Paving the Way to Efficiency: Evaluating Transport Infrastructure Projects in Argentina Using Web-Scraped Data

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Abstract

Transport infrastructure plays a central role in shaping production costs, market integration, and economic performance, particularly in countries where freight relies predominantly on road networks. In Argentina, the deterioration of key highways used intensively for goods transportation constitutes a major source of logistical inefficiency, increasing travel times and operating costs for firms across multiple provinces. These constraints are especially severe in the Norte Grande region, an area characterized by high poverty rates, low economic density, and limited connectivity, where logistics costs are estimated to be up to 50 percent higher than in central regions. This paper evaluates the economy-wide impacts of selected road infrastructure projects in five provinces of Argentina's Norte Grande (Catamarca, Chaco, Corrientes, Jujuy, and Salta) using province-level Computable General Equilibrium (CGE) models. We integrate Python-based web scraping techniques with CGE modeling to construct realistic, route-specific transport cost shocks grounded in the actual structure of the national road network. Using automated web scraping applied to Google Maps, we identify the most time-efficient routes between 123 urban centers and map more than 46,000 origin-destination flows to specific road segments. Engineering-based estimates of road improvements are translated into percentage reductions in transport costs at the route level. The CGE simulations indicate that the evaluated road projects generate positive economic impacts across all five provinces, with average gains exceeding one percent of provincial GDP and particularly strong effects in Jujuy. Real household income increases by more than two percent on average. At the national level, the combined interventions are associated with an increase of approximately 0.68 percent in GDP, reflecting significant interprovincial spillovers.

Keywords: transport infrastructure; computable general equilibrium; web scraping; Norte Grande; Argentina; logistics costs

JEL Classification: R42; D58; O18; C68

1. Introduction

Transport infrastructure constitutes one of the most consequential determinants of economic performance in developing economies. By reducing the cost and time of moving goods across regions, investments in roads and railways can lower production costs, expand market access, and stimulate productivity across multiple sectors. These gains are particularly relevant in countries where the road network is the dominant mode of freight transport and where significant disparities in logistics efficiency exist across regions.

Argentina exemplifies this challenge. The country has the second-highest logistics costs in Latin America, nearly three times the OECD average, and only approximately one-third of its roads are paved, well below comparator countries at similar income levels (World Bank, 2021). Rural roads, which form the 'last mile' connections to key production zones, are frequently deficient or in poor condition. These structural constraints generate substantial inefficiencies in supply chains, particularly for agriculture and agro-industry, which depend heavily on reliable and affordable transport services.

The Norte Grande region of Argentina, comprising the northwestern (NOA) and northeastern (NEA) provinces, concentrates these challenges in particularly acute form. The region covers nearly 850,000 km² and is home to some 10 million people. Poverty incidence reaches 25.4% in the NOA and 33.2% in the NEA, the highest rates in the country. Business density is low and firms are predominantly small and local. The Norte Grande exported an average of 10.25 million metric tons of goods annually between 2016 and 2021, valued at USD 5.19 billion, with maize, soy, and wheat dominating exports (CFI, 2023). Logistics costs in the region are estimated to be up to 50 percent higher than in neighboring central regions, reflecting the combination of lower road density, poor road quality, and limited freight rail availability.

Against this background, this paper evaluates the economy-wide impacts of a set of selected road infrastructure projects located in five provinces of the Norte Grande: Catamarca, Chaco, Corrientes, Jujuy, and Salta. The evaluation relies on a methodological framework that combines Python-based web scraping of Google Maps routing data with province-level Computable General Equilibrium (CGE) models calibrated to 2018 Social Accounting Matrices (SAMs). Engineering-based estimates of cost reductions along specific road corridors, provided by Sant & García (2024), are translated into productivity shocks to road transport services and incorporated into the CGE models to simulate economy-wide effects.

