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Asymmetric Impact of Infrastructure (Roads, Electrification, Health) on Short-Term Post-Pandemic Regional Growth in South Kalimantan

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Abstract - *This research evaluates the relationship between various infrastructure systems and short-term regional growth during the post-pandemic recovery in South Kalimantan, Indonesia. It addresses three deficiencies in Indonesian research: the lack of post-pandemic evidence, the absence of sub-provincial analysis that integrates transport, energy, and social infrastructure, and a focus on quantitative metrics over qualitative and reliability assessments. The two-way fixed effects model that takes into account time-invariant district traits and common year shocks is based on a balanced panel of 13 regencies from 2021 to 2023. The road length, household electrification, the number of primary health facilities, and population are used to figure out real GRDP per capita. The results show that electrification has a positive and statistically significant semi-elasticity. In contrast, the road length exhibits a negative and significant correlation with per capita output, indicating that network quality and connectivity, rather than mere expansion, are crucial for short-term gains. Primary health facilities do not exhibit a statistically significant impact in the short term, which corresponds with the extended timeline of human capital development. Population growth is positive, which is in line with economies of scale. The policy implications back a quality-first agenda: put money into electricity service, move road budgets from expansion to maintenance and completion, and improve primary care while understanding that welfare improvements take time.*

Abstrak - Penelitian ini mengevaluasi hubungan antara berbagai sistem infrastruktur dan kesejahteraan regional jangka pendek selama pemulihan pasca pandemi di Kalimantan Selatan, Indonesia. Studi ini menanggapi tiga kekurangan dalam riset Indonesia, yaitu minimnya bukti pasca pandemi, ketiadaan analisis pada level subprovinsi yang mengintegrasikan transportasi, energi, dan infrastruktur sosial, serta fokus yang berlebihan pada ukuran kuantitatif dibandingkan penilaian kualitas dan keandalan. Model *two-way fixed effects* yang mempertimbangkan karakteristik kabupaten/kota yang tidak berubah sepanjang waktu dan guncangan tahun yang umum dibangun di atas panel seimbang 13 kabupaten/kota untuk periode 2021–2023. Panjang jalan, elektrifikasi rumah tangga, jumlah fasilitas kesehatan tingkat pertama, dan jumlah penduduk digunakan untuk menjelaskan PDRB riil per kapita. Hasil menunjukkan bahwa elektrifikasi memiliki semi-elastisitas yang positif dan signifikan secara statistik. Sebaliknya, panjang jalan berkorelasi negatif dan signifikan dengan output per kapita, yang mengindikasikan bahwa kualitas dan konektivitas jaringan, bukan sekadar perluasan jaringan, lebih menentukan manfaat jangka pendek. Fasilitas kesehatan tingkat pertama tidak menunjukkan dampak yang signifikan secara statistik dalam jangka pendek, sejalan dengan horizon waktu pengembangan modal manusia yang lebih panjang. Variabel penduduk berpengaruh positif, selaras dengan adanya skala ekonomi. Implikasi kebijakan mendukung agenda berorientasi kualitas: prioritaskan layanan listrik yang andal dan inklusif, alihkan anggaran jalan dari ekspansi menuju pemeliharaan dan penyelesaian jaringan, serta tingkatkan layanan primer dengan memahami bahwa peningkatan kesejahteraan memerlukan waktu.

Kata Kunci: Infrastruktur; Elektrifikasi; Puskesmas; *Fixed Effects*; Pertumbuhan Regional

INTRODUCTION

Infrastructure is widely acknowledged as a fundamental driver of sustainable growth. It affects productivity, makes it easier for markets to work together, and makes people more resistant to shocks. Classic and contemporary contributions elucidate the mechanisms by which public capital enhances private efficiency and long-term capacity, ranging from production complementarities to externalities in knowledge and human capital development (Agénor & Moreno-Dodson, 2006; Aschauer, 1989). The post-pandemic recovery policy debate highlights that strategically planned public investment can expedite reopening, stimulate private sector engagement, and foster equitable development, provided that quality and governance are maintained (International Monetary Fund, 2020).

