Impacts of road transport infrastructure investments on the Latin American Integration Route

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Abstract

Using structural impact analysis, this paper investigates the economic implications of road transport infrastructure investments on the Latin American Integration Route (LAIR) in the state of Mato Grosso do Sul (MS), Brazil. We aim to determine whether these investments can drive short-term local economic growth, identify sectors that benefit the most from the investments, and analyze the distribution of effects among MS municipalities. Based on three comparative scenario simulations, the findings indicate that infrastructure investments are likely to yield positive short-term impacts on MS's GDP. The intensity of these impacts varies across industries and municipalities, with Campo Grande (state capital) being a key beneficiary. Compared to other types of investments, those in transport infrastructure have a lower dispersion capacity in space. The main contribution lies in utilizing the S-curve to model the financial progress of each investment project, as this information is frequently unavailable. Additionally, adopting the spatial Location Quotient (LQ) estimates the spatial distribution of investments impacts. Lastly, the guided simulation of investments is a methodology to enhance the efficacy of formulating and executing public investment policies, considering the spatial consequences of these investments.

Keywords: Input-output, Structural Analysis, Public Investment, Transportation, Regional Fiscal Policy.

1. INTRODUCTION

Public investment plays a crucial role in ensuring sustained economic growth over time (Aschauer, 1993). Existing literature provides evidence that investments in transportation infrastructure projects have small positive effects on regional economic growth (Lall, 2007; Elburz and Cubukcu, 2021; Cetin, 2022), especially in developing countries (Elburz, Nijkamp, and Pels, 2017), with short-term effects smaller than the long-term effect, which tends to decline over time (Demetriades and Mamuneas, 2000). Additionally, residents are the primary beneficiaries of infrastructure improvements (Haughwout, 2002). While public investment is deemed necessary, it is not sufficient to drive endogenous growth on its own (Button, 1998). The articulation between public and local investment, as proposed by Ebberts and McMillen (1999), allows local firms to share public structures as production inputs, thereby reducing average production costs for each firm and increasing local business volume, thereby strengthening agglomeration economies.

Works such as Perobelli et al (2006) draw attention to other spillover effects beyond the borders of Brazilian states, generating interdependence between state economies. More recent work on the specific effects of transport infrastructure on the regional economy, such as the small long-term effects of connectivity on regional growth (Rokicki and Stępniak, 2018), draws attention to the fact that transport infrastructure alone is not enough to promote long-term economic growth in underdeveloped regions Yu et. al. (2012). Crescenzi and Rodriguez-Pose (2012) point out that even regions with high endowment or surrounded by transportation infrastructure have small insignificant effects on economic growth. As can be seen, the literature is very focused on long-term effects and on the national or regional economy, few of which focus only on the local economy and on short-term effects more associated with the expenses incurred in carrying out the projects.

Currently, Brazil's level of investment relative to GDP is among the lowest in the past 25 years, reaching 2.05% of GDP in 2021, with a slight increase since the historical low of 1.94% in 2017 (National Treasury, 2021). According to the 2021 Infrastructure Blue Book report by ABDIB (Brazilian Association of Basic Industries Infrastructure), approximately 70% of total investment comes from private companies, while public investment has significantly decreased in recent years.

The report emphasizes that the Brazilian economy should be investing around 4.3% of GDP annually to support economic growth in the face of population growth, productivity variations, and depreciation. When analyzing net investment figures, which account for depreciation, the investment of the general government (including central government, states, and municipalities) stands at -0.36%, representing a loss of fixed capital amounting to 30.9 billion BRL, according to data from the National Treasury organized by the Fiscal Policy Observatory of the Brazilian Institute of Economics of the Getulio Vargas Foundation.

In addition to the low level of investment, Brazilian states are burdened with debt. In 2018, the states' debt reached 9.8% of GDP, fluctuating since 1996 due to negotiations between state governments and the federal government, according to data from the National Treasury, as organized by the Fiscal Policy Observatory. This indebtedness can constrain the investment capacity of states, as evidenced by the findings of Kumar and Woo (2010) when analyzing the relationship between public debt and economic growth in emerging economies. They concluded that high public debt could lead to reduced productivity, investment capacity, and subsequently hinder economic growth.

The state of Mato Grosso do Sul (MS) experienced an average real GDP growth of 0.79% between 2015 and 2019, but in 2019, it recorded negative real growth of -0.53%. The State Secretariat of Environment, Economic Development, Production, and Family Agriculture (SEMAGRO) forecasts an average growth of 2.14% between 2020 and 2026, not accounting for the impact of the COVID-19 pandemic or periods of severe economic downturns since 2019.

In terms of productive composition, MS's economy comprises 17.10% in the agricultural sector, 21.53% in industry and civil construction, and 61.37% in the services and trade sector (SEMAGRO, 2019). The service sector has been particularly affected by the COVID-19 crisis and mobility restrictions, as indicated by Haddad et al. (2021). Tupy, Crocco, and Silva (2018) reinforce those states may have different capacities to absorb and recover from national crises, with those heavily reliant on exporting sectors experiencing more significant challenges. Given these considerations, it is unlikely that MS will experience substantially higher growth rates *ceteries paribus*.

Regarding public accounts, the state's total debt stands at 7.4 billion BRL and has remained around 6.5 billion on average between 2000 and 2018, with a consistent growth trend. This suggests that the debt is unlikely to be restructured or reduced in the short term (within the next two or three years). The combination of high indebtedness, recent economic crises, and limited investment capacity may constrain MS's growth potential.

Recent infrastructure projects have been implemented, focusing on constructing and renovating roads, building bridges, and other structures to improve traffic conditions. Many of these projects aim to connect MS's highways to the Latin American Integration Route (LAIR), a production flow corridor connecting the Port of Santos in São Paulo, Brazil, to the ports of Antofagasta and Iquique in Chile, passing through MS, Paraguay, and Argentina.

This paper aims to analyze the impact of investments in road transport infrastructure within the context of LAIR. It seeks to address a gap in the literature generally interested in long-term impacts and spillover effects, while short-term and direct effects on the local economy remain lacking in research. We are interested in answering whether the transportation infrastructure investments made in MS for LAIR implementation can boost local economic growth in the short term, which sectors could potentially benefit the most from these investments, and how the effects of these investments are distributed among MS municipalities.

Works closely aligned with our research include Araújo and Guilhoto (2005), Abrita et al. (2022), and Abrita et al. (2023). Araújo and Guilhoto (2005) analyze the impact of BR-116 highway duplication in Brazil using GCE's MIBRA model for 1999. Their findings highlight positive heterogeneous effects, indicating economically dynamic regions tend to benefit more from infrastructure investments. Moreover, economically depressed regions display greater capacity to stimulate economic activity and reduce regional inequalities through such investments. On the other hand, the second and third papers, by Abrita et al. (2022, 2023), delve into LAIR implementation, policy prospects, and potential positive effects on the Mato Grosso do Sul economy.

This study pioneers the measurement of LAIR's impact on the MS economy, utilizing limited public data. Additionally, it delineates how planned LAIR infrastructures can affect economic sectors and yield local externalities. Given the information scarcity and unpredictable policy landscape, the paper offers a methodological guide to assessing potential policy impacts. It enables a comparative assessment of potential policy impacts vis-à-vis transport infrastructure projects. It also helps to fill a gap about behavior, short-term effects and direct impacts on the local economy. Finally, it contributes to the impact analysis literature by integrating the S curve for modeling uncertainties/limited information. And spatial locational quotient QL to understand the spatial distribution of investment effects.

3. METHODOLOGY

We conduct a structural impact analysis using an updated input-output matrix for the state of Mato Grosso do Sul in 2021 prices. Following Bishop and Brand (2000) and Batey (1992), we identify the primary transportation infrastructure projects that connect the existing transport infrastructure to LAIR. The total values of these projects were utilized to construct a disbursement curve within an S-curve framework, thus avoiding the unrealistic assumption of a single disbursement over time. Integrating this process with input-output matrices to model projects with uncertainties and limited public information directly contributes to projecting public policy planning scenarios. This integration empowers policymakers to conduct simulations and comprehend the simulated impacts of the policy. Additionally, available data on the disbursement of alternative projects were used to create two other comparative impact scenarios, a cost-benefit analysis of the infrastructure projects.