A distinctive contribution of this paper is the use of web scraping to construct route-specific transport cost shocks that go beyond the stylized distance-based assumptions typically employed in CGE applications. By querying Google Maps for the most time-efficient routes between 123 urban centers across the country, and mapping more than 46,000 origin-destination freight flows to specific road segments, the methodology allows improvements to particular corridors to be consistently translated into economy-wide cost reductions, reflecting the actual routing decisions of freight carriers.

The paper makes two additional contributions. First, it develops five provincial Social Accounting Matrices for Catamarca, Chaco, Corrientes, Jujuy, and Salta with base year 2018, which constitute a novel and replicable dataset for regional economic analysis in Argentina. Second, the methodological framework is designed to be generalizable to other infrastructure evaluation exercises, providing a systematic and transparent bridge between project-level engineering estimates and economy-wide simulation models.

The remainder of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 describes the methodological approach, including the construction of the SAMs, the CGE model, and the scenario design using web-scraped routing data. Section 4 presents and discusses the simulation results. Section 5 concludes.

2. Literature Review

The economic evaluation of transport infrastructure investments has generated a substantial body of empirical and methodological literature. A first strand of research focuses on identifying the channels through which transport improvements translate into economic gains. Park and Yi (2026) examine these mechanisms for U.S. regions using mediation analysis and two-stage least squares, finding that transport infrastructure affects regional economic growth not only directly by increasing capital stock, but also indirectly through productivity improvements and labor market expansion. Their results show that the total effect of infrastructure investment is nearly 1.5 times larger than the direct effect alone, underscoring the importance of capturing indirect and induced channels when evaluating infrastructure policies. This finding motivates the use of economy-wide models rather than partial equilibrium or reduced-form approaches, which tend to focus exclusively on direct effects and may therefore substantially underestimate the social returns to infrastructure investment.

Within this broader literature, CGE models have emerged as the preferred tool for assessing the economy-wide impacts of transport infrastructure, precisely because they capture intersectoral linkages, factor market adjustments, and regional spillovers that simpler approaches cannot. As Ishikura and Yokoyama (2022) argue, conventional cost-benefit analysis, while widely applied, fails to capture broader economic impacts such as changes in sectoral production outputs, income distribution, and agglomeration gains. Similarly, multiregional input-output models, though computationally tractable, assume fixed technical coefficients and lack supply-side feedback in prices and resource constraints, limiting their ability to simulate the full propagation of transport cost shocks through the economy. CGE and spatial CGE (SCGE) models address these limitations by incorporating Walrasian general equilibrium mechanisms, enabling the simultaneous clearing of goods, services, and factor markets under conditions of optimizing behavior by all agents.

Several studies have applied CGE and SCGE frameworks to evaluate specific road infrastructure projects, demonstrating both the versatility of the approach and the heterogeneity of its findings across different geographic and institutional contexts. Ishikura and Yokoyama (2022) construct a spatial CGE model disaggregated at the municipality level to assess the economic impacts of completing ring road sections in the Greater Tokyo Area, implementing the policy shock as a reduction in vehicle travel time that lowers the iceberg transport cost between origin-destination pairs. Their results show that while aggregate welfare gains are positive across all prefectures, the spatial distribution of benefits is highly uneven, with some municipalities experiencing welfare losses due to intensified interregional competition in tradable goods. Yang et al. (2021) employ a multiregional, multisectoral CGE model to compare the economic and environmental effects of railway and road investment in China, finding that road investment generates stronger GDP and household welfare gains by stimulating output in motor equipment, construction, and road transport sectors. Li et al. (2025) extend this line of research by constructing a county-level CGE model, adapted from the TERM framework, to evaluate highway expansion in Gansu Province, distinguishing between national and provincial highways and their differential roles in intra- and interregional trade integration. Their findings confirm that transport infrastructure improvements generate positive economic effects at both provincial and county levels, with particularly pronounced gains in economically lagging regions characterized by high initial logistics costs and limited market connectivity, a pattern that resonates strongly with the context of Argentina's Norte Grande.

