LATIN AMERICAN ECONOMIC REVIEW

Volume 36: Issue 50th Anniversary Division of Economics | Article 1 | 2025

Disconnected Roads: How Transport Infrastructure Falls Short in Southern Mexico*

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Submission received: January 29, 2025
Final version received: July 31, 2025
Accepted: August 1, 2025
Published: September 12, 2025

Abstract

This paper studies the effectiveness of transport infrastructure in promoting development in lagging regions. Using detailed road and census data combined with a spatial general equilibrium model calibrated to Mexico, we show that infrastructure investments in poorer areas are more effective when they enhance connectivity to the national network and are paired with productivity improvements. Between 2004 and 2019, Mexico's southern states received over one-fourth of all new paved roads but saw limited connectivity gains, as investments focused on low-speed, locally administered roads that primarily connected low-productivity municipalities within states. While the national road expansion raised national real income by 1.0% and welfare by 1.7%, the income elasticity with respect to new roads in the South was only half that of the North. To highlight the critical role of local economic conditions in shaping these returns to new transport infrastructure, we show that a counterfactual 2,200km highway in the South generates only one-third the welfare gains of an equivalent highway in the North—unless accompanied by a 5.5% productivity boost.

Keywords: Economic geography, Transport infrastructure, Regional development.
JEL codes: R42, O18, R12, F15.

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*I would like to thank Santiago Levy and Jonas Gathen for their valuable comments and suggestions, as well as participants at CIDE's 50th Anniversary Workshop, and two anonymous referees. AI tools were used to proofread the manuscript. All errors are my own.

1. Introduction

Transport infrastructure is widely considered crucial for economic development, as it facilitates the movement of goods and people, a fundamental requirement for economic growth (Banerjee et al., 2020). The literature has consistently shown that well-developed infrastructure can significantly boost welfare by reducing transportation costs, improving market access and trade across regions (Redding and Turner, 2015; Donaldson, 2018; Morten and Oliveira, 2018). As a result, countries invest annually between 0.5% and 5% of their GDP in improving or expanding their internal transportation networks (OECD, 2020). Mexico is no exception. Between 2004 and 2019, it expanded its paved roads and highway network from approximately 115,000 to 201,000 kilometers—a 75% overall increase. However, this expansion was not uniform across the country. Four southern states—a region with a long history of economic underdevelopment—accounted for more than one-fourth of the newly constructed paved road kilometers.[1] Despite these large investments, the region remains the poorest.

In this paper, we aim to shed light on the reasons preventing southern states from fully reaping the benefits of such infrastructure. We do this by combining highly detailed data on all segments of paved roads and highways in Mexico from 2004 to 2019 with the Economic Census and a standard economic geography model. Armed with this data and model, we show that two key factors explain this puzzle: first, the fundamentally different type of infrastructure built in the South; and second, the fact that it primarily connected low-productivity municipalities within each state, rather than linking these states to the broader national network and to larger, more productive markets.

We proceed in two steps. First, we characterize the location and features of new paved roads and highways built between 2004 and 2019, and assess how they affected market access and regional connectivity. To do this, we draw on two key data sources: the National Highways Network—a catalog of all paved road and highway segments in Mexico produced by the Ministry of Transportation and Communications (SCT) and the National Institute of Statistics and Geography (INEGI); and the Mexican Economic Census, also collected by INEGI, which provides information on all establishments operating in fixed facilities across all industries, locations, sizes, and formality statuses.

In southern states, new infrastructure was twice as likely to be low-speed, state-level, toll-free roads compared to the rest of the country. By contrast, in northern border states fewer kilometers were built but prioritized high-speed, federal toll highways. This disparity had distinct effects on the South's integration. Market access—a standard trade measure—increased by only half as much as in the North or the Baja California and Yucatán peninsulas. Network centrality—an eigenvalue-based graph theory measure—fell in the South, despite extensive road construction, reducing its relative importance in the national network.

In the second step, we employ a standard economic geography model to examine the importance of heterogeneous municipal characteristics in shaping the aggregate and regional effects of new infrastructure between 2004 and 2019. The model, adapted from Allen and Arkolakis (2014), features numerous municipalities with varying levels of local amenities and productivity. These municipalities produce goods that are traded under iceberg trade costs, which depend on the highway network and travel times. The economy is populated by freely mobile workers who both congest municipal amenities and enhance local productivity through positive agglomeration externalities. When new infrastructure is introduced, its direct and indirect effects on municipalities depend on the interaction between these two forces.