Changes in final demand can occur due to household consumption, investment, or government spending. We address changes in government spending g_i and assume that all other components remain constant in a comparative statics analysis. The vector of change in final demand results from demand before (y_0) and after (y_1) the additional realized spending Δy = y_1-y_0. The variable y_0 is given by the value of government spending available in the input-output matrix, while y_1 will be the value of y_0 growth from new annualized spending on selected transport infrastructure projects listed in Table 1, the values of Δy are presented in Table 2, also in annual values.

By performing the pre-multiplication of the vector of variations in demand by the inverse Leontief matrix as in Leontief (1986), we obtain the new output of the economy.

$$\Delta x = (I - A)^{-1} \Delta y \tag{1}$$

Multipliers and Rasmussen-Hirschman indices were calculated following the traditional estimations from input-output models by Miller and Blair (2009). The former serve as indicators of direct and indirect employment generation, remuneration, and value-added for each additional monetary unit of final demand. Meanwhile, the latter represents the chaining capacity of each sector within the economy.

We introduced alternative investment scenarios simulating private involvement in large-scale infrastructure projects to offer a comparative perspective on public infrastructure investment analysis. Analyzing the spatial distribution of investment impacts is challenging and often requires simplifying assumptions or complex local data systems to estimate multi-regional input-output matrices. Policymakers, typically lacking these alternatives, find this information crucial. To address this, we calculated a spatial Location Quotient (LQ), considering the neighborhood effects of investment implementation. This indicator was computed utilizing data from the Annual List of Social Information detailing job numbers in each industry per municipality in Mato Grosso do Sul. The simulation of investment impact spatial distribution using this indicator assumes impacts align with industries' job generation capacity, particularly emphasizing labor-intensive companies adapting to demand increases. Hence, labor-intensive companies will need to increase their intensity further when confronted with increases in demand.

Since these effects are short-term, this hypothesis does not introduce any disadvantages to the analysis. The need for technological insertions or capital investment required for economies of scale due to new demand would depend on a longer maturation process of the new capital generated by the profits from the additional demand. Refer to the appendices for further details on applying the S-curve framework and spacial LQ calculation.

4. DATABASES

Various databases were employed to design the impact scenarios, sourcing information from contracts, agreements, and public announcements by federal and municipal governments. These databases include the Secretariat of Infrastructure of Mato Grosso do Sul website, specifically the bidding page for construction works and highways, the State Secretariat of Environment, Economic Development, Production, and Family Agriculture website, which consolidates official data studies for Mato Grosso do Sul, and the Database of the State of Mato Grosso do Sul. Additionally, the recently released Logistical Diagnosis of Mato Grosso do Sul page and reports from the Brazilian Association of Infrastructure and Basic Industries (ABDIB) were consulted. This data was compiled and analyzed to create a list of proposed investments for Mato Grosso do Sul, aiming to connect existing infrastructure in the state's municipalities to the LAIR route.

The selection criteria for identifying these investment projects were: 1) the project's initiation (bidding or commencement of works) in 2021; 2) the project's focus on transportation infrastructure implementation; and 3) the relevance of these infrastructure projects to the LAIR route, either complementing or connecting to it.

Furthermore, the FUNDEMS (2015) input-output matrix for the state of Mato Grosso do Sul, disaggregated into 16 economic sectors, was utilized for the year 2015. This matrix is the most up-to-date state-scale matrix available and operates under an industry-by-industry structure as an open input-output system, without considering household consumption as endogenous.

To update the matrix to 2021 prices, the sectoral price indexes from the National Accounts System - SNA were applied. This involves updating the inverse Leontief matrix using the approach outlined in equation 2, based on Tian, Kahsai, and Jackson (2013) and Miller and Blair (2009). The process includes creating the price index, diagonalizing this price vector for each sector in the matrix, pre-multiplying it by the inverse Leontief matrix for the year 2015, and finally after-multiplying it by the inverted matrix of the same price vector.

$$\underline{A}_{16x16} = P_{16x16} A_{16X16} P^{-1}_{16x16} \quad (2)$$

This procedure yields $\underline{A}$, the updated Leontief matrix at 2021 prices, which provides impact results and indicators considering the prices of this year. An important underlying assumption is that the economy produces in 2021 using the same quantity compositions as in 2015. This assumption is supported by two facts: 1) the production function adopted to calculate the matrix, as suggested by Sawyer (1992), indicates that the element that varies the most is prices rather than quantity, leading to a certain rigidity; 2) constructing a matrix at the state level for periods less than five years in Brazil is not possible due to data unavailability.

Finally, the spatial QL for 2021 was calculated following the formulation specified by Abrita et al. (2020) and Abrita et al. (2023), utilizing employment data from the Report of Annual Social Information - RAIS, disaggregated into major economic sectors according to the National Classification of Economic Activities (CNAE).

4.1 Scenarios design

The official projections of the MS economy for 2021 serve as a baseline for comparing the simulated effects of transport infrastructure at 2021 prices. This comparison encompasses not only new infrastructure projects, but also incremental ones aimed at improving existing infrastructure. The selected projects commenced execution in 2021, with most expected to be completed between 2023 and 2024, representing the maximum timeframe for project spending. For projects with execution timelines extending beyond this horizon, only their values were presented for the respective years.

The available information in licitation announcements and records was insufficient to identify the specific types of expenditures made by the projects or to determine the sequence and amount of physical/financial expenses for each project. As a result, the total values of each project were used as inputs in a simulation known as the S-curve, which models the disbursement flow for projects. This approach facilitated the construction of the temporal evolution of each project's investment, creating more realistic scenarios by considering that the entire contract amount would not be spent in a single year. For projects in the planning stage, they were kept separate due to the higher uncertainty regarding their realization.

The S-curve is a widely utilized project management tool that predicts the structure of project disbursements based on predefined calculation criteria. It allows managers to monitor project execution by comparing actual disbursement progress with the S-curve predictions. Additional details on the calculation process and parameters are provided in Appendix B, along with tables presenting the results.

Table 1: Investment projects planned or being executed in Mato Grosso do Sul.

Project Id.	Investment Projects	Investment Amount (R$)	Status in 2022*	Execution Deadline/ Term*
1	MS-306 Highway Concession	932,000,000.00	Contracted	2050
2	Paving and duplication of 1.3 km of the BR-267 highway at the entrance of Porto Murtinho	7,869,870.94	Contracted	2023
3	Construction of an International Bridge over the Paraguay River in the municipality of Porto Murtinho - MS	548,050,000.00	Contracted	2023
4	Restoration of BR-267 between Rio Brilhante and Porto Murtinho	83,011,602.00	Contracted	2024
5	Access to BR-267 to the headwaters of the International Bridge over the Paraguay River in the municipality of Porto Murtinho - MS	2,106,335.86	Licitation	2023
6	Elaboration of the Executive Project for the Road Ring and Rua Cel. João Paes de Barros, at the entrance of the city, and sidewalk reconstruction on Avenida 13 de Junho in the city of Porto Murtinho	266,809.97	Licitation	2023
7	Preparation of environmental studies: for asphalt paving of the access to the Port District, stretch: BR/267 - Paraguay River, with a total extension of 7.5 km in the municipality of Porto Murtinho - MS	90,805.40	Licitation	2023
9	Technical feasibility study of the	1,544,000.00	Licitation	2021

	International Bridge over the Paraguay River in the municipality of Porto Murtinho - MS			
10	Revitalization of the 29-km stretch between the towns of Camapuã and Chapadão do Sul on BR-060	6,900,000.00	Executed	2022
11	Duplication of BR-262 between Campo Grande and Três Lagoas	2,027,945,019.00	Executed	2037
12	Restoration of BR-262 between Anastácio and Três Lagoas	281,213,637.00	Expected	2037
13	Construction of the Pantanal Railroad (EF-267) between Maracaju and Porto Murtinho	13,800,000,000.00	Expected	2037
14	Construction of the Porto Murtinho Railroad Terminal	47,345,020.00	Expected	2037
Total		17,738,343,100.17	-	-

Source: Prepared by the authors with data and information available on the SEINFRA's Licitation Portal - Secretary of State for Infrastructure; Transparency Portal of the State of Mato Grosso do Sul; AGESUL - State Agency for Management and Enterprises; SEMAGRO - Secretary of State for Environment, Economic Development, Production and Family Agriculture; Logistic Diagnosis of Mato Grosso do Sul (2022).* Note: Both the column of status in 2022, as well as the execution and term represent the announcements/forecasts made by the listed sources. Especially in those jobs where there is a forecasted occurrence, the uncertainties about the execution in the foreseen timeframes are greater. To the limit of what has been disclosed so far, this is the current information that will be considered as the basis for the projection of the annual scenarios.