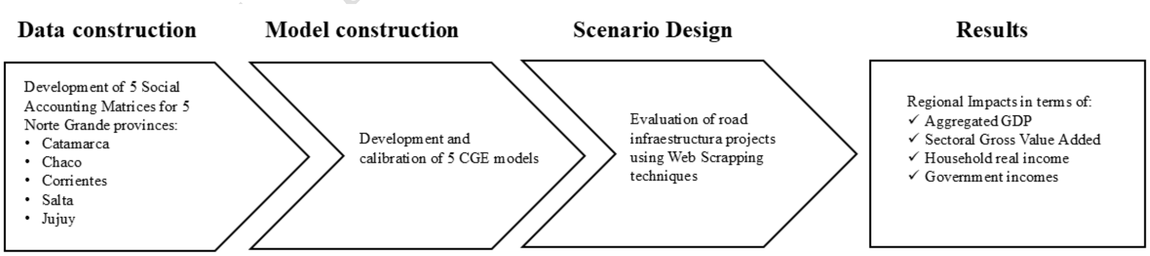
Despite these advances, a common limitation of CGE-based transport evaluations is the manner in which project-level improvements are translated into model shocks. Ishikura and Yokoyama (2022) derive transport cost reductions from a traffic assignment model that computes shortest travel times under network equilibrium conditions, an approach that is data-intensive and requires detailed road network and origin-destination traffic data that are often unavailable in developing country contexts. Li et al. (2025) instead apply uniform elasticity parameters linking highway mileage increases to market scale and cost reductions, following Zhang et al. (2018). Yang et al. (2021) externalize fixed asset investment flows by transport mode. While these approaches are internally consistent, they share a common shortcoming: none explicitly reconstructs the actual routes followed by freight carriers or identify which specific origin-destination flows are affected by a given corridor improvement. As a result, the shocks introduced into the model may not accurately reflect the spatial incidence of project benefits across regions and sectors.

The present paper addresses this limitation by integrating Python-based web scraping of Google Maps routing data into the scenario design process. Rather than relying on aggregate distance-based proxies or traffic assignment models requiring specialized network data, the methodology reconstructs the most time-efficient routes followed by freight carriers between 123 urban centers across Argentina, mapping more than 46,000 origin-destination flows to specific road segments. This approach allows improvements to particular corridors to be translated into transport cost shocks that are grounded in the observed structure of freight routing, providing a more empirically credible and transparent bridge between project-level engineering estimates and economy-wide CGE simulations, one that is also replicable in other developing country contexts where detailed transport network data are scarce.

3. Methodology

Figure 1 presents a schematic overview of the methodology employed in this study. The framework proceeds in four sequential steps: (i) the construction of five regional SAMs; (ii) the calibration of five province-level CGE models; (iii) the design of simulation scenarios using web-scraped routing data; and (iv) the extraction of results in terms of regional GDP, sectoral value added, household income, and tax revenues. Each step is described in detail in the subsections below.

Figure 1. Methodological scheme.



Source: Own elaboration.

3.1. Construction of Regional Social Accounting Matrices

A multisectoral model such as a CGE requires a substantial base of consistent economic information. A SAM fulfills this role by representing the circular flow of an economy in a square matrix format, where each row records the income of a given sector or agent and the corresponding column records its expenditures. The budget constraint (total income equals total expenditure) must hold for every account in the matrix, both at the individual and aggregate levels.

For this project, five SAMs were constructed for the provinces of Catamarca, Chaco, Corrientes, Jujuy, and Salta, with 2018 as the base year. The choice of 2018 reflects its status as the most recent macroeconomically stable year for which sufficient regional data are available to support this type of estimation. To ensure comparability across provinces, each SAM adopts the same sectoral disaggregation, comprising the 14 productive sectors listed in Table 1, plus a 'Rest of Argentina' account that captures interprovincial trade flows.

