioning of production and trade activities. Within the classical Solow growth framework, infrastructure is considered a form of physical capital accumulation that enhances total factor productivity and contributes directly to long-term output expansion. Accordingly, well-developed infrastructure increases productive capacity and generates multiplier effects that stimulate investment, employment, and income growth.

In developing economies such as Indonesia, infrastructure plays a dual role: it acts as a driver of economic performance and as a mechanism for reducing spatial inequalities. According to Calderón and Servén (2010), the expansion of infrastructure networks promotes inclusive growth by improving market access, reducing transportation costs, and facilitating labor mobility. However, Indonesia continues to face uneven infrastructure distribution, with Java Island serving as both the nation's economic core and a reflection of regional disparities. Java contributes more than 58 percent of Indonesia's Gross Domestic Product (GDP), yet provincial inequalities persist—Jakarta and East Java

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exhibit strong industrial and service sectors, while regions such as Yogyakarta and Banten lag in terms of infrastructure quality and economic diversification (BPS, 2023).

This spatial imbalance reveals that although Java Island enjoys relatively advanced infrastructure, the benefits are not evenly distributed across provinces. Urban and industrial centers possess superior road networks and electricity access, whereas rural and peripheral areas often face limitations in transportation and energy infrastructure. These disparities hinder the flow of goods, labor mobility, and market integration, resulting in uneven regional growth. As Sahoo and Dash (2012) emphasized, the quality and accessibility of infrastructure are critical in enhancing economic efficiency and supporting industrial development, particularly in rapidly urbanizing regions.

Population dynamics represent another key determinant of regional economic performance. The classical Malthusian theory suggests that unchecked population growth may strain resources and depress per capita income, while modern endogenous growth models proposed by Romer (1990) and Lucas (1988) view human capital accumulation as the primary channel through which population growth fosters innovation and productivity. In this sense, population growth can be either a burden or an asset, depending on the capacity of the economy to transform demographic expansion into productive employment and human capital development.

Empirical evidence from Indonesia presents mixed findings regarding the interplay between infrastructure, population, and economic growth. Dewi (2021) found that infrastructure investment significantly enhances regional productivity by increasing connectivity and reducing logistic costs. Similarly, Arumsari and Naidah (2020) demonstrated that road and electricity infrastructure have a complementary effect on regional GRDP growth. However, Zakaria (2022) reported that population growth in Banten Province does not significantly influence economic performance due to weak labor absorption and skill mismatches. These divergent outcomes indicate that while infrastructure consistently supports economic performance, population effects are context-dependent and mediated by education, labor market structure, and technological adaptation.

In response to these challenges, Indonesia's *National Medium-Term Development Plan (RPJMN) 2020–2024* emphasizes infrastructure development as a strategic priority for accelerating national transformation and enhancing regional equity. Major initiatives such as the *National Strategic Projects (PSN)* aim to expand toll roads, strengthen electricity networks, and enhance interregional logistics systems. However, empirical evaluation remains essential to determine whether infrastructure investments translate into sustainable regional economic growth and whether demographic factors amplify or constrain this process.

Against this backdrop, the present study aims to analyze the impact of road infrastructure, electricity infrastructure, and population growth on regional economic performance across six provinces in Java Island from 2016 to 2021. Specifically, it seeks to address two research questions. To what extent does infrastructure development influence provincial Gross Regional Domestic Product (GRDP) across Java Island. Does population growth contribute significantly to regional economic growth in an already densely populated and urbanized context?

This study contributes to the literature on regional development and economic growth in three keyways. First, it provides updated empirical evidence using a panel data approach that captures both spatial and temporal variations in infrastructure and population dynamics. Second, it integrates demographic variables into the infrastructure–growth nexus, offering a holistic understanding of how physical and human factors interact to shape regional economies. Third, it yields practical policy implications for promoting balanced regional growth and enhancing economic resilience in Indonesia.

In sum, this research not only quantifies the relationship between infrastructure, population, and economic performance but also contextualizes it within Indonesia's regional development agenda. By

employing an evidence-based analytical approach, the study aims to guide policymakers in designing more effective infrastructure investment strategies and human capital development programs that collectively foster inclusive and sustainable growth across Java Island.