We calibrate the model to match the trade geography and the distributions of labor and wages across Mexican municipalities in 2019. Our baseline calibration estimates that southern states are in average 2.5 times less productive than Mexico City but value local amenities twice as much. This rationalizes why these states remain highly populated despite offering lower real wages. In contrast, northern states show the opposite

[1] Guerrero, Oaxaca, Chiapas, and Veracruz.

pattern: their amenities are valued one-third of those in Mexico City, but their productivity matches that of the capital. This accounts for their high wages and large, growing populations.

From the baseline calibration, we obtain three main findings. First, newly paved roads and highways from 2004 to 2019 resulted in welfare gains of 1.7% and aggregate income gains of 1% in 2019. These income gains are equivalent to the GDP share of states like Aguascalientes, Durango, or Morelos in that year. However, these gains are not evenly distributed across municipalities. In fact, the distribution of real income gains indicates a reallocation of economic activity. While municipalities above the 95th percentile of the real income gains distribution saw their real income increase by more than 12%, those below the 5th percentile experienced a decline of more than 2%.

Second, despite receiving the highest number of new paved road kilometers per capita and experiencing the fastest network growth, the real income gains in the South (4.4%) were similar to those in the North (4%)—a region with 40% fewer new roads per capita and a 10-percentage-point lower share of new kilometers of roads (26.5% vs. 15.2%). In fact, the elasticity of real income gains with respect to new paved road kilometers in the South was half that of the North (0.4 vs. 0.8).

Third, to shed light on the mechanisms behind the lower gains from new infrastructure in the South, we perform a policy experiment. The experiment proposes a new 2,200-kilometer highway with an average speed of 120 km/h to be built either in the North or the South. While in the North it would generate aggregate welfare gains of 0.3% and aggregate real income gains of 0.18%, in the South it would generate only one-third the welfare gains and no aggregate real income gains. In fact, to generate the same welfare gains, the highway in the South would need to be accompanied by a 5.5% increase in productivity in all municipalities crossed by the new road. This result highlights the importance of local productivity in shaping the economic impact of new highways.

Together, our findings reveal that while national-level road expansion has been significant, its distribution and impact vary substantially across regions. The uneven regional effects highlight the importance of complementary conditions in shaping the benefits of infrastructure. In particular, the limited gains observed in the South—despite greater investment—underscore the key role of local productivity in translating new roads into stronger economic progress. Rather than discouraging infrastructure development in lagging regions, these results point to the need for integrated policies. To unlock the full potential of transport investments in the South, such efforts should be paired with strategies that enhance local productivity—such as attracting high-productivity formal firms (Levy, 2018; Fentanes and Levy, 2024), facilitating skilled migration (Bryan and Morten, 2019), establishing special economic zones (Hausmann and Rodrik, 2003), or improving governance (Rodrik, 2004).

This paper relates to the spatial economics literature (Allen and Arkolakis, 2014; Redding, 2016; Redding and Rossi-Hansberg, 2017). While this class of models has demonstrated the benefits of reducing trade and commuting costs through transport infrastructure, it typically remains agnostic about the heterogeneity in the physical and operational characteristics of the underlying transportation network. In this paper, we document that large road networks—measured in total kilometers—do not necessarily lead to significant gains in market integration.

Our work also relates to the literature on the effects of transport infrastructure on economic development (Donaldson, 2018; Banerjee et al., 2020). We contribute to this literature by providing evidence that when governments have incentives to build underperforming roads in economically lagging regions, the impact on economic development may be limited. In addition, this paper contributes to the literature on transport infrastructure in the context of Mexico (Dávila et al., 2002; Pérez and Sandoval, 2017; Blankespoor et al., 2017; Busso and Fentanes, 2024). We extend this body of work by offering a detailed characterization of newly paved roads and by examining their heterogeneous interactions with local productivity across regions.

The rest of the paper is organized as follows. Section 2 describes the data used and presents stylized facts about the expansion of the highway network in Mexico from 2004 to 2019. Section 3 examines the impact of this expansion on regional network integration and discusses the empirical evidence. Section 4 outlines and calibrates a version of the Allen and Arkolakis (2014) model. Section 5 presents our main findings and includes a sensitivity analysis. Section 6 explores the effects of two hypothetical highways—one in the South and one in the North of Mexico. Finally, Section 7 offers concluding remarks.