Table 1. Sectoral classification of the Social Accounting Matrices

No.	Sector
1	Agriculture, livestock, forestry and fishing
2	Mining and quarrying
3	Manufacturing industry
4	Electricity, gas and water
5	Construction
6	Commerce
7	Hotels and restaurants
8	Road transport
9	Other transport and communications
10	Real estate, professional and financial services
11	Public administration and defense
12	Education and health
13	Other services
14	Rest of Argentina

Source: *Own elaboration.*

The primary data sources used in the construction of the SAMs include: regional value added, gross output, and intermediate consumption published by the Ministry of Economy of Argentina; international trade data from the INDEC International Trade Consultation System; provincial government revenue and expenditure from the Cash-Based Savings-Investment-Financing tables; and household income and consumption from the National Household Expenditure Survey (ENGHO 2017/2018) and the Permanent Household Survey (EPH). Where regional data were unavailable, the 2004 national census and regional GDP estimates for that year were used as supplementary references. The national SAM for Argentina 2018 developed by Mercatante et al. (2025) served as the starting point for constructing the regional matrices.

3.2. The Computable General Equilibrium Model

CGE models are numerical representations of an economy that explicitly account for the behavior of households, firms, the government, and the rest of the world, with interactions occurring across goods, services, and factor markets (Burfisher, 2021). Their distinguishing feature is the ability to capture not only the direct impact of a policy change in a specific market, but also the indirect effects propagated through second- and third-order interactions among economic agents.

From the supply side, the model assumes that each productive sector is represented by a single representative firm operating under constant returns to scale, combining intermediate inputs with primary factors (labor and capital) to produce output. From the demand side, firms may source inputs both domestically and from imports, treating them as complementary in intermediate consumption. Households, governments, and the rest of the world demand final goods and services, maximizing their preferences subject to their respective budget constraints.

Equilibrium is achieved when all markets, goods, services, and factors, clear simultaneously under conditions of perfect competition. The simulation results measure the deviation from a counterfactual baseline scenario in which no infrastructure improvements occur, thereby isolating the effect of the road projects on the structure of provincial and national economies.

The five CGE models were implemented using the General Algebraic Modelling System (GAMS) software, which provides the computational algorithms required to solve large-scale multisectoral systems of equations.

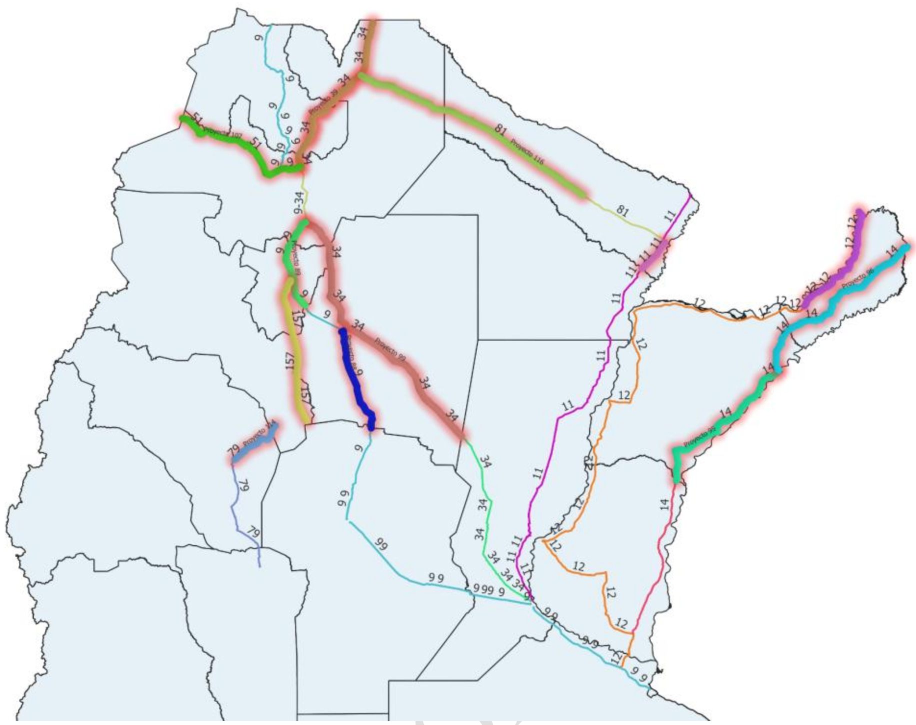
3.3. Scenario Design: From Engineering Estimates to CGE Shocks

