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Article

Enhancing regional well-being: An assessment of how infrastructure investments affect gross territorial product

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Abstract: The role of infrastructure in promoting regional well-being has gained significant attention. Infrastructure is critical in integrating the regional economy, multiplying economic development, and improving quality of life. Effective decision-making is crucial to maximize the return on these capital investments. This study assesses infrastructure investments' short-term and long-term impacts. Short-term efficiency is evaluated through the multiplier effect on other sectors, while long-term efficiency focuses on the influence on economic growth. A polynomial model is constructed using regression analysis based on investments in highway construction projects and the corresponding dynamics of gross territorial product in surrounding areas. This model explains the nature of the multiplier impact of transport infrastructure investments. This study significantly contributes to understanding how infrastructure investments can be strategically targeted to enhance economic growth and regional well-being, providing valuable insights for researchers, policymakers, and professionals in economics, urban planning, and infrastructure development.

Keywords: infrastructure investment; regional well-being; multiplier effect; gross territorial product; polynomial model; transport infrastructure

1. Introduction

The relationship between infrastructure investment and regional development is a complex and multifaceted subject that has garnered significant attention in academic and policy circles. While numerous studies have explored the broad connections between infrastructure, economic growth, and regional outcomes, there remains a pressing need for more nuanced research to elucidate the specific mechanisms and effects at play (Rokicki and Stępniak, 2018; Zhu et al., 2023). The existing literature suggests that infrastructure investments can yield both immediate and long-term benefits. In the short term, these initiatives can act as economic catalysts, stimulating activity across various sectors through a multiplier effect (Pereira and Pereira, 2019; Rokicki and Stępniak, 2018). However, the long-term advantages may be even more substantial, as robust infrastructure can facilitate labor mobility, enhance communication networks, and foster overall economic expansion (Palei et al., 2022). These potential benefits underscore the importance of continued research in this field to inform policy decisions and optimize the impact of infrastructure investments on regional development.

Despite the apparent advantages, the link between infrastructure spending and local prosperity is not always straightforward or universally positive. Infrastructure projects can place significant strain on regional finances due to ongoing maintenance costs and regulatory compliance requirements (Sebayang and Sebayang, 2020). Moreover, the current literature often falls short in delineating the precise mechanisms through which infrastructure influences regional outcomes (Srinivasu and Rao, 2013; Xueliang, 2013). To address these knowledge gaps, this study focuses on the impact of transportation infrastructure investment on the economy and well-being of the Russian Republic of Tatarstan, specifically examining the Shali (M-7)—Bavly (M-5) highway, which forms part of the new Europe-Western China international route. By investigating both the short- and long-term effects of this particular infrastructure project, the study aims to provide methodological tools for evaluating and justifying investments in regional infrastructure (Du et al., 2022; Helal, 2023). This research endeavors to answer critical questions regarding the relationship between transportation infrastructure investments and Gross Territories Product (GTP) growth rates, the existence of a multiplier effect on local economies, and the methods available for quantifying the financial impact of transportation infrastructure on regional prosperity and economic growth.

Based on the information provided and the current gaps in the literature, here are two additional research questions that could help address the existing knowledge gap:

- How does the spatial distribution of transportation infrastructure investment within a region influence the distribution of economic benefits and social well-being across different localities?
- To what extent do the long-term environmental impacts of transportation infrastructure projects offset or complement their economic benefits in terms of overall regional sustainability?

These questions aim to explore more nuanced aspects of infrastructure investment impacts, focusing on spatial dynamics and the balance between economic and environmental outcomes, which appear to be underexplored in the current literature as described.

2. Literature review

2.1. Transportation infrastructure and economic growth

The relationship between transportation infrastructure investment and economic growth has been extensively studied in academic literature. Rather than a broad examination of infrastructure and regional development, this review will focus on the impact of transportation infrastructure, particularly road networks, on economic growth.

Previous studies have consistently found a positive correlation between road infrastructure and gross domestic product (GDP) per capita. Queiroz and Gautam (1992) analyzed data from 98 countries and found a continuous and substantial association between GDP per capita and paved road length per capita. Their time series analysis in the US since 1950 corroborated this finding. The data shows that high-income countries have significantly better road infrastructure per capita than middle- and low-income countries. For example, the average density of paved roads (km/million inhabitants) is 170 in low-income nations, 1660 on average, and 10,110 in high-income countries, with the latter being in low-income countries. Road conditions also affect economic development, with the average density of good-condition paved roads (km/million inhabitants) being 40 in low-income nations, 470 in the Middle East, and 8550 in industrialized countries.