2. Data and facts

Our primary data source is the National Road Network (NRN) datasets from 2004 and 2019, produced by the National Institute of Statistics and Geography (INEGI) and the Ministry of Communications and Transportation (SCT). This digitized network is a rich geospatial dataset that maps the structure and attributes of Mexico's road system. For all highway segments, it provides information on jurisdiction—indicating whether a road is under federal, state, or municipal control—as well as surface type (e.g., paved, unpaved, asphalt, concrete), segment length, number of lanes, and maximum allowed speed (in km/h).

The NRN categorizes roads into three groups: (i) all national, state, and municipal paved highways; (ii) all urban paved roads; and (iii) all unpaved roads. In this paper, we study changes in the first group, referring to them interchangeably as highways or paved roads. We exclude changes in the second group (urban roads) because our focus is on travel times across municipalities. While we do not explicitly exclude the third group (unpaved roads), we assume they are transited at a strictly lower speed than the slowest paved road ($\leq$30 km/h).[2] We classify a paved road or highway segment as *new* if it appears in the 2019 network but not in the 2004 network. To avoid misclassifying segments due to slight positional shifts between the two years, we define a 2019 segment as new only if it falls outside a 500-meter buffer around the 2004 segments.[3]

Finally, the NRN allows us to compute a matrix of minimum travel times for all origin–destination pairs across the country's J municipalities, denoted as $\{T_{i,j}\}_{i,j\in J}$. Travel times between municipality centroids $(T_{i,j})$ are calculated using the Dijkstra (1959) algorithm, which identifies the fastest path between any two locations.[4] This matrix is used throughout the paper to compute measures of market access and network centrality, and to characterize the geography of trade costs for the 2004 and 2019 road networks.

To track changes in economic outcomes, we use the 2004 and 2019 waves of the Mexican Economic Census at the municipal level, collected by the National Institute of Statistics and Geography (INEGI).[5] As of 2024, Mexico has 2,478 municipalities. However, for the purposes of this paper, we restrict our sample to the 2,062 municipalities with more than 2,500 inhabitants that report salaried workers in the census.[6] The census includes all establishments operating in fixed facilities, regardless of size or formality status, and across all 6-digit industries in the North American Industry Classification System (NAICS). Tables 7 and 8 in the Appendix show the census coverage by industry and state. In 2004, the census recorded 3 million establishments and 16.2 million workers; in 2019, it recorded 4.8 million workers and 27.1 million establishments.

[2]As of 2023, the approximate number of kilometers (in thousands) was 200 for paved highways, 130 for urban paved roads, and 530 for unpaved roads (INEGI-SCT, 2023).

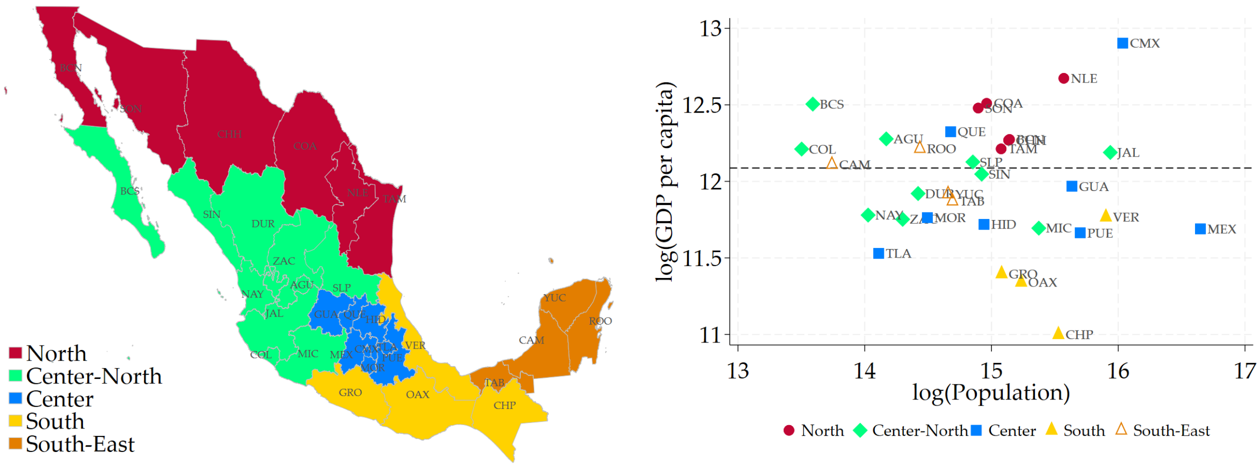
[3]Positional shifts may result from digitization errors or from physical modifications to existing roads, such as realignments, widenings, or reconstructions.