LITERATURE REVIEW

The relationship between infrastructure and economic growth has long been central to development economics. Infrastructure functions as both an input and an enabling condition for production, influencing productivity, technological diffusion, and spatial equity. Within the Solow–Swan neoclassical growth model (Solow, 1956), capital accumulation is considered a key determinant of long-term economic output, where infrastructure represents a vital component of physical capital. Aschauer (1989) extended this framework by empirically demonstrating that public infrastructure investment substantially contributes to private sector productivity. Subsequent works, such as those by Calderón and Servén (2010), reinforced this argument by showing that infrastructure development not only accelerates aggregate growth but also reduces income inequality by improving access to markets and employment opportunities.

The mechanisms through which infrastructure affects growth operate via several channels. Improved road networks lower transportation costs, reduce travel time, and expand market reach, thereby enhancing trade efficiency and attracting investment (Straub, 2011). Electricity infrastructure, in turn, provides the energy foundation required for industrial expansion, technological innovation, and improved household welfare (Lee et al., 2020). The World Bank (2022) emphasizes that infrastructure directly contributes to total factor productivity by facilitating the integration of regional economies and enabling economies of scale. In developing countries, where institutional and market constraints are prevalent, infrastructure investment often plays a disproportionate role in driving structural transformation and industrial diversification (Sahoo & Dash, 2012).

Empirical evidence consistently supports the positive linkage between infrastructure and economic growth, though the magnitude of this effect varies across contexts. Fan and Zhang (2004) found that rural road investment in China significantly boosted agricultural output and poverty reduction. In India, Sahoo and Dash (2012) showed that infrastructure contributed to long-run growth through increased capital formation and private sector productivity. Similarly, in Indonesia, Dewi (2021) observed that improvements in road and electricity infrastructure significantly enhanced regional economic performance. Arumsari and Naidah (2020) also revealed that infrastructure expansion fosters interprovincial trade and industrial development, particularly in regions with high urban density such as Java Island.

While infrastructure plays a fundamental role in stimulating growth, demographic factors such as population dynamics introduce complexity into the growth process. Classical economists, including Malthus, argued that population growth could outpace resource availability, leading to diminishing returns and potential stagnation. However, modern endogenous growth theories developed by Romer (1990) and Lucas (1988) revised this perspective, suggesting that population growth can contribute positively to economic performance when accompanied by human capital accumulation and innovation. According to the endogenous model, knowledge spillovers and learning-by-doing mechanisms amplify productivity, turning demographic expansion into a source of dynamic efficiency.

Empirical studies on the relationship between population growth and economic performance reveal diverse outcomes. Bloom et al. (2019) identified that demographic transition, characterized by a rising working-age population relative to dependents, can produce a “demographic dividend” if economies invest adequately in education, health, and job creation. In contrast, Setiawan and Kuncoro (2020) argued that when labor absorption fails to match population growth, unemployment and

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underemployment increase, thereby dampening economic output. In Indonesia, Zakaria (2022) found that rapid population growth in Banten Province had no significant impact on GRDP, primarily because of weak industrial absorption and low productivity among the labor force. These findings highlight that the economic effects of population depend largely on the quality of human capital and the structure of regional economies.

The spatial dimension of economic growth further complicates the interaction between infrastructure and demographic factors. Krugman's (1991) core–periphery model posits that economic activities tend to concentrate in regions with superior infrastructure and market access, generating self-reinforcing agglomeration effects. Such concentration, however, can exacerbate regional inequality if peripheral areas remain underinvested. Java Island exemplifies this duality: as the industrial and administrative center of Indonesia, it benefits from extensive infrastructure, yet disparities persist between metropolitan provinces like Jakarta and peripheral regions such as Yogyakarta. The concentration of investment and population in growth poles contributes to the uneven distribution of income and economic opportunities across the island.