While the causal relationship between income and road infrastructure remains debated, investing in roads is generally considered an effective way to boost economic growth (Collier et al., 2015). Improved road networks can enhance access to markets, resources, and jobs, increasing trade, productivity, and earnings (Zhu et al., 2023). This attracts further business and investment, creating a self-reinforcing cycle of economic development (Magazzino and Mele, 2021).

Scholars have employed various methods to quantify the impact of transportation infrastructure on economic growth. The most common approach is production functions, typically the Cobb-Douglas form, which provides a straightforward analytical framework (Cheng and Han, 2013). However, this method may struggle to capture detailed cost structures and the differences between public and private capital. Behavioral methods that calculate infrastructure capital-based cost or profit functions offer more flexibility but still face issues of causation and endogeneity (Rodríguez-Sanz and Rubio Andrada, 2023).

Vector autoregression (VAR) models have been used to overcome these limitations by applying economic constraints to determine the impact of infrastructure investment on economic growth (Lütkepohl, 2013). While more complex, VAR models may better understand the dynamic relationship between transportation infrastructure and GDP. Cross-sectional industry regression analysis of investment spending is another approach that examines how government spending affects infrastructure capital in specific industries (Okolo et al., 2018). This strategy, while useful for targeted analysis, may not capture the macroeconomic implications of infrastructure investment.

The scholarly literature has long shown a link between economic growth and transportation infrastructure. Investing in transportation infrastructure has been proven to positively correlate with a number of economic variables, including GDP, employment, and productivity (Lu, 2024; Moljevic, 2016). This is so that a region's economic potential can be realized through transportation infrastructure, which speeds up communication, cuts down on travel time, and encourages the sharing of ideas and information between companies and individuals. Transportation networks can support the emergence of new sectors, the expansion of already-existing ones, and the creation of job opportunities as they become more accessible and efficient. These factors all contribute to the general development and growth of the economy.

2.2. Infrastructure and regional development

Infrastructure development and a region's overall economic growth and competitiveness are closely related. Regional development strategies require well-developed infrastructure networks, such as energy grids, transportation systems, communication networks, and social service facilities (Zhou et al., 2021). By reducing the costs associated with transportation and logistics, this interconnection promotes economic growth and opens up markets for consumers and businesses. This can result in higher levels of investment, productivity, and business opportunities.

The quantity and caliber of an area's infrastructure greatly affects its ability to compete economically (Alonazi et al., 2023; Malecki, 2017). Strong infrastructure can draw in capital, generate employment, and strengthen the economy as a whole (Srinivasu and Rao, 2013). A region's ability to attract firms, investors, and talented workers is directly related to the quality of its infrastructure. This includes contemporary communication systems, dependable energy sources, and effective transportation networks. These factors all play a major role in the region's economic development and progress. On the other hand, areas with antiquated or inadequate infrastructure would find it difficult to adapt to the quickly shifting economic environment, which could result in economic stagnation or downturn.

Investments in infrastructure can affect regional growth in the near and long terms. During the construction period, infrastructure projects have the potential to generate employment opportunities and stimulate the economy in the short term (Pereira and Pereira, 2019).

Long-term funding and corporate attraction are two further ways that well-maintained infrastructure may boost the region's economic potential. An area's capacity to compete and prosper in the global economy can be significantly impacted by infrastructure investment through enhancing connectivity, lowering transportation costs, and easing the movement of people, products, and services.

knowledge the larger relationship between infrastructure and economic growth requires a knowledge of the interdependencies between transportation infrastructure and regional development. Because they are better able to allow the movement of people, products, and services, well-developed transportation networks are associated with higher levels of economic activity. This is because they encourage economic development and competitiveness. This emphasizes how crucial it is to make calculated investments in transportation infrastructure as part of an all-encompassing regional development plan.