[4]Following Busso and Fentanes (2024), the Mexican territory is divided into 382,181 hexagons, with travel speed through each hexagon determined by the fastest road that crosses it.

[5]The 2019 Economic Census reflects economic outcomes from 2018, and the 2004 census reflects those from 2003. This information is publicly available through the Automated System of Census Information (SAIC).

[6]Most of the excluded municipalities are in Oaxaca, where only 250 out of 570 are retained in the sample but account for 92% of the state's employment. The final sample covers 99.5% of total employment in the full census.

Figure 1. Regions and GDP per capita, 2019



(a) Regionalization of Mexico

(b) GDP per capita (2019) and population (2020)

Notes: **North** includes Baja California (BCN), Chihuahua (CHH), Coahuila (COA), Nuevo León (NLE), Sonora (SON), and Tamaulipas (TAM); **Center-North** includes Aguascalientes (AGU), Baja California Sur (BCS), Colima (COL), Durango (DUR), Jalisco (JAL), Michoacán (MIC), Nayarit (NAY), San Luis Potosí (SLP), Sinaloa (SIN), and Zacatecas (ZAC); **Center** includes Mexico City (CMX), State of Mexico (MEX), Guanajuato (GUA), Hidalgo (HID), Morelos (MOR), Puebla (PUE), Querétaro (QUE), and Tlaxcala (TLA); **South** includes Chiapas (CHP), Guerrero (GRO), Oaxaca (OAX), Veracruz (VER); and **South-East** includes Tabasco (TAB), Campeche (CAM), Quintana Roo (ROO), and Yucatán (YUC). Panel (b) uses data from INEGI's National Accounts 2019 and Population Census 2020. GDP per capita excludes oil. Horizontal line is national GDP per capita.

We focus on two municipal-level economic outcomes by year: total labor and average wage. Total municipal labor is calculated as the sum of all workers reported in the census, including blue- and white-collar workers, owners, outsourced workers, and piece-rate workers. The municipal wage is calculated in two steps. First, we compute the average wage at the establishment level by dividing total remuneration for blue- and white-collar workers by their headcount. We focus on this subset of workers because, unfortunately, the census does not report remuneration for owners or family members. Second, we calculate the median wage across establishments at the municipal level using the establishment-level wages estimated in the previous step.[7]

Throughout the paper, we classify the 32 federal states into the four regions defined by the Mexican Central Bank in its *Regional Economic Reports*. Additionally, we further divide the Southern region into South and South-East to highlight the heterogeneity in economic outcomes and infrastructure policy within this area. The map in Figure 1a illustrates this regional classification and lists the states in each group.

2.1. Geographical distribution of economic activity in 2019

Economic activity in Mexico is unevenly distributed and marked by a pronounced north-south divide. Figure 14 in the Appendix maps the share of GDP by state in 2019. Forty percent of the country's GDP was generated in just four states: Mexico City (16%), the State of Mexico (9%), Nuevo León (8%), and Jalisco (7%).

Additionally, two regions stand out: the industrialized north (Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas), which borders the United States and has 22.9 million people, and the South (Guerrero, Oaxaca, Chiapas and Veracruz), which is predominantly rural, poorer, and home to 21.2 million

[7] By focusing on the median, this measure remains robust to outliers. All results in the paper are robust to using residualized wages (e.g., controlling for industry or workers education). These additional results are omitted for brevity but are available upon request.

people.[8] While the six northern states contribute 25.1% of national GDP, the four states in the South account for only 8.8%.

The fact that the South is similarly populated as the North but contributes a smaller share of GDP is illustrated in Figure 1b, which plots each state's population against its GDP per capita. All southern states are clustered below the national GDP per capita level (dashed line), while all northern states lie above it. Taken together, northern states have a GDP per capita that is 2.6 times higher than that of the South.