The MS-306 (First listed in Figure 1) state highway connects Inocência, Água Clara, and Ribas do Rio Pardo to Campo Grande. It represents the first highway in Mato Grosso do Sul to undergo the concession process, with high expectations that it will serve as a pilot experience for future concessions. This route enhances access and commercial integration between MS, MT, SP, GO, and MG, providing a potential pathway for the export of sugar, alcohol, cotton, soy, and corn.

The concession project includes various enhancements such as a shoulder along the entire highway, a third lane in critical segments, adaptation of intersections, new traffic circles, and improvements to bridges and viaducts. Additionally, the project offers services to users, including mechanical and medical assistance, traffic inspection, customer service stations, and a modern Operational Control Center (CCO). These elements ensure that the investment's effects extend beyond infrastructure development, generating economic impacts on the state economy.

The BR-060/MS (Seventh listed in Figure 1) section between Camapuã and Chapadão do Sul spans 29 km and underwent a micro-coating and reprofiling procedure to improve asphalt conditions, facilitating smoother traffic flow at lower costs. This stretch is crucial as it connects the municipality of Camapuã with BR-163, providing access to the state capital Campo Grande, and subsequently connecting to the LAIR route.

The access to the International Bridge over the Paraguay River on the Brazilian side spans approximately 13 km and includes a viaduct on BR-267 (Eighth listed in Figure 1). Coordination with the Paraguayan side is essential, with the work expected to be completed in 2023. All the investments are presented in Figure 1, depicting the links between the projects and LAIR.

The feasibility study for the Paraguay River Bridge was conducted by a firm contracted by the Mato Grosso do Sul state government, confirming the physical and economic-financial feasibility of the project and initiating negotiations with Paraguay. These negotiations resulted in the project being scheduled for execution by 2023, and the construction began in 2022. Financing will be provided by the Paraguayan government with a significant contribution from the Binational Itaipu Power Plant. As this started in 2022, these amounts were not considered in Impact Scenario A.

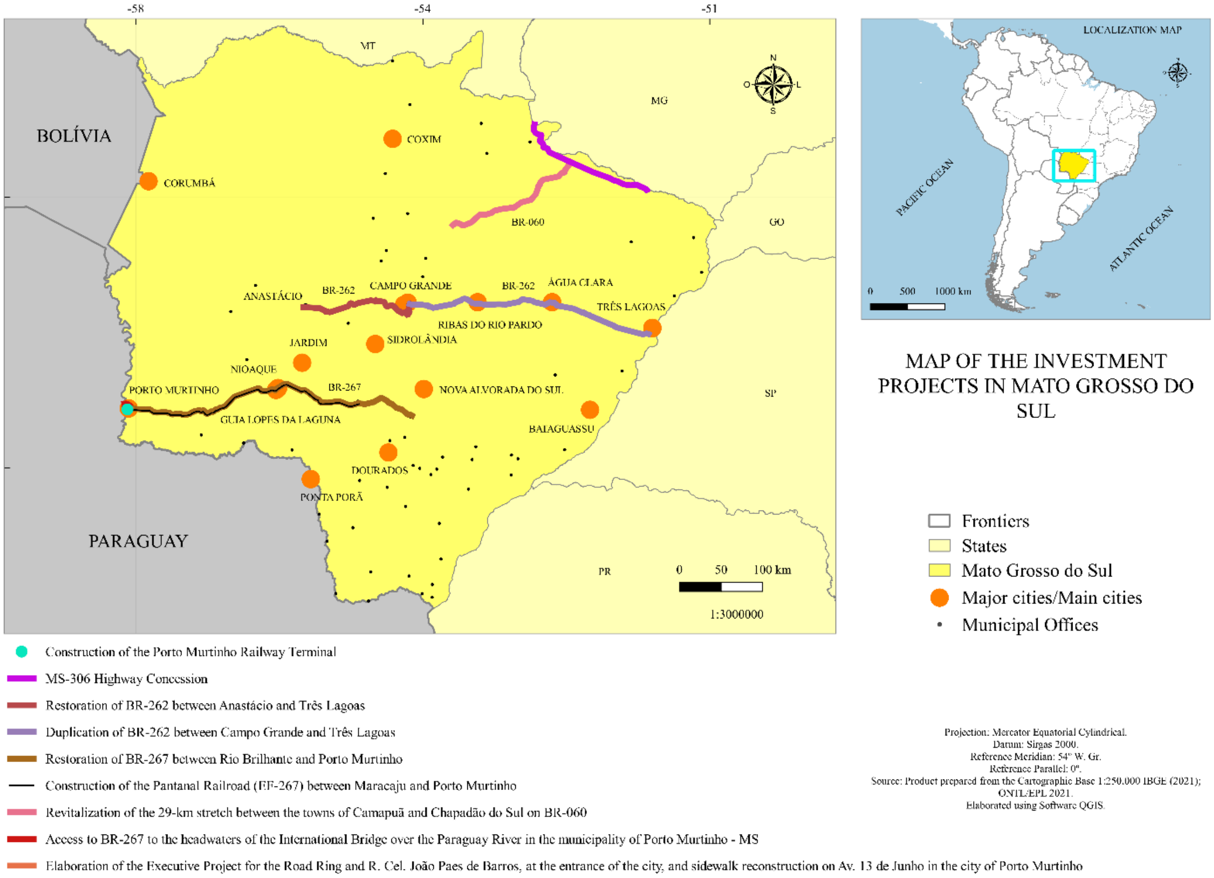
The bridge and its accesses are pivotal for LAIR implementation, enhancing access to Paraguay, with each country's respective government covering their respective access costs. Projects 5, 6, and 7 pertain to these accesses, closely tied to improving stretches within Porto Murtinho's urban perimeter. The stretch connecting Porto Murtinho to Rio Brilhante via BR-267 links MS municipalities primarily in the Southern Cone region, known for significant agricultural production.

The BR-267 project (Fifth listed in Figure 1) holds great relevance for LAIR, serving as a key route connecting Brazilian states through MS territory to Latin American ports. Additionally, it addresses the need to update an outdated highway structure, significantly increasing capacity with the planned projects.

Projects 13 and 14 pertain to railway modal expansion and improvement. The Pantanal railroad aims to connect Maracaju to the rail terminal of Porto Murtinho (First listed in the Figure 1, blue dot), crucial as Maracaju is a highly productive municipality for grain, with a large Chinese multinational having its headquarters there. Utilizing the rail's low cost and speed due to the lack of traffic, these combined projects are expected to significantly reduce time and costs for grain distribution. The revitalization of the terminal at Porto Murtinho will transform it into a multimodal terminal.

Finally, projects 10 and 11 connect municipalities in the eastern region of MS to Campo Grande, while BR-262 links Campo Grande to the route of BR-267 (Third and fourth listed in Figure 1). This establishes an important second route for two reasons: first, enabling connection to the state of São Paulo, and second, linking the eastern region of the state to Campo Grande and LAIR. The region boasts significant production of eucalyptus and pine trees, cellulose, and a concentration of industries.

Figure 1: Map of Infrastructure Projects in Mato Grosso do Sul.



Source: Own preparation based on the information in Table 1. For a better geographical orientation, the municipalities where the infrastructure projects that create the LAIR have passed through are highlighted in orange dots with their respective names. The black dots represent the municipal seats of the other MS municipalities. The projects listed in Table 1 are shown here by the dashes in the exact locations where they will be implemented or executed. Note that they are listed in the same order as in the table and in different colors to simplify visualization. The auxiliary map shows the location of the state of Mato Grosso do Sul in yellow and its borders with other Brazilian states and other Latin American countries. Detailed maps of the complete LAIR path in Latin American countries and along the municipalities of the MS can be found in Abrita et al. (2023)

Based on the selection of projects (Table 1 and Figure 1) and the calculations presented in Appendix B, we have established a scenario illustrating the variation in the total demand of the economy of Sul-Mato Grosso resulting from additional government spending on these infrastructure projects.