Recent studies continue to emphasize the multifaceted role of infrastructure in reducing these disparities. Yanti et al. (2018) found that both road density and electricity accessibility significantly influence regional productivity and income convergence. Nadya and Atmanti (2022) further noted that the efficiency of infrastructure-driven growth depends heavily on governance quality, institutional coherence, and fiscal capacity at the regional level. Meanwhile, technological advancements, particularly in digital infrastructure, have emerged as a new determinant of economic competitiveness. According to Zhang (2021), electricity and digital connectivity jointly shape productivity patterns in Asia, suggesting that infrastructure policies must evolve to accommodate technological transformations.

Despite the extensive literature, gaps remain concerning the combined analysis of infrastructure and demographic factors in the Indonesian context. Most studies examine these dimensions separately, either focusing exclusively on the role of physical infrastructure or on the demographic transition without accounting for their potential interaction. This study seeks to bridge that gap by employing a panel data framework that captures both the spatial heterogeneity of infrastructure distribution and the temporal evolution of demographic trends in Java Island. By integrating these factors into a unified empirical model, the research aims to provide a more comprehensive understanding of the drivers of regional economic performance.

In summary, theoretical and empirical perspectives converge on the view that infrastructure is a foundational determinant of economic growth, while population dynamics exert conditional effects depending on institutional quality and human capital development. The interplay between these factors determines the extent to which regions can achieve sustainable and inclusive growth. Within this conceptual framework, the present study hypothesizes that road and electricity infrastructure exert positive and significant impacts on regional GRDP, whereas population growth yields an indeterminate effect influenced by local socioeconomic structures. The findings are expected to refine the understanding of infrastructure-led growth and inform policies aimed at promoting balanced regional development in Indonesia.

METHODOLOGY

This study adopts a quantitative research design with an explanatory approach to examine the impact of infrastructure development and population growth on regional economic performance across six provinces of Java Island—Banten, West Java, Central Java, Yogyakarta, East Java, and DKI Jakarta—during the period 2016–2021. The use of a panel data model allows the integration of cross-

sectional and time-series observations, which increases the efficiency of estimation and enables the control of unobserved heterogeneity among provinces. Panel data analysis is particularly appropriate for this study because it captures both spatial variations and temporal changes in infrastructure and demographic dynamics, providing a more comprehensive understanding of the determinants of economic growth.

The analysis relies on secondary data obtained from official and credible sources, including Statistics Indonesia (BPS), the Ministry of Finance, and the Ministry of Public Works and Housing (PUPR). The dependent variable is the Gross Regional Domestic Product (GRDP) at constant 2010 prices, representing regional economic output. The independent variables consist of road infrastructure, electricity infrastructure, and population. Road infrastructure is measured by the total length of roads in good condition (kilometers), electricity infrastructure by the total number of electrified households or installed power capacity (megawatts), and population by the total number of inhabitants in each province. All variables are transformed into natural logarithmic form to normalize their distribution and to interpret the coefficients as elasticities, which is consistent with standard practice in growth modeling studies (Calderón & Servén, 2010; Sahoo & Dash, 2012).

The model specification used in this research is expressed as follows:

$$\ln\text{GRDP}_{it} = \beta_0 + \beta_1 \ln\text{ROAD}_{it} + \beta_2 \ln\text{ELEC}_{it} + \beta_3 \ln\text{POP}_{it} + \mu_i + \epsilon_{it}$$

where $\ln\text{GRDP}_{it}$represents the natural logarithm of the GRDP for province $i$in year t; $\ln\text{ROAD}_{it}$, $\ln\text{ELEC}_{it}$, and $\ln\text{POP}_{it}$denote the natural logarithms of road infrastructure, electricity infrastructure, and population, respectively. The term $\mu_i$captures unobservable province-specific effects that remain constant over time, while ϵ_{it}represents the idiosyncratic error term. The coefficients β_1, β_2,and $\beta_3$measure the elasticity of GRDP with respect to each independent variable.

Three panel data estimation models are considered: the Common Effect Model (CEM), the Fixed Effect Model (FEM), and the Random Effect Model (REM). The CEM assumes homogeneity across provinces and time, implying that all units share a common intercept. The FEM allows for province-specific intercepts, capturing unobserved time-invariant heterogeneity, while the REM assumes that the individual effects are random and uncorrelated with the explanatory variables. To determine the most appropriate model, a series of statistical tests are conducted: the Chow Test to compare the CEM and FEM, the Hausman Test to select between FEM and REM, and the Lagrange Multiplier (LM) Test to assess the superiority of REM over CEM. The model that meets efficiency and consistency criteria is then chosen as the preferred specification.