3. Materials and methods

The Shali (M-7)—Bavly (M-5) highway construction project presented a unique opportunity to analyze the economic impacts of a large-scale transportation infrastructure investment. The 294 km highway was jointly funded by the governments of Russia and the Republic of Tatarstan, helping to avoid issues of endogeneity that can arise when modeling the relationship between infrastructure spending and economic outcomes. The construction project of the Shali (M-7)—Bavly (M-5) highway (294 km long, estimated speed—150 km/h) as part of the Europe-Western China international transport corridor creation was launched in 2005 and was planned to be completed by 2019. The construction of the highway is conditionally divided into four sections: "Shali (M-7)—Sorochya Gory"—40 km; bridge crossing over the Kama River near the village of Sorochya Gory—14 km; "Alekseevskoye—Al-metyevsk"—145 km; Almetyevsk—Bavly (M-5)—95 km.

The project aimed to strengthen international trade links as part of a longer Asia-Europe transport corridor, with objectives outlined in Russia's national transportation development strategy. At the time of writing, 294 km of the highway stretching across four sections in Tatarstan had been completed according to schedule, though portions of two sections remained under ongoing construction. We would anticipate both short-term effects from job creation during build-out and longer-term impacts stemming from increased trade flows, transportation cost savings, and future toll revenue collections once the project is fully operational.

To assess these impacts quantitatively, we obtained time series data on annual GDP, industrial output, and other indicators for Tatarstan covering 2005 to 2019 from the national statistics authorities of Russia. **Table 1** now provides descriptive statistics on the key variables to characterize the data used in our analysis. The Almon Polynomial Distributed Lag model was deemed suitable to capture the likely lagged effects of the infrastructure investment on economic outcomes based on our literature review. We established a maximum lag length of four years for the distributed lag specification based on the project timeline to avoid overfitting, but also estimated longer distributed lag response patterns up to nine years as found in prior studies. Model selection was guided by minimizing information criteria to identify the optimal lag structure, with the four-year specification showing the best fit to the data.

Table 1. Initial and transformed data on investments in the Shali-Sorochy Gory road (M7) construction and the total GRP of the nearby Alekseevsky and Rybno-Slobdsky districts, mln. Rub.

Year	GTP	Inv_t	Inv_{t-1}	Inv_{t-2}	Inv_{t-3}	Inv_{t-4}	Z_0	Z_1	Z_2	Z_3
2005	250,596	3.46								
2006	305,086	3.22	3.46							
2007	391,116	3.33	3.22	3.46						
2008	4,827,592	3.40	3.33	3.22	3.46					
2009	6,059,115	3.50	3.40	3.33	3.22	3.46	16.91	33.56	101.06	338.42
2010	7,574,014	3.55	3.50	3.40	3.33	3.22	17.00	33.17	98.59	326.69
2011	9,260,567	3.58	3.55	3.50	3.40	3.33	17.36	34.07	101.43	336.47
2012	885,064	3.62	3.58	3.55	3.50	3.40	17.65	34.78	103.68	344.08
2013	1,001,623	3.72	3.62	3.58	3.55	3.50	17.97	35.43	105.89	352.11
2014	1,305,947	3.84	3.72	3.62	3.58	3.55	18.31	35.90	107.22	356.54
2015	1,437,001	3.60	3.84	3.72	3.62	3.58	18.36	36.46	108.58	360.46
2016	1,551,472	1.40	3.60	3.84	3.72	3.62	16.18	36.92	110.36	366.44
2017	16,714	2.80	1.40	3.60	3.84	3.72	15.36	35.00	109.88	371.96
2018	18,250	2.80	2.80	1.40	3.60	3.84	14.44	31.76	102.24	356.96

Thus, as an example, we analyzed the impact of the Shali (M-7)—Bavly (M-5) highway construction project on the economy of the Republic of Tatarstan (Rus-sia). The transit volume of goods from Asia to Europe through the territory of the Russian Federation is about 20 million tons, with one-third going through the territory of the Volga Federal District. Moreover, in the next two decades, at least a fivefold increase in the volume of freight traffic in Russia is predicted. The time of goods delivery along the new Europe-Western China international corridor is half the time for the delivery of goods by another road.

To assess the impact of transport infrastructure on regional productivity, we employed the Almon Polynomial Distributed Lag (PDL) model, which Shirley Almon proposed in 1965 (Almon, 1965). Roibás and Baños (2010) utilized the Almon PDL model to analyze the dynamic impact of infrastructure on Spanish provinces from 1986 to 2006. Their results were comparable to those obtained from other dynamic approaches applied to the Spanish economy, such as vector autoregression by Bajo-Rubio and Sosvilla-Rivero (1994) and Pereira and Roca-Sagalés (2003) production function. The study by Roibás and Baños (2010) is particularly relevant to our research. It demonstrates that the impact of infrastructure on the economy is not immediate, reflecting the time required for deploying productive forces. They found a complete influence period of 9 years, with an immediate elasticity of 0.06 and an accumulated elasticity of 0.25 over the entire 9-year period.