In this simplified economic environment, three representative agents are involved: the government, representing an aggregate of municipal and state governments responsible for identifying public demands and financing them through taxation; the industries distributed across

16 economic sectors and municipalities, producing goods and services, paying taxes, and demanding labor; and households, representing individuals consuming goods and services, paying taxes, and providing labor.

The economic mechanism underlying this scenario involves the government identifying infrastructure needs based on the agenda set by organized groups in society, such as businessmen. After internal analysis and viability assessment, the government can opt to execute the infrastructure project, funding it through its own resources and taxes or establishing Public Private Partnerships (PPPs) with interested industries. The execution of the project involves the government supervising the work, making payments as per the contract, and ensuring fund accountability.

As the project is carried out, the economy's aggregate demand increases due to additional government spending. This spending multiplies through increased household income, leading to higher expenditure on goods and services and generating more demand for industries. The contractors hired for the project will also stimulate demand for inputs like bricks, cement, sand, and machinery, resulting in production and purchases from various industries in the economy.

This process creates a chain of buying and selling links between industries, multiplying each monetary unit spent on the project. Since the economy relies on interregional import and export flows of goods and services, it is not self-sufficient. The additional demands also lead to increased tax payments by households and industries, boosting government revenues.

Table 1: Scenarios of impacts on final demand caused by varying public investment in infrastructure.

Industries	2021		
	A	**B**	**C**
Construction	31,600,607.33	-	-
Manufacturing Industry	-	1,346,771,227.69	
Agriculture and Livestock	-		421,438,615.47
Total	31,600,607.33	1,346,771,227.69	421,438,615.47

Source: Own preparation using data from the Input-Output Matrix and Table 1.

Table 2 presents values representing the additional aggregate demand in the Mato Grosso do Sul economy for the year 2021. Three scenarios were analyzed: Scenario A considers the annual investments in transportation infrastructure projects with annualized disbursement values listed in Table 1 (further details in Appendix A).

In Scenario A, the entire additional demand is channeled towards the construction industry, as companies within this sector bid for and secure contracts with the government for project execution. Other services not within the scope of the construction industry are assumed to be subcontracted for optimal performance, as outlined in the government's bidding contract.

Scenarios B and C serve as comparative illustrations of the hypothetical effects of increased demand from the manufacturing industry and agribusiness, respectively. These scenarios facilitate comparison and discussion about the mechanisms guiding public policy decisions and the differing impacts based on the treated mechanisms. In fact, those scenarios illustrate a potential trade-off between government spending on creating infrastructure and/or subsidizing private industries with tax reductions so that they settle in the state and start producing.

The key distinction between Scenario A and Scenarios B and C lies in the latter two being driven by additional private sector investments, specifically by industries. The values for Scenarios B and C are based on a real case, the Cerrado Project, entailing the construction of a new wood pulp production unit by Suzano in Três Lagoas, with launch and start-up scheduled for 2021. The total planned investment amounts to 19.3 billion reais, with 14.7 billion allocated to the industrial plant and 4.6 billion for forestry, logistics, and other investments. These figures were subjected to S-curve calculations and annualized to generate the values in Table 2. The plant investment pertains to the transformation industry, while the forestry investment is directed towards the agriculture and livestock industry.

5. RESULTS AND DISCUSSION

The initial findings pertain to indicators derived from the input-output matrix. Table 3 presents the linkage indicators, reflecting the intersectoral connections of an industry with other industries comprising its supply and demand chains. An industry is classified as a key industry when its BL (backward linkage) and FL (forward linkage) indicators exceed one. This signifies that it exhibits numerous connections with other industries in its supply and demand chains, allowing it to transmit the impacts of additional demand more effectively throughout the economy.

The results reveal that the key industries for the MS economy are Agriculture, Livestock, Forestry, Fishing and Aquaculture, Manufacturing, Industrial Services of Public Utility (ISPU), and the Information and Communication sector. The Extractive Industries and Construction sectors exhibit greater connections with their input suppliers, while Trade, repair of motor vehicles and motorcycles; Transportation, storage, and mail; Insurance financial activities and related services; Real estate activities; and Activities and services to businesses are more closely linked with purchasing industries. The remaining industries demonstrate weaker connections.

Table 3: Forward and backward linkage indices for the economy of Mato Grosso do Sul.

Ind. ID.	Industry	BL	FL	Classification
1	Agriculture, livestock, forestry, fishing and aquaculture	1.08	1.34	**Key Industry**
2	Extractive Industries	1.23	0.72	**Key Industry**
3	Manufacturing industries	1.43	1.47	**Key Industry**
4	Industrial Utility Services (IUS)	1.06	1.11	**Key Industry**
5	Construction	1.17	0.81	Back Linkage
6	Trade, motor vehicle and motorcycle repair	0.99	1.47	Forward Linkage
7	Transportation, Warehousing and Mail	0.96	1.16	Forward Linkage
8	Accommodation and meals	0.99	0.70	Weak Linkage
9	Information and Communication	1.23	1.01	**Key Industry**
10	Insurance financial activities and related services	0.94	1.04	Forward Linkage
11	Real Estate Activities	0.71	1.37	Forward Linkage
12	Activity and services to companies	0.87	1.06	Forward Linkage
13	Public administration, defense and social security	0.82	0.64	Weak Linkage
14	Education, human health and social services	0.89	0.68	Weak Linkage
15	Activity and services to families	0.98	0.76	Weak Linkage
16	Domestic services	0.64	0.64	Weak Linkage

Source: Calculated by the authors from the Mato Grosso do Sul input-output matrix.

The indices serve as crucial indicators for selecting industries to receive public policy or private investment to generate a more profound impact on the overall economy. The binding capacity of an industry determines how the effects of new investments or public policies disperse to other industries through their input requirements for production. When the economy experiences higher demand, firms in each industry must procure more inputs to meet this demand, thus impacting other sectors as well.

Table 4 in Appendix A computes the type I multipliers, indicating the monetary value directly and indirectly generated in each industry due to variations in final demand by one unit. These multipliers are expressed in monetary values, except for employment, which is measured in labor units. For instance, an additional monetary unit of final demand in construction would generate an extra 0.17 cents in compensation for households.