Indonesia's policies are in line with this point of view. Infrastructure has always been at the center of the national agenda for long-term development. This is to lower logistics costs, improve connectivity across the archipelago, and make the country more competitive. In 2024, the government made it clear that providing infrastructure is linked to trade performance, welfare improvements, and attracting investment. This shows that infrastructure is seen as strategic capital for the whole economy, not just as construction (Kementerian Sekretariat Negara Republik Indonesia, 2024)

Even though everyone agrees on this at the macro level, the effect of infrastructure on growth is different in different places and sectors. Evidence from around the world shows that electricity and telecommunications usually lead to big long-term benefits. However, when quality, network design, or other conditions are poor, the short-term effects of transportation can be small or even bad. These patterns indicate thresholds and nonlinearities, such as when telecommunication networks reach a critical mass that activates productivity effects (Röller & Waverman, 2001; Timilsina et al., 2024; World Bank, 1994).

Research in developing and emerging economies consistently links better energy access to stronger economic performance, although the magnitude and timing of these effects vary with prices, reliability, and production structure. Evidence from Pakistan shows that electricity use rises with income and customer base but is dampened by price pressures and shortages, underscoring the need for dependable and affordable supply for productive use (Zaman et al., 2015). Recent Indonesian evidence indicates that infrastructure expansion can raise growth while easing inequality when basic services and transport advance together and institutions allow benefits to diffuse (Nugraha et al., 2020). Subnational research from India further finds that public infrastructure investment is positively associated with state level growth, reinforcing the importance of well-planned and well delivered projects (Das & Dutta, 2025). Complementary guidance for low and middle-income countries argues that outcomes hinge on coherent selection and implementation since weak policy choices can blunt the returns from public capital (Xu, 2024).

South Kalimantan provides a pertinent example of such heterogeneity observable over short timeframes. From 2021 to 2023, after the pandemic, differences in welfare measured by real GRDP per capita stayed large across all thirteen of its regencies and municipalities. Official statistics reveal significant disparities in economic indicators and service delivery, forming the foundation for a district-level evaluation of the infrastructure types most correlated with welfare outcomes during the recovery phase (Badan Pusat Statistik Provinsi Kalimantan Selatan, 2023).

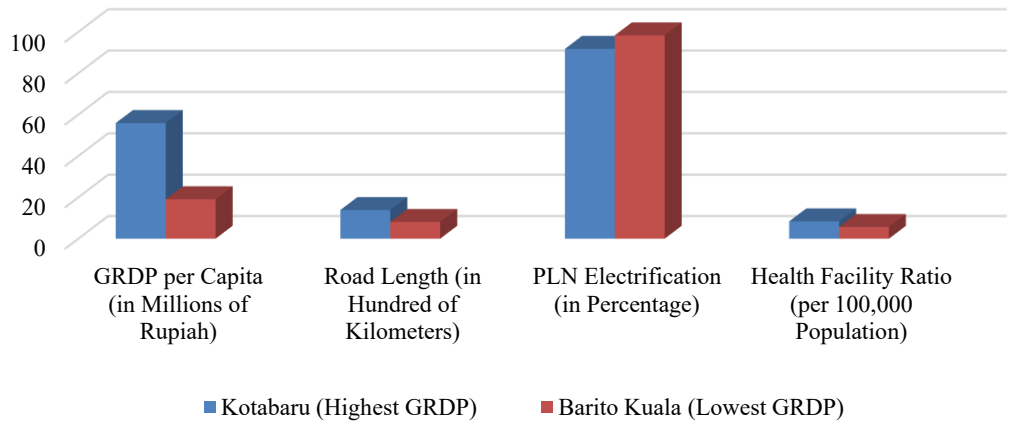

Figure 1. Comparison of Economic Conditions and Infrastructure between Kotabaru and Barito Kuala

Source: Data processed from Statistics Indonesia (BPS) publications (2021-2023).

Figure 1 shows a complicated and interesting picture. It seems that the area with a higher GRDP per capita (Kotabaru) does have a larger road network and more health facilities than the area with a lower GRDP per capita (Barito Kuala). Conversely, a significant anomaly arises: the electrification rate in Barito Kuala is nearly universal, exceeding that of the more affluent Kotabaru. This puzzle implies that the correlation between infrastructure provision and economic growth is neither linear nor uncomplicated. This observation prompts the current study to examine more thoroughly the actual empirical effects of various types of infrastructure, specifically roads, electricity, and health on regional economic growth in South Kalimantan.