Besides, the Almon Polynomial Distributed Lag (APDL) model has been employed in various studies. Nevondo et al. (2019) applied it to estimate the lead period and return on investment in beef cattle improvement using time series data from 1970–2014. Lu and Deng (2012) investigated the relationship between fixed asset investment and telecommunication business revenue with this model. Giussani and Tsolacos (1994) developed an econometric model of investment in UK industrial buildings using quarterly data from 1957 to 1991, also utilizing the APDL model. These applications demonstrate the versatility of the APDL model in analyzing the effects of investment on various outcomes, including revenue forecasts.

In the Polynomial Distributed Lag model, it is assumed that the dependence of coefficients at explanatory variable lag values on the lag value is described by an m-degree polynomial (Almon, 1965). The model has the form:

$$y_t = \alpha + \beta_0 x_t + \beta 1 x_{t-1} + \dots + \beta p x_{t-p} + \varepsilon t \quad (1)$$

where:

y—is the value at time period t of the dependent variable y,

x—is an explanatory variable,

α—is the intercept term to be estimated,

βi—is called the lag weight (also to be estimated) placed on the value i periods previously of the explanatory variable x,

ε—is the error term,

p—is the value of the lag, $m \leq p$, $\beta s = \alpha_0 + \gamma_1 S + \gamma_1 S_2 + \ldots + \gamma m S m$.

In our study, we determine the actual value of the lag through a rigorous process. We construct several regression equations and then choose the best parameters. Another approach we take is to focus on formal criteria, such as the Schwartz criterion (Schwarz, 1978), or a method for measuring the tightness of the relationship between the result and the lag values of the factor. The degree of polynomial must be one more than the number of extremes in the lag structure. Additionally, the optimal value of the lag aids in determining a priori economic information or previously conducted empirical studies. In cases where a priori information about the lag structure is unavailable, the value of the lag p is determined by comparing models constructed for different p values and then selecting the best one, a process we have thoroughly explained. There are two undoubted advantages of the Almon Method. Firstly, it is remarkably versa-tile, as it can be used for modeling processes characterized by various structures of lags. Secondly, it can be used to build models with a distributed lag of any length if we consider a relatively small number of variables that do not lead to the loss of a significant number of degrees of freedom. However, it is essential to note that the Almon Method has a limitation- it can only be applied when the number of variables is limited to 2–3.

4. Results and discussion

According to **Table 1** which shows the initial and converted data on investments in the Shali—Sorochy Gory Road (M7) construction and the total Gross territorial product of the nearby Alekseevsky and Rybno-Slobdsky districts. The first two columns present the initial data on the total Gross territorial product of the nearby Alekseevsky and Rybno-Slobdsky districts and investments in the infrastructure project. Next, the original data is presented with a lag from 1 to 4 in the four columns. In the last four columns, the converted data is given according to the formula:

$$\begin{aligned} Z_0 &= x_t + x_{t-1} + x_{t-2} + x_{t-3} + x_{t-4}; \\ Z_1 &= x_{t-1} + 2x_{t-2} + 3x_{t-3} + 4x_{t-4}; \\ Z_2 &= \mathrm{x}_{t-1} + 4x_{t-2} + 9x_{t-3} + 16x_{t-4}; \\ Z_3 &= x_{t-1} + 8x_{t-2} + 27x_{t-3} + 64x_{t-4}; \end{aligned} \quad (2)$$

We constructed a distributed lag model for $p = 4$, assuming that a third-degree polynomial describes the lag structure.