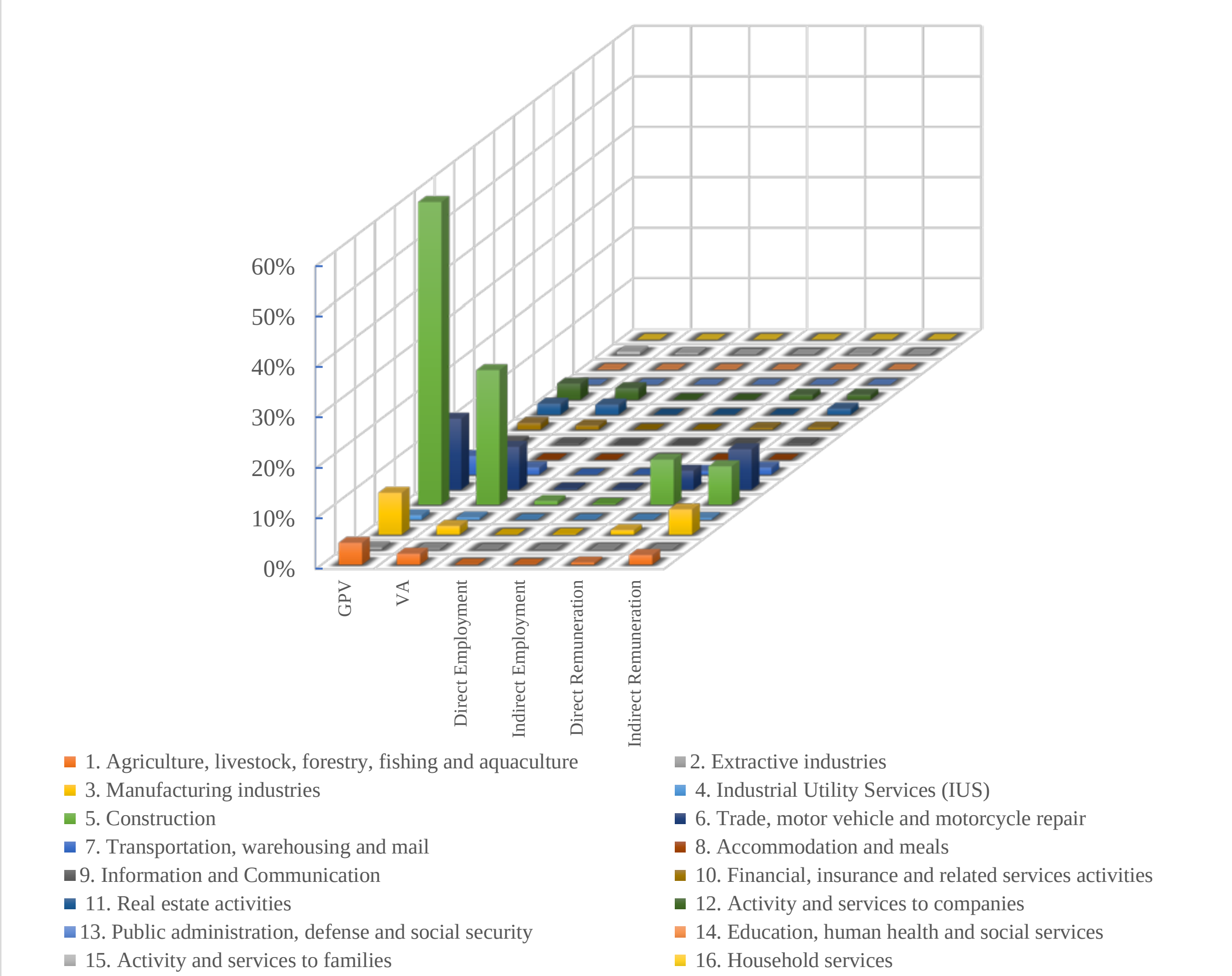
The first scenario analyzed is scenario A, involving an additional demand of 31.6 million BRL at 2021 prices in the construction industry. This scenario simulates the government contracting construction companies to execute projects 1, 4, 8, and 9. The amount represents the government's payments for the stages executed by these projects in 2021 and will continue until 2024.

Figure 2 illustrates the simulation results of this impact using the input-output matrix. The construction industry shows the most significant response to this additional demand, with a 60% increase in the gross value of production. Other affected industries include agriculture, livestock, forestry, fishing and aquaculture, manufacturing, trade, repair of motor vehicles, transportation, storage and mail, financial activities, insurance and related services, real estate activities, and business services.

The impact absorbed by the construction sector in scenario A generates noteworthy effects, particularly on the trade sector, as indicated by the multipliers and linkage indices. The trade sector, though not considered a key sector, exhibits intense backward linkages, implying strong connections with its supply chain. This supply chain is closely linked to the commercial sector, but its repercussions on many other sectors of the economy are relatively weak.

The trade sector's effects tend to be localized in MS, centered on urban commerce primarily catering to local demands. Consequently, the effects of increased construction demand leading to additional commerce demand are spatially dispersed. The commercial sector comprises mainly small businesses, especially those involved in the repair of motor vehicles and motorcycles, reinforcing the local impact of spending.

Figure 2: Impacts of Scenario A by Industry.

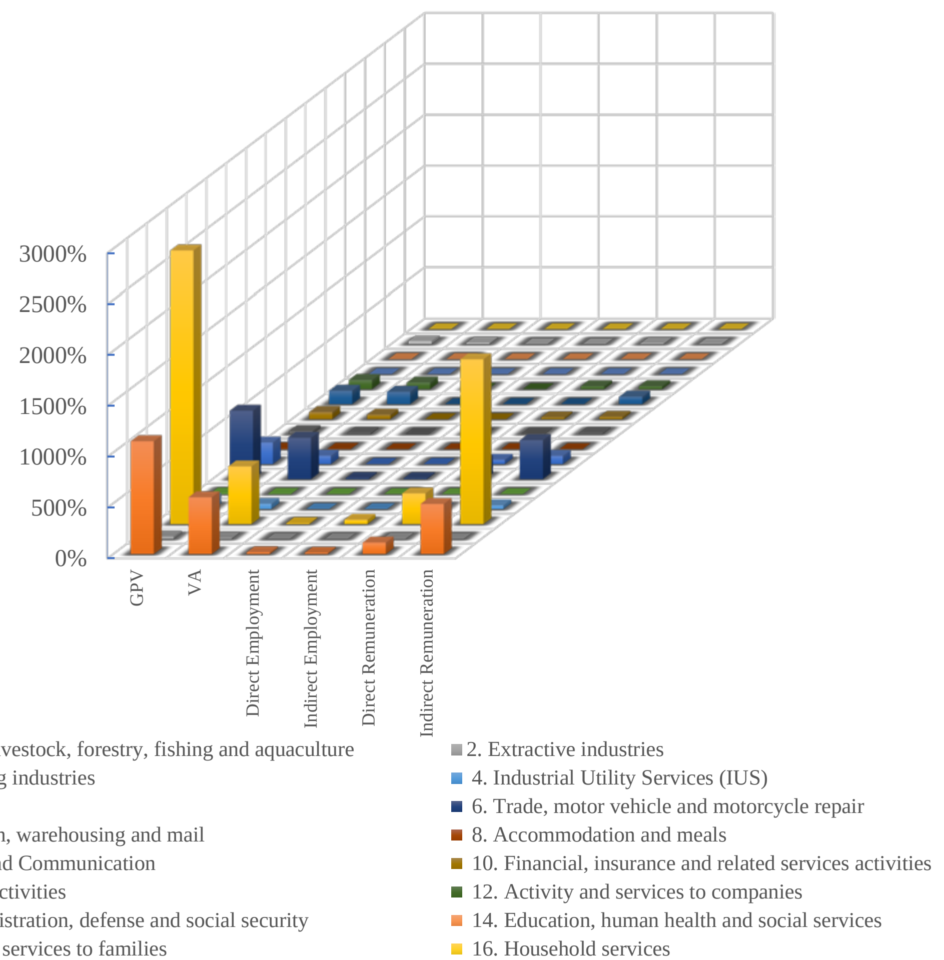


Source: Calculated by the authors based on the input-output matrix data for the year 2021. Note: GPV – Gross Production Value, VA – Value Added. Note that it has three axes: y, x and z. On the vertical y-axis are the magnitudes of the effects calculated in percentage values, on the horizontal x-axis are the effects on the macroeconomic aggregates analyzed for the MS, while on the diagonal z-axis are each of the 16 sectors of the economy, which can also be observed by the colors listed in the legend. The sectors experiencing the most significant impact are discernible by the heightened prominence of their respective bars on the figure.

Scenario B considers an additional demand of 1.3 billion BRL for the manufacturing industry, aiming to simulate the effects of the Cerrado Project, which involves establishing a new pulp production plant. This project entails a private investment to expand the production capacity of the manufacturing industry. Based on the calculated linkage indices, the transformation industry is identified as a key sector, expected to have longer chains and strong connections with multiple industries, leading to a dispersion of effects when receiving additional demand.

The multipliers indicate a higher capacity for multiplication in the manufacturing industry concerning GVA, Compensation, and VA. Upon simulating the impact of scenario B, the results align with the expected outcomes based on the calculated indicators. The manufacturing industry shows the most significant immediate results, with at least 9 out of the 16 industries in the model experiencing an increase in response to the additional demand from the industrial sector, as depicted in Figure 3. Agriculture, trade, and transportation (1, 6, and 7) are the sectors with the most intense impacts after manufacturing. An intriguing finding is a considerable effect on indirect remuneration within the manufacturing industry, agriculture and livestock, and trade.

Figure 3: Impacts of Scenario B by Industry.