This paper tackles three shortcomings. First, most Indonesian studies concentrate on pre-pandemic years or specific sectors, thereby constraining our understanding of short-term dynamics during the recovery phase. Cross-regional evidence indicates that the growth effects of various infrastructure types are inconsistent and influenced by the quality of governance, underscoring the necessity to analyze multiple sectors collectively rather than in isolation (Maciulyte-Sniukiene & Butkus, 2022). Second, there is insufficient sub-provincial evidence that simultaneously assesses transport, energy, and social infrastructure, even though policy is formulated and implemented locally where synergies are significant. Recent findings from cross-country and cross-income studies indicate that infrastructure can facilitate growth; however, the magnitude and direction of short-term effects differ across contexts. This underscores the necessity for detailed district-level analysis in Indonesia (Nisa & Khalid, 2024). Third, quality and reliability often matter more than just the quantity of stocks when it comes to effectiveness. A synthesis of macro-level evidence on electricity and development reveals significant correlations with developmental outcomes; however, there are relatively few methodologically robust causal estimates at the macro level. This indicates that meticulous empirical design is crucial, and that reliability and service quality are fundamental to impact (Burke et al., 2018).

Thus, we create a balanced administrative panel for the thirteen districts of South Kalimantan and use a two-way fixed-effects model that takes into account both time-invariant local factors and common year shocks. This method is in line with the best practices in panel econometrics for minimizing bias from unobserved heterogeneity while concentrating on short-term, policy-relevant correlations (Baltagi, 2021; Wooldridge, 2010). The contribution has two parts. Substantively, we present new evidence regarding the relationship between road length, household electrification, and primary health facilities with welfare-consistent outcomes during the recovery period from 2021 to 2023 in a resource-dependent province. Methodologically, we contextualize the local analysis within international findings that highlight asymmetric timing and the enduring significance of energy and communications. We recognize that transportation may exhibit subdued or negative short-term correlations when expansion surpasses quality or connectivity. These viewpoints align with multi-country analyses and recent state-level findings from India that associate well-planned public infrastructure with enhanced growth results (Das & Dutta, 2023; Timilsina et al., 2020).

Lastly, this framing gives us a reason to ask our main question. How do transportation, energy, and social infrastructure correlate with real GRDP per capita in South Kalimantan's regencies and municipalities during the recovery period. We established three objectives that direct the empirical sections. The first objective is to quantify the relationship among road length, electrification, health facility density, and real GRDP per capita utilizing a uniform panel design. The second goal is to provide short-term evidence that adds to longer-term findings from cross-country studies and national studies. The third is to make suggestions that provincial and district planners can use to prioritize investments when they have limited funds and want to balance short-term productivity gains with long-term improvements in human capital. We use global reviews, telecom threshold findings, energy demand evidence, and Indonesian studies on infrastructure and poverty to put our results in the context of the larger body of research. This guarantees that the discourse connects local assessments to globally recognized mechanisms and policy instruments (Nugraha et al., 2020; Röller & Waverman, 2001; Timilsina et al., 2024; World Bank, 1994; Zaman et al., 2015).

LITERATURE REVIEW

The theoretical and conceptual foundation of this study is based on both classical and contemporary growth theories that regard infrastructure as productive public capital, which improves the efficiency of private inputs and fosters long-term development. In the neo-classical framework, public capital enhances the economy's productive capacity by complementing labor and private investment; however, diminishing returns indicate that continuous growth necessitates technological advancement (Aschauer, 1989; Gramlich, 1994). Endogenous growth theories stress that infrastructure can create externalities, spread

knowledge, and improve human capital, all of which can lead to innovation and higher returns (Barro, 1991; Romer, 1990).

Regional development perspectives emphasize the spatial function of infrastructure in reducing transaction costs, enhancing accessibility, and integrating local markets, while also underscoring that convergence relies on complementary institutions and the quality of governance (Hirschman, 1973). Policy frameworks broaden the concept of infrastructure to encompass social systems such as health and education, which influence human capital and foster inclusive development (Calderon & Serven, 2010; World Bank, 1994). These frameworks inform the measurement strategy in this study, which evaluates roads for connectivity, electricity for production capacity, and primary health care for human capital.