The analysis is conducted using EViews 12 statistical software. Descriptive statistics are first computed to summarize data characteristics, followed by correlation analysis to assess potential multicollinearity among variables. Classical assumption tests, including normality, heteroskedasticity, autocorrelation, and multicollinearity checks, are applied to ensure the validity and reliability of the regression results. Variance Inflation Factor (VIF) values below the threshold of 10 indicate the absence of multicollinearity, while the Durbin–Watson statistic is used to assess serial correlation. The goodness of fit is evaluated using the coefficient of determination (R^2), the F-statistic, and the significance levels of individual coefficients.

Panel data regression is preferred in this study because it combines the advantages of both cross-sectional and time-series analyses. This method increases the degrees of freedom and reduces collinearity among explanatory variables, leading to more efficient parameter estimates. It also allows for the inclusion of unobservable factors that may influence economic growth, such as institutional quality, governance efficiency, and regional policy frameworks, which remain constant within each province but vary across them. By controlling for these province-specific effects, the panel model

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provides more robust and unbiased estimates of the relationship between infrastructure, population, and economic performance.

The expected signs of the estimated coefficients are derived from theoretical and empirical considerations. Road infrastructure is expected to have a positive and significant effect on GRDP, as improved transportation reduces transaction costs and facilitates the flow of goods and services. Electricity infrastructure is also expected to exert a positive and significant influence, as reliable access to energy supports industrial production and stimulates technological innovation. The impact of population growth on GRDP, however, is ambiguous. While a growing population may expand labor supply and demand, it may also create pressure on resources and infrastructure if economic opportunities do not keep pace with demographic expansion.

To ensure data reliability, all variables are measured consistently across provinces and time periods using standardized indicators from the same institutional sources. The model's validity is assessed through statistical testing and robustness checks by comparing alternative specifications. Interpretation focuses on both statistical significance and economic relevance to ensure that the findings are not only empirically sound but also meaningful for policy formulation.

Overall, this methodological framework integrates rigorous econometric techniques with theoretically grounded assumptions to evaluate how infrastructure and population jointly affect economic growth in Java Island. The empirical approach enables the identification of key determinants of regional economic performance and provides a strong analytical foundation for policy recommendations aimed at fostering balanced, inclusive, and sustainable growth in Indonesia.

RESULT AND DISCUSSION

Descriptive Analysis

The descriptive analysis provides an overview of the key variables used in this study, namely Gross Regional Domestic Product (GRDP), road infrastructure, electricity infrastructure, and population across the six provinces of Java Island over the period 2016–2021. The data indicate that Java Island remains the center of Indonesia's economic activity, but regional disparities persist. DKI Jakarta, with its highly developed infrastructure and diversified economy, consistently records the highest GRDP. East Java and West Java follow closely due to their strong industrial bases and well-established transportation networks. In contrast, Yogyakarta and Banten display lower GRDP levels, reflecting their smaller industrial capacity and less extensive infrastructure development.

In terms of road infrastructure, the data show steady growth in the total length of roads in good condition during the observation period. East Java and Central Java maintain the largest road networks due to their geographical size and extensive transportation needs, while DKI Jakarta exhibits the highest road density per area unit, which facilitates efficient connectivity. The expansion of road infrastructure in these regions supports the mobility of goods and people, enhances market integration, and improves access to production and consumption centers.

Electricity infrastructure also shows substantial improvement across all provinces. The electrification ratio has exceeded 98 percent, indicating near-universal access to electricity across Java Island. This expansion has been crucial in supporting industrialization and household welfare. However, the reliability and quality of power distribution still vary across provinces, particularly between urban centers and rural areas. Regions with more stable power supply have been able to attract investment in manufacturing and digital services, reflecting the strong linkage between electricity infrastructure and regional competitiveness.