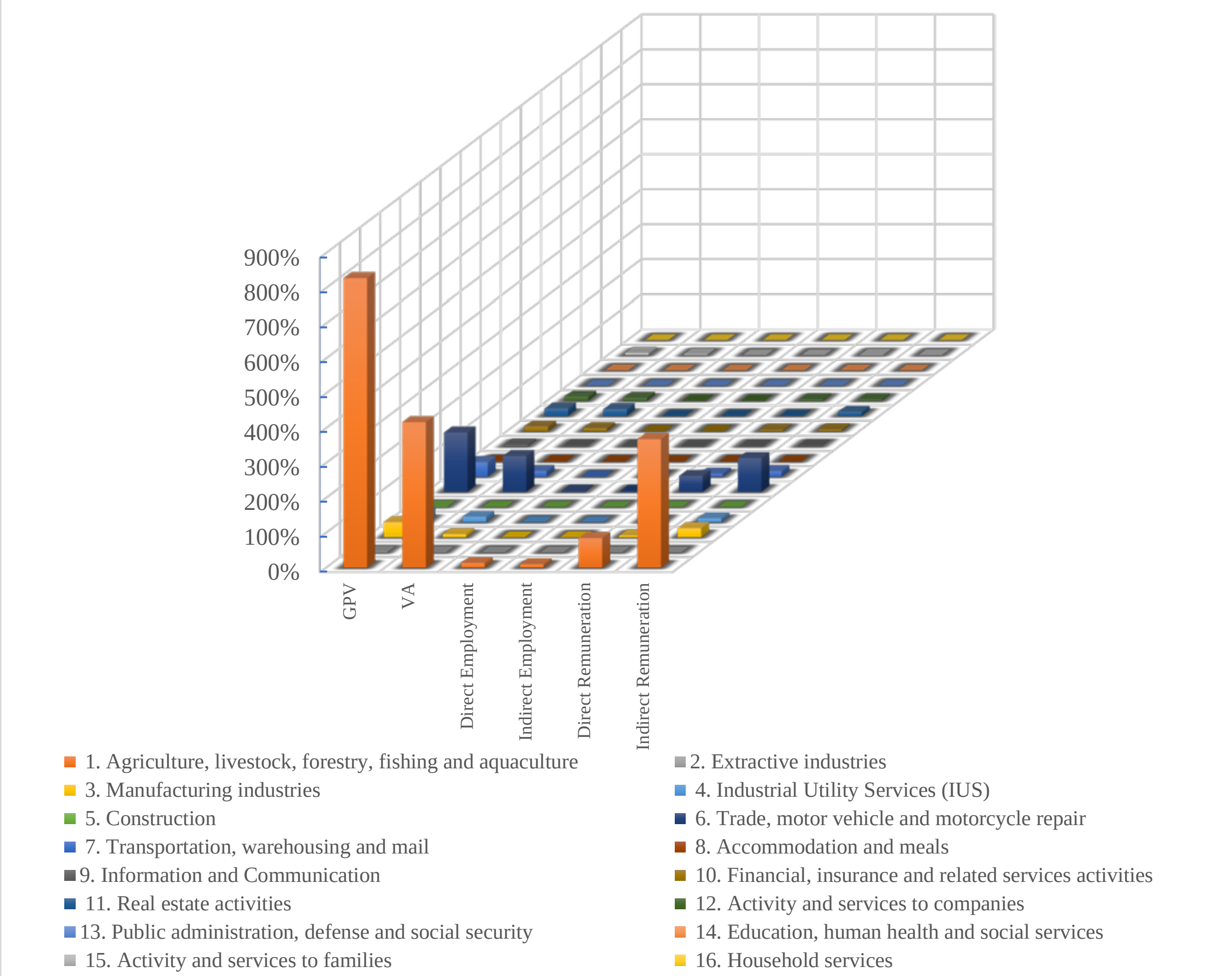
Source: Calculated by the authors based on the input-output matrix data for the year 2021. Note: GPV – Gross Production Value, VA – Value Added. Note that it has three axes: y, x and z. On the vertical y-axis are the magnitudes of the effects calculated in percentage values, on the horizontal x-axis are the effects on the macroeconomic aggregates analyzed for the MS, while on the diagonal z-axis are each of the 16 sectors of the economy, which can also be observed by the colors listed in the legend. The sectors experiencing the most significant impact are discernible by the heightened prominence of their respective bars on the figure.

The high indirect effects of remuneration indicate a greater number of repercussions on the economy. The indirect effect can be understood as a second wave of effects triggered by direct or first-order impacts. These effects become more pronounced when the impacted sector stimulates demand in other sectors. As these sectors require more inputs to meet the new demand, it sets off a chain reaction, leading to other industries demanding more inputs or labor factors, thus indirectly increasing households' compensation. Due to this strong spillover capacity to more sectors and the intensified indirect effects, the impact on the manufacturing industry is likely to be more spatially dispersed compared to the farming industry.

This disparity is justified by the creation of an additional demand in this scenario. Scenario C also reflects the implementation of the Cerrado Project, with the variation in demand solely directed by the project's execution, focusing on forest products that will serve as future inputs for the new industrial plant. The impact of the additional demand amounted to 421 million BRL for the year 2021.

Similar to Scenario B, the manufacturing industry, agriculture, livestock, forest production, fishing, and aquaculture are considered key sectors. However, the distinguishing factor is that the multipliers for agriculture and livestock are smaller than those of the manufacturing industry.

Figure 4: Impacts of Scenario C by Industry.



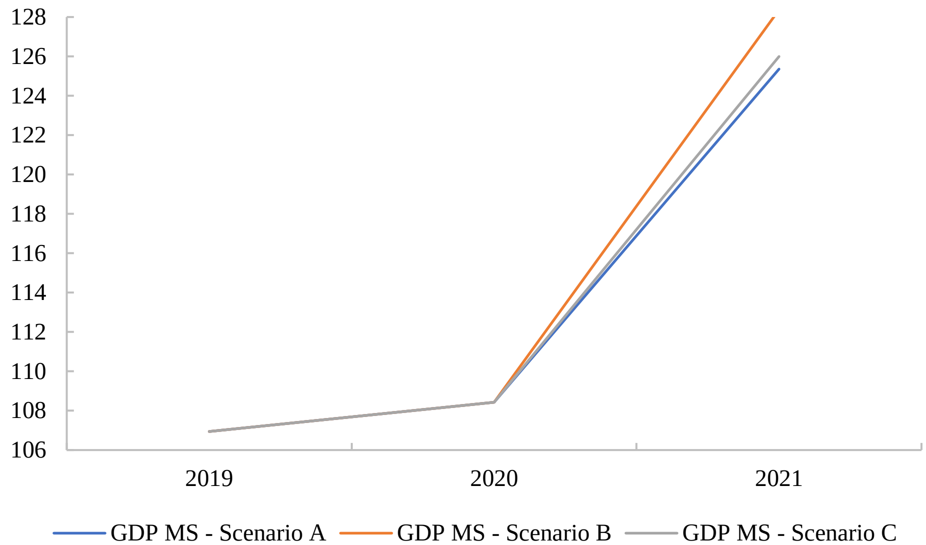
Source: Calculated by the authors based on the input-output matrix data for the year 2021. Note: GPV – Gross Production Value, VA – Value Added. Note that it has three axes: y, x and z. On the vertical y-axis are the magnitudes of the effects calculated in percentage values, on the horizontal x-axis are the effects on the macroeconomic aggregates analyzed for the MS, while on the diagonal z-axis are each of the 16 sectors of the economy, which can also be observed by the colors listed in the legend. The sectors experiencing the most significant impact are discernible by the heightened prominence of their respective bars on the figure.

Upon analyzing the impacts of scenario C, it becomes apparent that the additional demand has a more concentrated and intense effect on agriculture and livestock, as well as on trade and the repair of motor vehicles and motorcycles. Although seven other sectors also respond to this impact, their reactions are less pronounced. Compared to the manufacturing industry, the intensity of the impact on demand is lower for agriculture and livestock. However, both industries experience significantly more intense effects than the construction sector. Although the impact values differ, the overall intensity of the impacts remains much higher.

The indirect effects in scenario C are also less intense and primarily concentrated in agriculture and livestock, as well as in trade. Agriculture and livestock play a vital role in the economic activity of various municipalities, with significant production of crops such as soybeans, corn, cotton, and forestry. The state also has a significant presence in fish farming and ranks among the country's top beef cattle producers. As a result, it is expected that the effects of the scenarios' impacts will be widespread across many municipalities, driven primarily by their agricultural and livestock economic bases, rather than solely through the activation of economic chains.