Empirical evidence regarding the infrastructure–growth relationship is complex and varies over time, sectors, and indicators. International research frequently identifies robust correlations between electricity and economic growth, whereas the impacts of transportation fluctuate based on time frame, quality, and supplementary conditions. Evidence from Sub-Saharan Africa indicates beneficial impacts of electricity and water, while transport and ICT exhibit ambiguous or adverse correlations under specific circumstances (Abdullahi & Sieng, 2023). Cross-country evidence for numerous economies indicates substantial long-term benefits from electricity and telecommunications, whereas the short-term impacts of roads and railways may be diminished or adverse in cases of inadequate network quality or connectivity (Timilsina et al., 2020). A multi-country study on Belt and Road participants indicates that enhanced infrastructure accumulation correlates with increased growth, highlighting the necessity for synchronized investment and policy frameworks across sectors (Chin et al., 2021).

Access to energy is related to development outcomes other than income. A systematic review of health literature indicates that enhanced electricity access is typically linked to superior health outcomes and service quality, whereas inconsistent supply is associated with inferior outcomes and underutilization of services (Irwin et al., 2020). A synthesis concentrating on low and middle-income nations indicates that electrification correlates with enhancements in antenatal care quality, vaccination rates, emergency preparedness, and primary health services, thereby underscoring the significance of dependable power for frontline facilities (Khogali et al., 2022). A mini-grid in rural Tanzania shows that electrification can improve health and local economic activity right away, but it also shows that high tariffs can make it hard for more households to get electricity (Falk et al., 2021). Additional cross-country analyses corroborate that electricity consumption and reliable supply are strongly associated with development outcomes when affordability constraints are managed and when network reliability reaches serviceable quality (Meka'a et al., 2024; Timilsina et al., 2024). These results show that the benefits of developing electricity depend on more than just network reach. They also depend on reliability, affordability, and how services are delivered.

In Indonesia, district studies frequently reveal that utilities serve as more reliable indicators of performance compared to basic transport stock metrics at the subnational level. In South Kalimantan, electricity and clean water significantly account for variations in Gross Regional Domestic Product, whereas road length is insignificant in certain specifications. This indicates that quantity-based indicators may underestimate the importance of quality and effective connectivity in the short term (Dwitasari et al., 2020). A path analysis for Tapin Regency similarly indicates minimal direct effects of infrastructure and investment on employment and welfare, identifying growth as the primary determinant, which suggests indirect or delayed channels of impact (Yuaidi & Siregar, 2023). Evidence from Papua demonstrates that electricity consumption mediates the relationship between electrification and labor outcomes, suggesting that access must be converted into actual and productive use to achieve broader benefits (Karay et al., 2022). This is consistent with recent findings that digital connectivity, broadband diffusion, and network performance conditions can shape the size and timing of gains from physical infrastructure (Saha, 2024).

New empirical research emphasizes the quality, composition, and governance of infrastructure portfolios, in addition to access and quantity. A recent study in North-Eastern India finds that economic infrastructure in roads, power, irrigation, banking, and transport is positively associated with growth, reinforcing the case for balanced investments that address the weakest links in regional systems (Sajjad & Dar, 2025). Research on the quality dimension also warns that short panels and stock-only indicators can miss transportation effects that happen through network design, logistics efficiency, and maintenance. These effects become clearer over longer time periods or in situations where connectivity is the problem instead of kilometers of roadbed (Fedderke & Bogetić, 2009). Evidence from China regarding contemporary infrastructure categories, including digital and innovation-related systems, indicates that the nature of investment may influence the enhancement of growth quality, although the extent of benefits is contingent upon context and implementation (Du et al., 2022).

This review reveals two gaps. First, there is limited evidence specifically for the post-pandemic recovery period, which is important for understanding resilience and short-run productivity effects across

districts. Second, social infrastructure is seldom integrated with roads and electricity in sub-provincial contexts, notwithstanding its theoretical significance for human capital. The present study addresses these gaps by focusing on 2021 to 2023 for South Kalimantan, by introducing primary health infrastructure measured as *Puskesmas* (community health center) per one hundred thousand population, and by using real Gross Regional Domestic Product per capita to reflect welfare-consistent outcomes. The empirical design utilizes a two-way fixed-effects model with robust covariance to address unobserved heterogeneity across districts and years. This review leads to the testing of three hypotheses in the study. H1 posits that road infrastructure exerts a positive and significant influence on real Gross Regional Domestic Product per capita. H2 posits that electrification has a big and positive effect on real Gross Regional Domestic Product per person. H3 posits that health infrastructure has a big and positive effect on real Gross Regional Domestic Product per person.