Population growth exhibits a relatively stable pattern, although Java Island remains the most densely populated region in Indonesia. West Java and East Java account for the largest populations,

contributing to both economic opportunities and development challenges. A large population increases labor supply and consumer demand, yet it also generates pressure on infrastructure and public services if not accompanied by proportional investment in employment and human capital. The uneven relationship between population and infrastructure underscores the importance of coordinated planning to transform demographic potential into productive capacity.

Overall, the descriptive findings highlight that Java Island has achieved significant progress in infrastructure expansion and economic performance, yet disparities remain across provinces. These variations provide the empirical foundation for assessing the quantitative relationship between infrastructure, population, and GRDP using panel data regression.

Model Selection and Diagnostic Tests

The regression analysis employs panel data techniques to estimate the effect of road infrastructure, electricity infrastructure, and population on GRDP. Before selecting the most appropriate model, diagnostic tests are performed to ensure statistical validity.

The Chow Test, which compares the Common Effect Model (CEM) and the Fixed Effect Model (FEM), indicates that the FEM is more suitable, suggesting the presence of provincial-specific effects. The Hausman Test, which compares FEM and Random Effect Model (REM), yields an insignificant chi-square value, implying that the REM provides more efficient and consistent estimates since the unobserved effects are uncorrelated with the independent variables. The Lagrange Multiplier (LM) Test further confirms that the REM outperforms the CEM by accounting for random variations across provinces. Consequently, the Random Effect Model is selected as the best-fitting model for further interpretation.

The REM estimation yields a high coefficient of determination (Adjusted $R^2 = 0.8414$), indicating that approximately 84.14 percent of the variation in GRDP across provinces and over time is explained by the combined effects of road infrastructure, electricity infrastructure, and population. The overall model significance is confirmed by an F-statistic with a p-value less than 0.01, suggesting that the explanatory variables jointly exert a significant impact on regional economic performance. The Durbin–Watson statistic approximates 2, confirming the absence of autocorrelation, and all Variance Inflation Factor (VIF) values remain below the critical threshold of 10, ensuring no multicollinearity among independent variables.

These diagnostic outcomes validate the reliability of the estimation results and support the robustness of the Random Effect Model as a suitable specification for explaining economic growth variations in Java Island.

Empirical Findings

The estimation results reveal that both road and electricity infrastructures have positive and statistically significant effects on regional economic performance, while population growth does not exhibit a significant relationship with GRDP.

The coefficient of road infrastructure is positive and significant at the 5 percent level, indicating that improvements in road conditions and expansion in road length contribute meaningfully to regional economic growth. Specifically, a one percent increase in road infrastructure is associated with an approximate 0.42 percent rise in GRDP, holding other factors constant. This finding supports the theoretical expectation that transportation infrastructure reduces transaction costs, enhances mobility, and promotes trade efficiency. The improved accessibility between production centers and markets accelerates the circulation of goods and services, thereby boosting productivity and regional output. These results align with the findings of Dewi (2021) and Sahoo and Dash (2012), who

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demonstrated that road infrastructure plays a central role in regional competitiveness and industrial expansion.

Similarly, electricity infrastructure exhibits a strong positive and statistically significant effect on GRDP, significant at the 1 percent level. The elasticity coefficient of approximately 0.57 implies that a one percent increase in electricity availability leads to a 0.57 percent increase in GRDP. This outcome confirms the pivotal role of reliable energy supply in supporting manufacturing, technology, and service sectors. Regions with higher electrification rates experience faster industrialization and better integration into digital and global value chains. This finding is consistent with studies by Lee et al. (2020) and Zhang (2021), which highlighted electricity infrastructure as a foundational driver of sustained economic growth in developing economies.

In contrast, population growth has a positive but statistically insignificant coefficient, suggesting that demographic expansion in Java Island does not directly contribute to regional economic performance. This result reflects the challenges of transforming population growth into productive economic outcomes in the absence of sufficient job creation, education quality, and labor market adaptability. It supports the observations of Zakaria (2022), who found that population increases in Banten Province had limited economic impact due to the structural mismatch between labor supply and industrial demand. The finding aligns with the endogenous growth theory, which emphasizes that the productivity effects of population growth depend on the quality of human capital and institutional capacity.