Figure 5 illustrates the comparison between the impact effects of each scenario on GDP. For these effects, the projected GDP for the year 2021 was used, as the 2019 GDP is the most recent official data available. The projected GDP for 2021 is estimated at 125.3 billion BRL. Scenario A resulted in a modest increment of 0.05% in GDP, while Scenario B showed a more substantial increase of 2.45%, and Scenario C contributed with a 0.56% growth. All scenarios would positively impact GDP to varying extents and through different mechanisms.

Figure 5: Impact on the GDP of Mato Grosso do Sul: a comparative view between scenarios.



Source: Own preparation based on the results of the economic impacts obtained from each scenario. Note: The simulation uses as base year the GDP projected for the year 2021 by SEMAGRO, available in the technical document Projection of the Gross Domestic Product of Mato Grosso do Sul. The last GDP released by IBGE for the states is for the year 2019. The projection made by SEMAGRO considers the real average growth rate of the state's GDP.

To understand the spatial distribution of this investment, simulations were performed using the Spatial Locational Quotient (QLS) of each industry, which was derived from employment data. This indicator served as a basis for the spatial breakdown of investment values. Figure 2 presents the set of simulations for each scenario, with state highways depicted in red, providing insights into how the presence or absence of transportation infrastructure influences the dispersion of effects.

5.1 A brief policy discussion

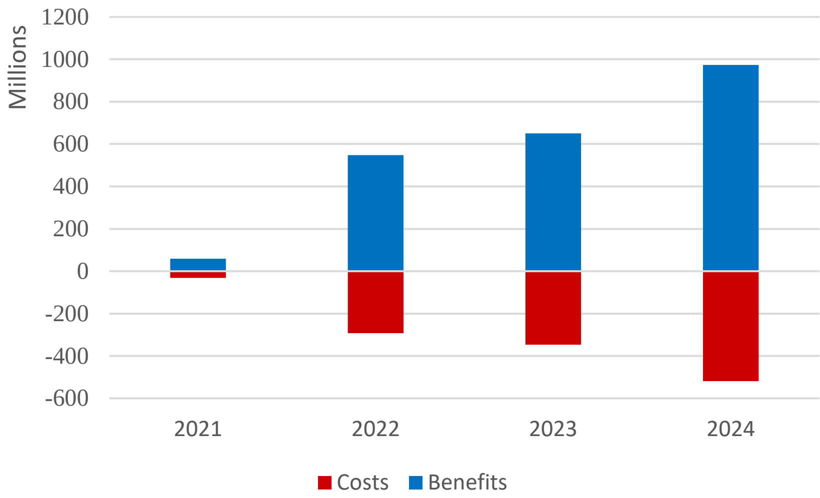
Input-output matrices are not universally accessible for all Brazilian states. Even on a national scale, real-time estimation of these matrices for the present year is unfeasible. Moreover, estimating these matrices for geographic units smaller than states is uncommon and often hindered by data unavailability or disclosure constraints. Consequently, utilizing these databases for timely policy decisions is largely confined to academic circles and typically involves a time delay.

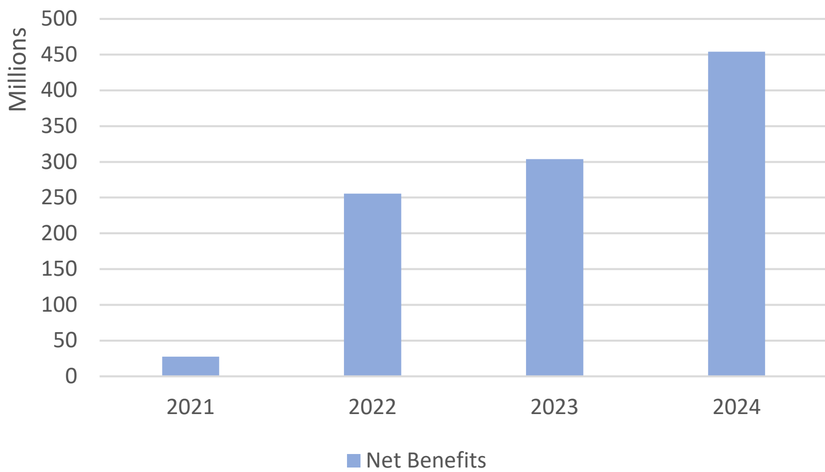
Insufficient pre- and post-implementation project information poses a challenge in analyzing the true impacts of such public policies of investments. Although Mato Grosso do Sul often ranks high in public account transparency within Brazil, obtaining comprehensive details regarding execution, expenditure amounts, and contract types for these investments from transparency portals (websites providing public spending information) remains difficult.

Cost-benefit analysis should be a natural step in deciding whether to implement public policies. Given these limitations, organizing the total costs and benefits of projects such as these is a task that is rarely carried out by public authorities. Although factors such as environmental costs and possible social costs are not included in our analysis, we have done our best with the information available to construct a cost-benefit analysis prior to implementation for the set of projects listed.

In conducting the cost-benefit analysis, we regarded the total public investments from 2021 to 2024 (Table 8, Supplementary Material) as costs. Employing the impact simulation previously outlined for 2021, factoring in these disbursements, we calculated the GDP impact values as benefits. The augmented GDP values signify a crowding-in effect resulting from the transportation-related public investments within each period. These amounts should be interpreted as present values at 2021 prices in millions of BRL.

Figure 6: Cost-benefit values calculated for 2021 - 2024.

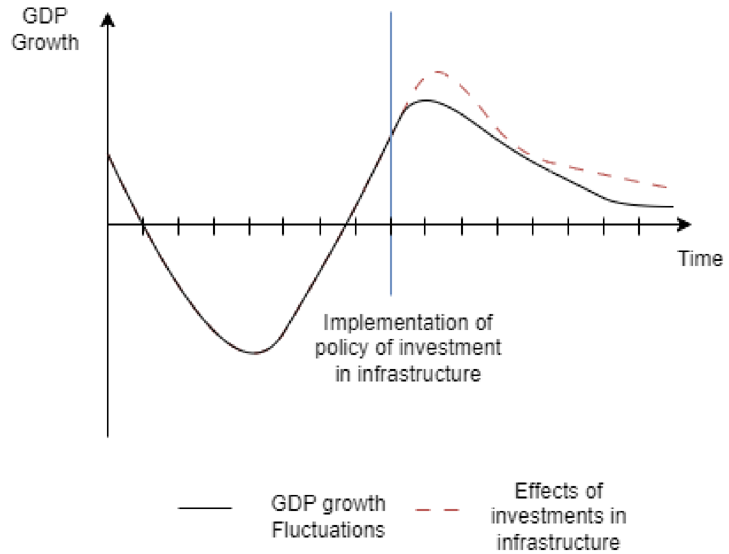




Source: Prepared by us using data from the Table 8, in the Supplementary Material that describe the potential economic annual disbursement values calculated using S-Curve framework of projects 1 – 9 in Table 1, that are the projects with the status of Contracted, In Execution, and Under Bidding**.**

The cost-benefit analysis demonstrates consistent positive net benefits throughout the years coinciding with infrastructure project investments. These net benefits escalate with the implementation of more projects, aligning with increased resource allocation in the construction phase.

Figure 7: Theoretical mechanisms of the effects of infrastructure investment policies.