METHOD

This research utilizes a quantitative methodology, employing a panel data design to examine the correlation between infrastructure and regional economic growth. Panel data, which integrates cross-sectional and time-series data, is especially beneficial as it facilitates the control of unobserved, time-invariant heterogeneity among individual units, thus yielding more robust estimates than cross-sectional data alone (Baltagi, 2021). The dataset is a balanced panel that includes all 13 regencies and municipalities in South Kalimantan province. It was collected over three years, from 2021 to 2023. There are 39 observations in total (13 cross-sections times 3 periods). All secondary data were obtained from official publications by Statistics Indonesia (BPS).

The study includes one dependent variable, three key independent variables, and one control variable. To mitigate issues of multicollinearity and to interpret the coefficients as elasticities, a natural logarithm transformation was applied to non-percentage and non-ratio variables (Gujarati & Porter, 2009).

Table 1. Operational Definition of Variables

Variable	Code	Operational Definition	Unit/Transformation
GRDP per capita (constant prices)	GRDP	Gross Regional Domestic Product per capita at constant 2010 prices	Rupiah per capita, Ln
Road length	ROAD	Total road length by regency/municipality	Kilometers, Ln
Electricity access	ELEC	Percentage of households with PLN electricity connection	Percent (%)
Health facilities	HEALTH	Number of *Puskesmas* per 100,000 population	Units per 100,000 people
Population	C	Total population of each regency/municipality	Persons, Ln

Source: Author's estimation results using EViews 13 (2025).

With the help of EViews 13 software, the data were analysed using panel data regression. The main goal of panel data analysis is to find unobserved differences that might be related to the independent variables (Wooldridge, 2010). A systematic selection process was used to find the best model based on the empirical results.

The Chow Test was conducted to differentiate between the Pooled Ordinary Least Squares (OLS) model and the Fixed Effect Model (FEM). The Chow test checks for individual-specific effects by looking at whether the intercepts are the same across all cross-sections (Gujarati & Porter, 2009).

Second, the Hausman Test was performed to differentiate between the Fixed Effect Model (FEM) and the Random Effect Model (REM). The Hausman test checks to see if the unobserved individual effects (μi) are related to the regressors (Hausman, 1978). The overall structure of the panel data regression model employed in this research can be articulated as follows:

$$GRDP_{it} = \beta 0 + \beta ROAD_{it} + \beta 2ELEC_{it} + \beta 3HEALTH_{it} + \beta 4POP_{it} + \mu_i + \tau_t + \varepsilon_{it}$$

This specification enables the study to assess the impact of infrastructure indicators (roads, electricity, and health facilities) on regional economic performance, while accounting for population size, and addressing unobserved heterogeneity across regencies and years through fixed effects. We use a two-way fixed effects model to make estimates that take into account possible heteroskedasticity and autocorrelation. Standard errors are grouped by cross-section.

RESULTS AND DISCUSSION

Table 2 shows the descriptive statistics for the variables used in this analysis. It covers 13 regencies and municipalities in South Kalimantan from 2021 to 2023, giving us a balanced panel of 39 observations. The table shows the central tendency, dispersion, and range for the region's real Gross Regional Domestic Product (GRDP) per capita, road length, household electrification, the density of primary health facilities, and total population. This gives a basic picture of the region's economy and infrastructure.

Table 2. Descriptive Statistics

Indicator	Mean	Standard Deviation	Minimum	Maximum
GRDP	32,829	11,265	18,393	57,527
ROAD	1,114	448	506	2,072
ELEC	98.42%	2.59%	90.68%	99.99%
HEALTH	6.53	2.05	2.9	9.13
POP	338,384	148,465	131,000	675,500

Source: Author's estimation results using EViews 13 (2025).

The summary statistics in Table 2 reveal considerable variation across the panel. Most notably, real GRDP per capita exhibits a wide dispersion, with a standard deviation of 11,265 thousand Rupiah and a maximum value more than three times the minimum. This highlights the significant economic disparity that exists within the province. In terms of infrastructure, household electrification is consistently high with a mean of 98.42% and low variation, suggesting near universal access. Conversely, road length and the density of health facilities show substantial variation, indicating an uneven distribution of physical and social infrastructure across the regions. These initial findings underscore the heterogeneity of the panel and motivate the use of a fixed effects model to control for these underlying regional differences in the subsequent regression analysis.