Interpretation and Discussion

The results of this study reinforce the theoretical argument that infrastructure development serves as a key driver of regional economic growth. Within the Solow growth model framework, infrastructure functions as a component of physical capital that enhances productivity and facilitates efficient resource allocation. The significant coefficients for road and electricity infrastructure confirm that investment in these sectors yields substantial economic returns. Infrastructure reduces barriers to production, fosters industrial diversification, and promotes regional integration, all of which contribute to higher GRDP levels.

The insignificant role of population growth suggests that demographic expansion alone does not guarantee economic progress. Without complementary investments in education, vocational training, and job creation, population growth may exacerbate unemployment and income inequality. This finding aligns with the views of Romer (1990) and Lucas (1988), who argued that the economic benefits of population depend on the accumulation of human capital and innovation capacity. The situation in Java illustrates that while the island benefits from a large labor pool, productivity remains uneven across sectors and provinces. Consequently, policies aimed at improving human capital quality are essential to harness demographic potential.

Spatial differences across provinces highlight the unequal distribution of infrastructure benefits. Developed regions such as DKI Jakarta and East Java demonstrate stronger linkages between infrastructure and economic growth due to higher institutional capacity, investment inflows, and industrial diversity. In contrast, provinces like Yogyakarta and Banten exhibit lower returns from infrastructure, largely due to structural limitations and lower economic density. This outcome resonates with Krugman's (1991) core–periphery model, which posits that economic activities tend to cluster in regions with superior infrastructure, further reinforcing regional disparities.

Policy Implications

The findings of this study hold several policy implications for achieving balanced and sustainable economic growth in Indonesia. First, infrastructure development should be prioritized not only in major industrial centers but also in peripheral provinces within Java Island. Expanding transportation and electricity networks in underdeveloped areas can reduce regional inequality and support equitable economic participation. Second, infrastructure investment must be accompanied by institutional strengthening and human capital development. The integration of infrastructure policy with education and labor programs can ensure that population growth becomes a productive asset rather than a developmental constraint. Third, energy policies should emphasize reliable and affordable electricity access, particularly for small and medium-sized enterprises (SMEs), which form the backbone of regional economies. Enhancing the sustainability of energy infrastructure through renewable sources can further improve long-term resilience and reduce operational costs.

Finally, continuous monitoring and evaluation of infrastructure performance are essential to ensure policy effectiveness. Empirical approaches such as panel data analysis can be institutionalized within regional planning frameworks to guide evidence-based decision-making. Such practices will enhance accountability, optimize public expenditure, and ensure that infrastructure projects deliver measurable economic outcomes.

Comparative Insights with Previous Studies

The findings of this study are broadly consistent with both international and domestic empirical evidence. Calderón and Servén (2010) and Straub (2011) confirmed that infrastructure investment exerts a positive influence on productivity and growth across developing regions. Likewise, studies in Indonesia by Yanti et al. (2018) and Nadya and Atmanti (2022) demonstrated that road and electricity infrastructure contribute significantly to GRDP growth, though the magnitude of the impact depends on regional governance and fiscal management. The present study extends this literature by showing that infrastructure remains a dominant determinant of economic performance even in relatively developed regions such as Java Island. By incorporating population as a control variable, this research also clarifies that the infrastructure–growth nexus remains strong even when demographic factors are accounted for, underscoring the resilience of infrastructure's contribution to growth.

Summary of Findings

The empirical analysis confirms three major findings. First, road and electricity infrastructures have positive and significant effects on regional economic performance, affirming their roles as fundamental drivers of productivity and growth. Second, population growth does not exert a statistically significant influence on GRDP, suggesting that demographic expansion has not yet been effectively transformed into economic advantage. Third, the varying magnitudes of these effects across provinces highlight the need for equitable infrastructure distribution and coordinated human capital strategies.

Overall, the results demonstrate that infrastructure development continues to be the backbone of economic growth in Java Island. To transform demographic potential into a productive force, infrastructure investments must be complemented by education, innovation, and institutional reforms. These combined efforts are essential to realize inclusive and sustainable regional development across Indonesia.

CONCLUSION

This study analyzed the effects of road infrastructure, electricity infrastructure, and population growth on regional economic performance across six provinces in Java Island, Indonesia, over the period 2016–2021 using a Random Effect Panel Data Model. The results provide strong empirical evidence that

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infrastructure development plays a crucial role in driving regional economic growth, while population growth, in isolation, does not significantly contribute to economic expansion.