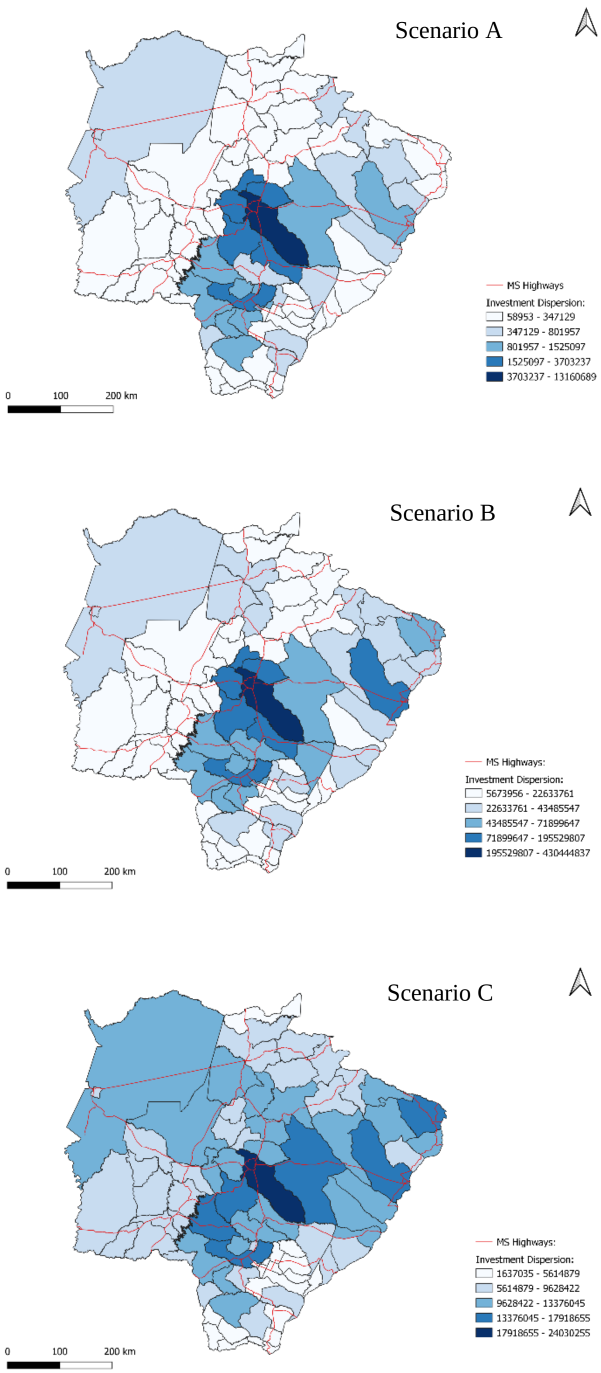
Source: Prepared by us.

While disbursements follow an annual schedule, smaller disbursements within shorter time frames, such as months, yield accrued benefits. However, the benefits from construction investments decline as disbursement volumes decrease or upon project completion. This is one of the reasons why literature (Yu et. al., 2012; Crescenzi and Rodriguez-Pose, 2012) does not observe such significant effects for the implementation of this type of project. This transition marks the onset of anticipated productivity and connectivity effects in local economies, as outlined by Hansen (1959), Crescenzi and Rodriguez-Pose (2012), and Elburz and Cubukcu (2021). Productivity gains resulting from previous investments materialize only upon full implementation of infrastructure projects. These gains emerge after construction spending effects have diminished, altering growth trajectories in the short to medium term (Figure 7, dashed red line). As Mato Grosso do Sul is in the initial stages of its investment cycle, anticipation arises for heightened economic growth patterns. Post-construction sustained higher growth is foreseeable due to the accrued productivity gains, however, complementary projects are needed to guarantee this growth trajectory (Button, 1998).

Although limited to an analysis of the local effects of project implementation in the short term, we recognize potential medium- and long-term effects that can be both positive and negative and that merit detailed investigation. Such as possible spillover effects beyond the borders of the MS, highlighted by Perobelli et al. (2006). In addition to variations in interregional and international trade patterns due to the additional connectivity generated by infrastructure projects.

A recent logistics diagnosis carried out for Mato Grosso do Sul points out that if all the planned transport infrastructure projects are implemented (considering a larger pool of projects and for more years), there could be a reduction in road transport costs estimated at between 20 and 25%. This reduction should generate an increase in the movement of people, cargo and exports, and the estimated impact on the local economy could reach 23% of MS's GDP from 2019 to 2035, (EPL, 2022). The latter requires not only time to implement, but also time for economic agents to adapt to using the new routes for the flow of goods and commute. Local businesses in some municipalities can also benefit from the increase in the number of vehicles that end up using the facilities on offer, such as gas stations, restaurants, groceries stores, and auto repair stores. As projected in forthcoming scenarios, cities with greater interconnectedness exhibit a more pronounced positive impact from local infrastructure investment effects, as pointed out by (Rokicki and Stępniak, 2018).

Figure 8: Simulation of the dispersion of investment impacts in space.



Source: Prepared by us using data from the QLS and the Ministry of Infrastructure's road network**.**

The simulation using QLS as the dispersion structure assumes that investment will disperse based on the spatial distribution of economic activity (firms and jobs) within each industry. This assumption is reasonable given the characteristics of the industries in the state and how investment dispersion mechanisms are influenced by intersectoral connections.

In scenario A, the impacts remain concentrated in Campo Grande and its surrounding municipalities, reflecting the significant number of construction companies and jobs in this area. Additionally, the expenditure on construction has substantial repercussions for the thriving trade sector in these cities, which is expected due to their higher population density and industry composition.

Scenario B shows a similar pattern to scenario A, with more intense responses observed in many municipalities in the eastern region. This aligns with the region's high industrial concentration, including the implementation of the Cerrado Project in Ribas do Rio Pardo. However, Corumbá and some neighboring municipalities exhibit less intense impacts, consistent with the significant mineral extraction industry in Corumbá. Nevertheless, the spatial pattern of impact dispersion for the manufacturing industry appears more concentrated than anticipated.

In the last scenario, the spatial distribution of impacts in the agricultural sector aligns with expectations, as the agriculture and livestock sector serves as the economic base for numerous municipalities across different regions of the state. Municipalities with high agricultural potential and their surroundings experience notable impacts.

Two crucial elements should be noted: Firstly, Campo Grande acts as a focal point for impact concentration in all scenarios due to its dense population, administrative headquarters, and large consumer market. Secondly, the existence of more highways appears to be linked to impact dispersion, particularly evident in scenario C, indicating that agribusiness impacts can gain dispersion capacity with the presence of transportation infrastructure.

6. CONCLUSIONS

The primary objective of this paper was to investigate the potential of transportation infrastructure investments in the state of Mato Grosso do Sul (MS) for stimulating local economic growth in the short term. Additionally, it aimed to identify the sectors that would benefit the most from these investments and examine the distribution of the investment effects among MS municipalities.

Based on the literature and simulations conducted, it can be concluded that investments in infrastructure are likely to have positive short-term impacts on MS's GDP. The intensity and dispersion of these impacts vary depending on the industry receiving the additional demand. In the simulated reference scenario, a 2.5% increment in MS's projected GDP for the year 2021 was observed. The projected results closely align with the recently released MS GDP data, indicating a higher-than-expected growth of approximately 4.6% for the year 2021.

Campo Grande concentrates on the effects generated by the additional demand, regardless of the sector in which the demand impact is introduced. However, the construction industry seems to have more limited effects in terms of both intensity and dispersion. On the other hand, the manufacturing industry and agriculture and livestock appear to generate more dispersed and intense effects. Agriculture and livestock, in particular, demonstrate a greater capacity to distribute the effects of additional demand among the municipalities due to their significant presence as the economic base in many areas.

It is important to acknowledge that exact predictions of the LAIR's implementation effects are challenging, especially since several possible side effects were not central to our objective, limiting our ability to make inferences. Nevertheless, based on the impacts of the implementation transportation infrastructure projects developed for the LAIR, it is plausible to envision a scenario of positive effects on the state's economic growth. Moreover, these infrastructure developments may create positive externalities for businesses and households, such as reduced production or commuting costs.

The final contributions of this work lie in providing a simulation and comparison method that enables policymakers to assess potential policy impacts. The analysis of the dispersion mechanism of investment impacts addresses a gap in the existing impact analysis literature and demonstrates, through a straightforward hypothesis, how investment impacts are distributed in space. Lastly, the study contributes to understanding the relationship between investments in transportation projects and the dynamics that foster local economic growth within the constraints of public investment.

Subsequent studies, leveraging comprehensive data and post-implementation assessments, can establish causal links between implemented projects and economic outcomes in the respective municipalities. In pursuit of this objective, local governments should enhance the accessibility and availability of comprehensive project information, enabling thorough analysis. Our research underscores the significance of assessing potential social and environmental costs linked to necessary infrastructure interventions. Numerous studies highlight a direct correlation between increased road infrastructure and amplified vehicular activity, consequently leading to adverse impacts like air pollution, noise, and alterations to the landscape. In addition, spillover effects beyond the edges of the MS economy and effects on interregional and international trade flows resulting from the connectivity generated by the projects in question form a rich agenda for future research.

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