If $p = 4$ and $m = 3$, then the original model:

$$y_t = \alpha + \beta_0 x_t + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \beta_3 x_{t-3} + \beta_4 x_{t-4} + \varepsilon_t \quad (3)$$

where,

$\beta_0 = \gamma_0$; $\beta_1 = \gamma_0 + \gamma_1 + \gamma_2 + \gamma_3$; $\beta_2 = \gamma_0 + 2\gamma_1 + 4\gamma_2 + 8\gamma_3$; $\beta_3 = \gamma_0 + 3\gamma_1 + 9\gamma_2 + 27\gamma_3$; $\beta_4 = \gamma_0 + 4\gamma_1 + 16\gamma_2 + 64\gamma_3$

The converted model has the form

$$y_t = \alpha + \gamma_0 z_0 + \gamma_1 z_1 + \gamma_2 z_2 + \gamma_3 z_3 + \varepsilon_t \quad (4)$$

where,

$$z_0 = x_t + x_{t-1} + x_{t-2} + x_{t-3} + x_{t-4};\ z_1 = x_{t-1} + 2x_{t-2} + 3x_{t-3} + 4x_{t-4}$$
$$\mathrm{z}_2 = x_{t-1} + 4x_{t-2} + 9x_{t-3} + 16x_{t-4};\ \mathrm{z}_3 = x_{t-1} + 8x_{t-2} + 27x_{t-3} + 64x_{t-4}$$

Next, using the Ordinary Least Squares (OLS), we estimate the parameters of the transformed model and then calculate the parameters of the original model with a distributed lag. The estimated initial model has the form (P-values are shown in parentheses for testing statistical hypotheses):

$$\underset{(0.11)}{y_t = 7.29} + \underset{(0.048)}{0.24x_t} + \underset{(0.026)}{1.03x_{t-1}} + \underset{(0.033)}{0.08x_{t-2}} + \underset{(0.047)}{1.148x_{t-3}} + \underset{(0.009)}{5.61x_{t-4}},\ R^2 = 0.86 \quad (5)$$

The estimated transformed model has the form:

$$\hat{y}_t = \underset{(0.25)}{-29.31} + \underset{(0.002)}{1.05z_0} + \underset{(0.018)}{0.42z_1} + \underset{(0.004)}{0.12z_2} + \underset{(0.0047)}{0.03z_3},\ R^2 = 0.94 \quad (6)$$

Moreover, all coefficients for variables are significant. The following estimates of the parameters of the transformed model were obtained:

$$y_0 = 0.88,\ y_1 = 0.42,\ y_2 = 0.12,\ y_3 = 0.03$$

The regression coefficients of the original model are:

$$\beta_0 = 1.05$$
$$\beta_1 = 1.05 + 0.42 + 0.12 + 0.03 = 1.62$$
$$\beta_2 = 1.05 + 2 \times 0.42 + 4 \times 0.12 + 8 \times 0.03 = 2.61$$
$$\beta_3 = 1.05 + 3 \times 0.42 + 9 \times 0.12 + 27 \times 0.03 = 4.2$$
$$\beta_4 = 1.05 + 4 \times 0.42 + 16 \times 0.12 + 64 \times 0.03 = 6.57$$

Thus, a model with a distributed lag has the form:

$$\hat{y}_t = -29.31 + 1.05x_t + 1.62x_{t-1} + 2.61x_{t-2} + 4.2x_{t-3} + 6.57x_{t-4} \quad (7)$$

We align with Roibás and Baños (2010) on firms' strategic decision-making in response to transport infrastructure, which occurs with a time lag. This infra-structure not only accelerates communications but also amplifies the competitive advantages of regions. Firms strategically choose locations with robust transport infrastructure projects to enhance their competitiveness. However, the redistribution of productive forces is not immediate. However, investments in transport infrastructure empower local firms to transition from their original activities to more profitable ones (Collier et al., 2015). This new investment infrastructure paves the way for specific opportunities for economic growth by optimizing pre-existing resources (Zhu et al., 2023). Nonetheless, there exists a time lag between the creation of infrastructure opportunities and the response of the private sector, highlighting the strategic role of policymakers and professionals in shaping regional development.

Therefore, we have a short-term multiplier of 1.05 and a long-term multi-plier of 6.57. This result means that an increase in investment in the highway's construction by one conventional unit will increase the GTP of the nearest districts by an average of 1.05 conventional units in the current period and 6.57 conventional units in four years.

In addition, based on the available data, we have built a quarterly forecast trend of the infrastructure project's annual impact on the gross territorial product of the Rybno-Slobodsky and Alekseevsky districts from 2005 to 2024 (see **Figure 1**).