The translation of project-level engineering estimates into economy-wide CGE shocks requires a systematic procedure that links the physical characteristics of road improvements to the cost structure of transport activities in the model. This subsection describes this procedure.

The road projects evaluated in this study are drawn from Sant & García (2024), who provide engineering-based estimates of reductions in vehicle operating costs and travel times along specific road corridors in the Norte Grande. These estimates constitute the primary input for the scenario design.

Figure 2 shows the location and extent of the road projects considered in the analysis. As illustrated, the projects span corridors across multiple provinces and do not necessarily coincide geographically with the five modeled provinces; however, they connect key freight distribution nodes throughout the country, and their improvements can affect the cost of interprovincial trade flows that transit through the affected segments.

Figure 2. Map of road routes and projects considered in this study. Note: Projects 1 and 2 were excluded from the analysis due to their scale



Source: Own elaboration.

To quantify the share of freight flows affected by each project, this study uses interprovincial trade flow data available, which records the volume of goods, expressed in metric tons, traded between 123 urban centers across the country for 147 product categories. This generates a dataset of more than 46,000 origin-destination pairs covering the entire national territory.

A key methodological innovation of this paper is the use of Python-based web scraping applied to Google Maps to reconstruct the actual routes followed by freight carriers between each pair of urban centers. For each origin-destination pair, a custom-built script queries Google Maps to identify the most time-efficient route along the national road network. The script then checks whether each identified route intersects with any of the road segments covered by the evaluated projects, and, where applicable, computes the number of kilometers of project segment traversed. This approach allows the analysis to move beyond stylized distance-based assumptions and to ground the transport cost shocks in empirically observed routing decisions.

Once the relevant freight flows for each project were identified, the cost reduction parameters from Sant & García (2024) were applied to the kilometers traversed within each project corridor to compute a weighted average efficiency gain. These gains were then aggregated using trade flow weights to construct province-level transport cost shocks. In the CGE model, these shocks are implemented as improvements in the productivity of road transport services, specifically, as an increase in the quantity of output that can be produced per unit of value added (labor and capital). This formulation is equivalent to assuming that, following the road improvement, transport firms are able to complete a greater number of trips at the same cost, thereby generating reductions in the relative prices of transport services and cascading benefits for transport-intensive activities throughout the economy.

It is important to note that the simulated results capture only the productivity gains associated with road improvements and do not include any economic effects related to the construction phase itself.

4. Results

This section presents the main results of the CGE simulations for the road projects evaluated across the five Norte Grande provinces. Results are reported in aggregated form at the provincial and sectoral levels, expressed as percentage changes relative to the baseline scenario.

4.1. Aggregate Provincial and National Impacts

Table 2 summarizes the aggregate impact of the evaluated road projects on key macroeconomic variables across the five modeled provinces. Taken together, the road improvements generate a combined increase of 1.04 percent in aggregate provincial GDP at basic prices, alongside a 2.36 percent rise in real household income. The latter figure reflects the pass-through of lower transport costs to consumer prices and factor returns, and is notably larger than the GDP effect, suggesting that welfare gains extend beyond output expansion to broader improvements in households' purchasing power. Tax revenues also increase, though modestly, consistent with the relatively limited fiscal sensitivity of transport cost shocks in the short run.