Before proceeding to the main estimation, a systematic procedure was conducted to select the most appropriate panel data regression model. This involved performing the Chow Test and the Hausman Test to compare the suitability of the Pooled Ordinary Least Squares (OLS), Fixed Effect Model (FEM), and Random Effect Model (REM).

First, the Chow Test was conducted to determine whether the individual-specific effects are constant across all regions, thereby choosing between the Pooled OLS and Fixed Effect models. The results are presented in Table 3.

Table 3. Results of Chow Test

Effects Test	Statistic	d.f.	Prob.
Cross-section F	2204.552190174043	(12,22)	5.672682068168099e-31
Cross-section Chi-square	276.6260305500986	12	3.736154956581888e-52

Source: Author's estimation results using EViews 13 (2025).

The null hypothesis of the Chow test, which states that the Pooled OLS model is adequate, is strongly rejected as both the F-statistic and Chi-square statistic have probabilities of 0.0000. This indicates the presence of significant individual-specific effects, making the Fixed Effect Model statistically superior to the Pooled OLS model.

Second, the Hausman Test was performed to decide between the Fixed Effect Model and the Random Effect Model. This test assesses whether the unobserved individual effects are correlated with the regressors. The results are summarized in Table 4.

Table 4. Results of Haussman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	87.65931562678758	4	4.136060586427173e-18

Source: Author's estimation results using EViews 13 (2025).

The null hypothesis of the Hausman test posits that the individual effects are uncorrelated with the explanatory variables, favoring the Random Effect Model. With a Chi-Square probability of 0.0000, this null hypothesis is decisively rejected. This result confirms that a correlation exists, and therefore, the Fixed Effect Model is the consistent and appropriate estimator for this analysis. Based on the outcomes of both the Chow and Hausman tests, this study proceeds with the Fixed Effect Model for the final estimation and interpretation.

Following the model selection procedure, the panel data were estimated using a two-way Fixed Effects Model (FEM) with robust standard errors to account for potential heteroskedasticity. With an Adjusted R-squared of 0.9989, the model fits the data very well. This high value is typical of fixed-effects models because it shows that time-invariant regional differences, which are shown by the cross-sectional fixed effects, account for a large part of the change in real GRDP per capita. The F-statistic is highly significant ($p < 0.01$), confirming the model's overall validity and explanatory power. The detailed regression output containing the coefficients, standard errors, and t-statistics for each variable is presented in Table 5.

Table 5. Two-Way Fixed Effect Model Regression Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ROAD	-0.2149	0.0835	-2.5731	0.0173
ELEC	0.0118	0.0057	2.0799	0.0494
HEALTH	-0.0078	0.0161	-0.482	0.6346
POP	3.0336	0.2057	14.7449	0
Constant	-20.5021	2.4102	-8.5065	0
Adjusted R-squared	0.9989			
F-statistic	2364.04		Prob(F-stat)	0
Observations	39			

Note: Standard errors are robust to heteroskedasticity (White cross-section).

Source: Author's estimation results using EViews 13 (2025).

Electrification becomes economically and statistically significant. The coefficient for household electrification is positive and statistically significant at standard levels, with an estimated semi-elasticity of approximately 1.18 percent. This indicates that a one percentage point increase in the proportion of electrified households correlates with a roughly 1.18 percent increase in real GRDP per capita, assuming other variables remain constant. In practical terms, going from 95% to 98% coverage is linked to a 3.5% rise in output per person. This amount is in line with what we know from other countries: when energy infrastructure is reliable and cheap, it can quickly boost productivity because it lets households and small businesses buy appliances that save time and make money and stay open longer. It also fits with what we know about electrification: its benefits are strongest when service quality and reliability are guaranteed, not just when the number of connections grows, as shown in recent cross-country syntheses and health-systems reviews that show better service performance with reliable power (Irwin et al., 2020; Khogali et al., 2022; Timilsina et al., 2020).

On the other hand, road infrastructure has a negative effect on welfare in the short term. The coefficient on the road length is negative and statistically significant. This means that a one percent increase in total road kilometers is linked to a drop of about 0.215 percent in real GRDP per capita. This pattern may seem strange at first, but it makes sense with a growing body of research that shows that investments in transportation can have weak or even negative short-term effects when network quality, route, and logistics performance are the most important factors. During the early years of expansion, new kilometers add maintenance costs before productivity gains are seen. Construction may focus on lower-return areas that don't yet connect production center to markets, and measuring based on length can hide problems like bad surface conditions, bottlenecks at junctions, or last-mile gaps. Cross-country studies also show that roads and rail often don't pay off as quickly as electricity and telecommunications do, unless certain conditions are met. Upgrading quality and connectivity usually leads to benefits over longer periods of time, rather than right away (Fedderke & Bogetić, 2009; Timilsina et al., 2024).