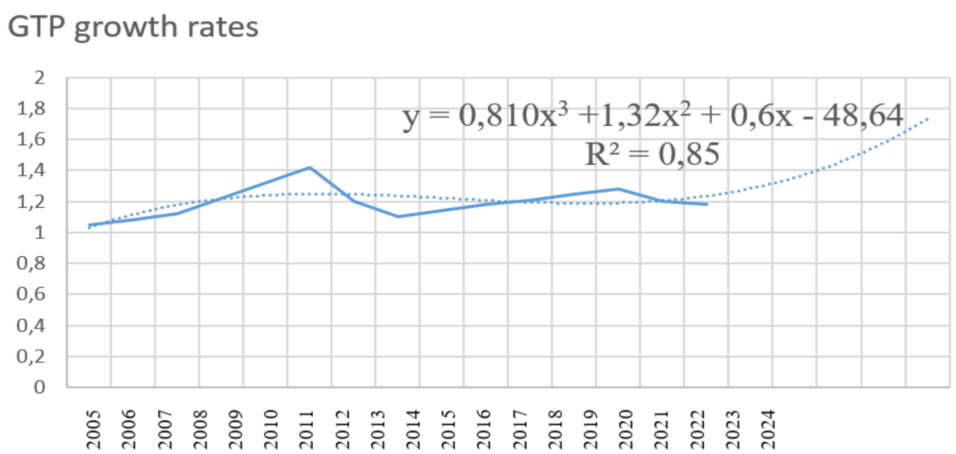

Figure 1. Analysis of the impact of investments in an infrastructure project on the growth rate of the Gross Territorial Product of the nearest districts (Rybno-Slobodsky and Alekseevsky) from 2005 to 2024 years.

The graphical representation of the model in **Figure 1** shows that the impact of infrastructure on the production of GTP is divided into four observed and one forecast period. During the first seven years, infrastructure investment increased the growth rate of GTP growth by creating jobs. i.e., transport infrastructure's initial impact is related to the economic activities planned during the infrastructure construction. Within seven periods from the beginning of the infrastructure construction, the new economic activity generated by this infrastructure ends, and it takes some time to explore new opportunities and physically move the activities of firms. Then, before the infrastructure is built and put into operation, its impact on the production of GTP is positive, but it decreases. Further, the fore-cast shows an increase in the impact of infrastructure investment on the growth rate of GTP due to indirect effects.

Systematic investment in infrastructure can catalyze regional economic growth (Palei et al., 2022). This can be achieved through improvements in the distribution of productive industries, strategic economic zoning, and the creation of growth hubs (Du et al., 2022). Furthermore, well-developed infrastructure fosters a favorable investment climate, attracting businesses and promoting cluster development in vital economic sectors (Hooper et al., 2020). Additionally, it supports small business formation by providing the necessary infrastructure and fostering an environment that stimulates entrepreneurial activity (Daradkeh et al., 2023). The positive externalities extend beyond the region, enhancing its transit attractiveness and facilitating the development of foreign economic activity and interregional cooperation. Most importantly, it unlocks the region's full potential for territorial collaboration and strategic growth, underscoring the broader bene-fits of infrastructure investment (Palei et al., 2022).

5. Conclusions, implications, and limitations and future research

The polynomial regression model developed in this comprehensive study, based on intricate indicators of infrastructure project investment and Gross Territorial Product (GTP) of the nearest regions, unveils a complex and multi-faceted relationship between infrastructure investment and regional economic growth. This relationship, unfolding across four meticulously observed periods and one carefully forecast period, provides a nuanced and in-depth understanding of how infrastructure investments impact regional well-being over an extended timeframe. The model's ability to capture both short-term fluctuations and long-term trends offers a holistic view of the economic ripple effects caused by significant infrastructure projects, shedding light on the intricate dynamics at play in regional development. Our findings make a substantial contribution to the theoretical understanding of infrastructure investment's role in regional economic development, challenging and expanding upon existing paradigms.

The observed relationship between investment and GTP growth proves to be far more intricate than previously conceptualized in economic literature, revealing a multifaceted pattern that begins with an initial surge in project activity and job creation. This initial boost, often characterized by heightened economic activity and increased employment opportunities, is followed by a plateau and subsequent period of diminishing returns during the prolonged construction phase. This observation aligns with the concept of economic cycles but adds a layer of complexity specific to large-scale infrastructure projects. Importantly, the model captures a significant revival in economic activity after project completion, highlighting the enduring and far-reaching impact of functional infrastructure on regional economies. This resurgence supports the notion of delayed benefits from infrastructure investments, a concept that has been underexplored in existing economic models but holds significant implications for long-term regional planning and development strategies. A key innovation of this study is the introduction of a "short-term multiplier" as a practical and quantifiable measure for evaluating the immediate economic effects of infrastructure spending on regional growth.