The distribution of impacts across provinces is markedly uneven, reflecting differences in initial logistics costs, economic structure, and proximity to the affected corridors. Jujuy records the largest proportional gains, with aggregate road project impacts amounting to 2.77 percent of provincial GDP and a 4.91 percent increase in real household income, the highest among all modeled provinces. Salta follows with GDP and household income gains of 1.84 and 4.19 percent, respectively. These two provinces concentrate the bulk of the aggregate impact, owing primarily to improvements along the main freight corridor connecting the northwestern provinces with the major consumption and export centers in central Argentina. Catamarca and Corrientes register more moderate gains, in the range of 0.18 to 0.28 percent of provincial GDP, while Chaco records a 0.16 percent increase.

The magnitude of impacts across provinces is closely related to the cost reduction parameters of the evaluated corridors and to the volume of freight flows that transit through the affected road segments. Provinces served by corridors with the largest operating cost reductions, estimated at up to 14.4 percent for a typical freight journey along one of the key evaluated routes, tend to exhibit the strongest economic responses, while those served by corridors with smaller or more localized improvements show correspondingly modest gains.

At the national level, the combined road improvements are projected to increase Argentina's GDP by 0.68 percent, a figure that substantially exceeds the aggregate provincial impact. This gap reflects significant interprovincial spillovers: improvements in the Norte Grande's road network reduce transport costs not only for locally produced goods but also for the large volumes of interprovincial freight that transit through the region's main corridors connecting the northwest with Buenos Aires and Santa Fe.

Table 2. Aggregate impact of road projects on provincial and national macroeconomic variables. Percentage change relative to baseline scenario.

Province	GDP at basic prices (%)	Real household income (%)
Catamarca	0.28	0.57
Chaco	0.16	0.54
Corrientes	0.18	0.31
Jujuy	2.77	4.91
Salta	1.84	4.19
Total (5 provinces)	**1.04**	**2.36**
National GDP	**0.68**	—

Source: *Own elaboration.*

4.2. Sectoral Impacts

Table 3 presents the aggregate impacts disaggregated by broad sector of economic activity across the five modeled provinces. The transport sector is the most directly benefited, registering a value added increase of 8.45 percent, an expected result given that the productivity shocks are introduced directly into road transport services. The magnitude of this response reflects the extent to which lower operating costs translate into higher returns for transport providers and, through backward and forward linkages, into cost reductions for sectors that rely heavily on freight services.

Agriculture is the second most benefited sector, with a 2.48 percent gain in gross value added. This result is consistent with the transport-intensive nature of agricultural production in the Norte Grande, where farm-to-market distances are long and logistics costs represent a substantial share of total production costs. The gains are particularly pronounced in Jujuy and Salta, where agriculture is closely linked to the main evaluated corridors. Manufacturing and mining also register positive gains of 1.31 and 0.89 percent, respectively, reflecting indirect benefits propagated through input-output linkages with the transport and agricultural sectors. The rest of the economy, encompassing services, commerce, and other activities, shows more modest gains of 0.21 percent, consistent with its lower dependence on freight transport costs.

Table 3. Sectoral gross value added impacts of road projects across the five modeled provinces. Percentage change relative to baseline scenario.

Sector	% change in gross value added
Agriculture, livestock, forestry and fishing	2.48
Mining and quarrying	0.89
Manufacturing industry	1.31
Transport	8.45
Rest of economy	0.21

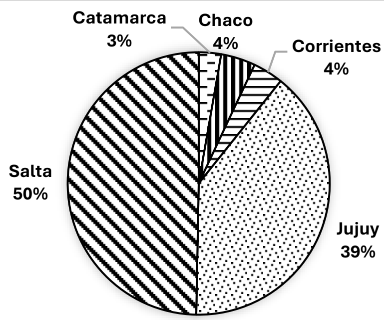
Note: *Gross value added is defined as the gross remuneration to productive factors including labor, capital, and mixed income.*

Source: *Own elaboration.*

4.3. Provincial Breakdown and Corridor-Level Drivers

Figure 3 illustrates the distribution of aggregate provincial GDP impacts across the five modeled provinces, expressed as percentage contributions to the total national effect. The concentration of impacts in Jujuy and Salta reflects the dominant role of the main northwestern freight corridor, the principal artery connecting these two provinces with the major consumption and export markets in central Argentina, which accounts for the majority of the aggregate gains in both provinces.