Health infrastructure seems to have no effect on the short three-year panel, but this shouldn't be taken to mean that it isn't important. The capacity of primary care usually impacts output via human capital channels that build up over time, such as healthier employees with fewer days absent and improved

cognitive performance. These effects are well-known, but they usually take longer to show up in macroeconomic indicators. This lack of significance supports the idea that it may take more than a few years for improvements in service coverage and quality to show up as measurable increases in per capita output at the district level (Bloom et al., 2004).

The large and very important control for population shows that agglomeration economies are present. Larger districts tend to have more scale, specialization, and knowledge spillovers, which makes each person more productive. This supports the idea that spatial organization affects the benefits of infrastructure. Investments can take advantage of thicker markets and shared services when density is high and connectivity is good. However, in thin markets, the same investments may not do as well in the short term.

These results, when looked at all together, support an infrastructure strategy that puts quality first. In terms of energy, policy should focus on closing the last-mile electrification gap while keeping costs low and reliability high so that households and small businesses can use electricity that they have access to. The findings suggest that instead of adding length to existing corridors, we should focus on improving their condition and connectivity, fixing important links, shortening travel times, and making logistics easier so that businesses can get to their suppliers and customers. To improve health, the right thing to do is to keep investing in primary care and keep an eye on intermediate indicators like service quality, utilization, and workforce productivity. This is because macroeconomic effects are likely to take longer to show up. A few more robustness extensions would make the evidence base even stronger. Instead of total length, use quality or performance metrics like the percentage of paved or good-condition roads, the average travel time to market, or the cost of freight per ton-kilometer. This would make the transport measure fit with the mechanisms that theory and practice show. Adding lags to infrastructure variables would help show effects that happen later, especially for roads and health facilities. Normalizing physical stocks by area or population may expose density or intensity effects. Looking at how urbanization, industrial structure, and distance to ports affect heterogeneity would show where bad transport links turn good once connectivity thresholds are reached. For the short panel, it is still right to cluster standard errors at the district level, as has already been done.

From a policy sequencing point of view, the electrification result shows that there are short-term benefits that can be acted on even when money is tight. The road result, on the other hand, warns against thinking that more kilometers mean better economic performance. Putting money back into maintenance backlogs, finishing networks at important bottlenecks, and managing logistics can help get more out of past investments. Continuing to make primary health care more professional will pay off in terms of productivity in the medium term. These benefits won't be fully clear for three years, but they are necessary for inclusive growth. The overall pattern of coefficients is similar to what other studies have found: energy infrastructure is a fast-acting enabler, transport is quality- and connectivity-dependent in the short run, and social infrastructure is a long-run productivity driver once service delivery improvements have time to build up.

CONCLUSION

The analysis demonstrates that not all infrastructure yields identical short-term economic benefits. From 2021 to 2023, districts with more households that had electricity had higher real GRDP per capita. This shows that reliable and cheap power can lead to short-term productivity gains. On the other hand, longer roads were linked to lower welfare, which shows that road quality, strategic connectivity, and logistics performance are more important than just the number of kilometers in the recovery horizon. Health infrastructure did not have an immediate impact on per capita output, which aligns with a longer maturation process via enhancements in human capital. The population's strong positive coefficient shows that scale and density make infrastructure benefits even better.

So, policy should shift from expanding based on quantity to focusing on quality. To make sure that households and small businesses can use energy productively, close the last-mile gap and make sure that it is always available. To cut down on travel time and make it easier for people to get to markets, put maintenance backlogs, corridor rehabilitation, and bottleneck removal at the top of your list of things to do. In health, keep strengthening primary care and keep an eye on intermediate service-quality indicators, knowing that there will be some lagged macro effects. The results confirm the efficacy of two-way fixed effects for short administrative panels and underscore the importance of augmenting stock measures with reliability and performance metrics. Future research should broaden the panel, integrate direct quality indicators for roads and electricity, and investigate heterogeneity by urbanization and sectoral structure to elucidate the pathways through which infrastructure fosters inclusive regional growth.

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