This new idea has the potential to significantly improve the theoretical frameworks currently in use to evaluate the effectiveness of infrastructure expenditures by giving a more precise and complex picture of their short-term effects. By providing a concrete measure that connects theoretical economic models with real-world policy execution, the short-term multiplier enables more accurate forecasting and assessment of the results of infrastructure projects. This tool helps policymakers to prioritize projects and allocate resources more intelligently by calculating the immediate economic boost that comes from infrastructure spending. This could result in a more effective and efficient use of public monies.

Our findings provide a multitude of useful insights that can guide decision-making processes, strategic planning, and project execution for regional politicians and infrastructure project managers. The multi-stage impact on GTP growth emphasizes how crucial it is to evaluate and carry out infrastructure improvements with a long-term perspective. Our model indicates that the economic advantages during the frequently drawn-out and resource-intensive construction phase may experience a brief dip, but that this decline is temporary and will be followed by increased and sustained growth once the infrastructure is fully operational. This information can be very helpful to managers in controlling expectations from stakeholders, obtaining ongoing funding for long-term projects, and convincing different stakeholders of the long-term financial advantages of infrastructure projects. Our findings give decision-makers a more precise understanding of the economic trajectory linked to infrastructure development, allowing them to create more robust and forward-thinking development strategies that can withstand short-term changes while promoting long-term prosperity.

Furthermore, in an environment where resources are scarce and goals are frequently conflicting, the "short-term multiplier" notion presented in this paper offers a strong and flexible instrument for investment prioritization. This tool helps authorities to strategically deploy resources in a way that maximizes short-term growth while concurrently establishing the foundation for long-term regional success by providing a way to evaluate the immediate economic rewards of infrastructure spending. This method helps make decisions that are better informed and balanced by considering both the urgent requirements of the present and the potential for future economic growth. With the ability to measure and contrast the short-term economic effects of various infrastructure investments, policymakers can design development policies that are more responsive and effective, which could result in more fair and sustainable regional growth. Additionally, even in the early phases of implementation, this technology can help establish public support for infrastructure projects by showcasing their observable economic advantages.

To present a fair analysis and open the door for more research, it is imperative to recognize and deal with the study's inherent limitations. Although it offers a helpful picture, focusing only on average annual infrastructure expenses may miss possible variances and swings over various building phases. This simplification may result in an overestimation of favorable effects throughout the later phases of the building period and an underestimating of the initial economic stimulation supplied by the project's start. These possible errors show that future research must collect and analyze more detailed data in order to fully reflect the complex economic effects that occur throughout the course of a project. Furthermore, there are significant concerns regarding the model's generalizability to other settings with distinct economic structures, regulatory regimes, and development trajectories due to its reliance on data from a particular location. Applying the model to different geographical settings requires careful consideration because each region has unique characteristics that may significantly influence the relationship between infrastructure investment and economic growth. These characteristics include its existing infrastructure, economic base, and growth patterns.

Thus, policymakers would be able to allocate resources and maintenance plans more intelligently with the support of this line of investigation, which would yield priceless insights on the sustainability and long-term efficacy of infrastructure projects. Future study should concentrate heavily on the sensitivity of economic output to different forms of public investment, as it is crucial to comprehending this long-term dependency. Detailed sector-specific evaluations may be necessary to ascertain which infrastructure investment categories provide the best long-term returns under various economic conditions. Furthermore, including social and environmental aspects into the model might offer a more thorough understanding of the effects of infrastructure investments, coordinating economic research with more general sustainability objectives.

In conclusion, our study offers up a plethora of new research and exploration opportunities while also offering insightful and practical information on the complex relationship between infrastructure investment and regional economic growth. Future research might build on this basis to create more thorough, reliable, and broadly applicable models by methodically resolving the limits revealed and broadening the area of the investigation. Policymakers, project managers, and economic planners will find these improved models to be extremely useful tools that will help them make better informed and strategic decisions that will optimize the regional benefits of infrastructure investments in terms of the economy, society, and environment. As the world struggles with issues like urbanization, climate change, and economic inequality, it is more important than ever to be able to predict and maximize the effects of infrastructure expenditures. By conducting continuous research and improving our knowledge in this area, we can endeavor to build more resilient, sustainable, and successful communities in a variety of geographic and economic contexts.

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