Figure 3. Share of each province in the total GDP impact of each province



Source: Own elaboration.

In Catamarca, the dominant source of impact is an improvement along a secondary corridor traversing the province from north to south, which generates the largest share of the province's total effect, followed by indirect spillovers from the main northwestern corridor. In Chaco, a single corridor crossing the province along its main north-south axis accounts for approximately two-thirds of the provincial impact. In Corrientes, one corridor concentrated along the province's principal east-west freight route is responsible for the vast majority of the provincial gains, reflecting the centrality of that route for the province's commercial flows.

The variation in impact magnitudes across corridors is driven by three main factors: the magnitude of the engineering-based cost reduction along each segment, the volume of freight flows that transit through the affected road, and the economic structure of the provinces served by each corridor. Corridors serving provinces with high initial logistics costs, strong dependence on primary production, and large interprovincial trade volumes tend to generate the largest economy-wide effects, a pattern that is consistent across all five modeled provinces and reinforces the case for prioritizing investments in high-traffic, transport-intensive corridors.

5. Conclusions

This paper evaluated the economy-wide impacts of 13 road infrastructure projects in five provinces of Argentina's Norte Grande using a novel methodological framework that combines Python-based web scraping of Google Maps routing data with province-level CGE models. The analysis is grounded in five Social Accounting Matrices for Catamarca, Chaco, Corrientes, Jujuy, and Salta, constructed with 2018 as the base year, and in engineering-based estimates of road improvement costs provided by Sant & García (2024).

The results indicate that the road projects evaluated in this study generate meaningful positive economic impacts across all five modeled provinces, with aggregate gains in provincial GDP exceeding one percent and real household income rising by more than two percent on average. These effects propagate through production networks and are particularly pronounced in transport-intensive activities such as agriculture and agro-industry, which are central to the Norte Grande economy. At the national level, the combined road improvements are estimated to raise Argentina's GDP by 0.68 percent, reflecting significant interprovincial spillovers that arise from the region's role as a transit corridor for national freight flows.

Project 99 on RN 34 emerges as the most impactful individual intervention, driven by its large operating cost reduction (14.4 percent) and its location on the principal artery connecting the northwestern provinces of Salta and Jujuy with the major population and export centers in central Argentina. The strong concentration of impacts in these two provinces, and the relatively smaller gains in Catamarca, Chaco, and Corrientes, underscores the importance of corridor-level geography in determining the distribution of benefits from road investments.

The methodological contribution of this paper is twofold. First, it provides a systematic and replicable procedure for translating project-specific engineering estimates into economy-wide CGE shocks, making the framework applicable to other infrastructure evaluation exercises in Argentina and beyond. Second, the use of web scraping to reconstruct actual freight routing decisions replaces the stylized distance-based assumptions commonly used in CGE applications, improving the empirical grounding of the simulated transport cost shocks.

Several extensions of this work merit consideration for future research. The inclusion of dynamic effects — for instance, through investment responses triggered by lower logistics costs — could provide a more comprehensive assessment of long-run welfare gains. Extending the framework to additional Norte Grande provinces or to other infrastructure modes would allow for a broader evaluation of regional connectivity investments. Finally, incorporating distributional dimensions, such as the differential impact of transport cost reductions across household income groups, would enrich the welfare analysis and strengthen its policy relevance.

Taken together, the findings of this paper reinforce the case for prioritizing road infrastructure investment in Argentina's Norte Grande as a tool for regional development and economic integration. By offering a rigorous, data-driven assessment of economy-wide impacts, the methodology and results presented here provide policymakers and development institutions with actionable evidence for infrastructure appraisal and investment prioritization.

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