The findings indicate that both road and electricity infrastructures exert positive and statistically significant influences on Gross Regional Domestic Product (GRDP). Improved transportation networks facilitate mobility, reduce logistics costs, and enhance trade connectivity between production and consumption centers. Similarly, reliable and accessible electricity infrastructure supports industrial activities, stimulates technological innovation, and improves overall productivity. These outcomes confirm the theoretical propositions of the neoclassical and endogenous growth models, which emphasize the centrality of capital accumulation and efficiency in determining long-term economic performance. Infrastructure investment enhances productivity not only through direct effects on production but also through indirect externalities that stimulate private investment and regional integration.

In contrast, population growth shows a positive but statistically insignificant relationship with GRDP. This result implies that demographic expansion in Java Island has not yet translated into proportionate economic gains. Although the island possesses a large and growing labor force, its economic benefits are constrained by limited employment opportunities, low labor productivity, and skill mismatches across sectors. These findings highlight that population growth alone does not guarantee higher economic performance unless it is accompanied by improvements in human capital quality, education, and institutional support. In other words, the demographic advantage of Java Island has yet to be fully leveraged to generate a demographic dividend.

The results also underscore the spatial heterogeneity of infrastructure's contribution to economic performance across provinces. Developed regions such as DKI Jakarta and East Java demonstrate stronger infrastructure–growth linkages, reflecting their higher institutional capacities, industrial diversification, and fiscal strength. Conversely, regions like Yogyakarta and Banten show relatively weaker effects due to structural and governance limitations. This outcome reflects Krugman's core–periphery theory, wherein infrastructure concentration in growth centers reinforces spatial inequality by attracting further economic activity to already developed regions. Therefore, addressing these disparities through equitable infrastructure investment and decentralization policies remains a key priority for Indonesia's regional development agenda.

From a policy perspective, this study highlights several strategic implications. First, infrastructure development should be expanded beyond major urban centers to peripheral and less developed provinces to ensure balanced regional growth. Targeted infrastructure projects—particularly in transportation and electricity—can enhance interprovincial connectivity and stimulate local economies. Second, policy design must integrate infrastructure investment with human capital development strategies. Training programs, education reforms, and vocational initiatives should be aligned with infrastructure expansion to ensure that population growth contributes positively to labor productivity and innovation. Third, governance and institutional quality should be strengthened to improve the efficiency and transparency of infrastructure spending. Empirical evidence suggests that infrastructure investment yields the highest returns in regions with effective public administration and accountability mechanisms.

Furthermore, the sustainability dimension of infrastructure development should not be overlooked. The expansion of road networks and electricity systems must be aligned with environmental and social considerations. Promoting renewable energy adoption and green transportation infrastructure can ensure that economic growth remains environmentally responsible and resilient to future challenges such as energy security and climate change.

Theoretically, this research reaffirms that infrastructure is a fundamental driver of regional economic growth in both classical and modern economic frameworks. It contributes to the empirical literature by demonstrating that even in relatively advanced and industrialized regions such as Java Island, infrastructure continues to yield significant productivity gains. The study also emphasizes the importance of integrating demographic and institutional factors into growth analysis to capture the complexity of regional development processes.

For future research, several extensions are recommended. First, incorporating additional variables such as digital infrastructure, human capital indicators, and regional investment flows could provide a more comprehensive understanding of growth determinants. Second, employing spatial econometric models could capture spillover effects of infrastructure investment across neighboring provinces. Third, longitudinal studies covering longer periods could evaluate the dynamic impact of infrastructure and demographic changes on economic convergence among regions.

In conclusion, this study provides clear evidence that infrastructure remains the backbone of economic growth in Java Island. Strengthening and expanding road and electricity infrastructure, while simultaneously investing in human capital and institutional reform, are essential steps toward achieving inclusive and sustainable regional development in Indonesia. The findings serve as a valuable reference for policymakers seeking to design balanced and evidence-based development strategies that harness infrastructure and demographic potential for long-term prosperity.

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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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