2.2. *Highways expansion, 2004-2019*

From 2004 to 2019, a total of 86,000 kilometers of new paved roads were constructed in Mexico, increasing the total network length from 115,000 to 201,000 kilometers—representing a 75% increase. Figure 2 illustrates this expansion across the country, with roads under local jurisdiction (state or municipal) shown in red and those under federal jurisdiction in black.[9] Although the federal network expanded by 20,000 kilometers, its share of the total network declined from 40% to 33%.[10]

The expansion of the network, illustrated in Figure 2, was heterogeneous across states. Figure 3 maps the share of new kilometers of roads and its correlation with the implied network size growth. All four southern states are among those with the largest shares of new roads and the highest implied network growth rates. In contrast, northern states exhibit the opposite pattern. This suggests that most of the new road kilometers built between 2004 and 2019 were concentrated in states with the most underdeveloped networks.

Table 1 summarizes the distribution and growth of new road infrastructure across the five regions. The south experienced the highest road network growth (120.7%) and had the highest new road construction per capita (1.22 meters), despite having only 17.5% of the population. The center-north contributed the largest share of new roads (30.5%), with a growth rate of 79.4% and a relatively high per capita measure (1.20 meters). In contrast, the center, with the largest population share (38.4%), had a lower per capita road expansion (0.45 meters), indicating relatively less infrastructure investment per resident.

Table 1. New highways per region

Region	**Network size growth (%)**	**Share of new roads (%)**	**Population share (%)**	**New meters per capita**
North	48.2	15.7	17.6	0.74
Center-North	79.4	30.5	21.0	1.20
Center	82.6	20.7	38.4	0.45
South	120.7	25.7	17.5	1.22
South-East	41.0	7.4	5.5	1.11
Total	**73.9**	**100**	**100**	**0.83**

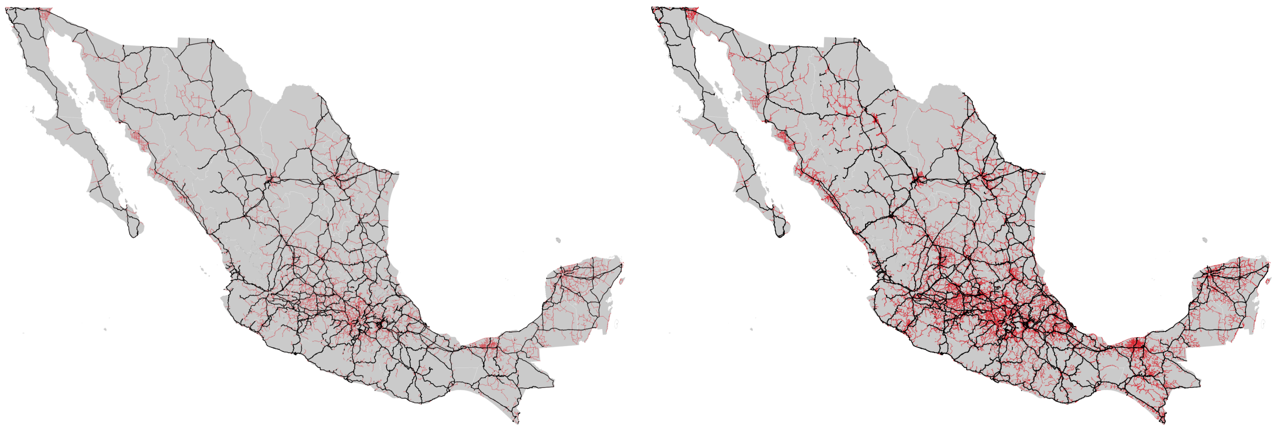
Notes: Population is based on data from the 2005 population survey. The total population in 2005 was 103 million. The population shares across regions remained stable in the Population Census 2020.

[8] Total population in Mexico in 2020 was 126 million (Population Census).

[9] By law, a road falls under federal jurisdiction if it is built with federal funds, crosses multiple states, or connects to border crossings or seaports.

[10] The 20,000 kilometers of new federal roads include 12,000 kilometers of newly constructed segments and 8,000 kilometers reclassified from municipal or state to federal jurisdiction.

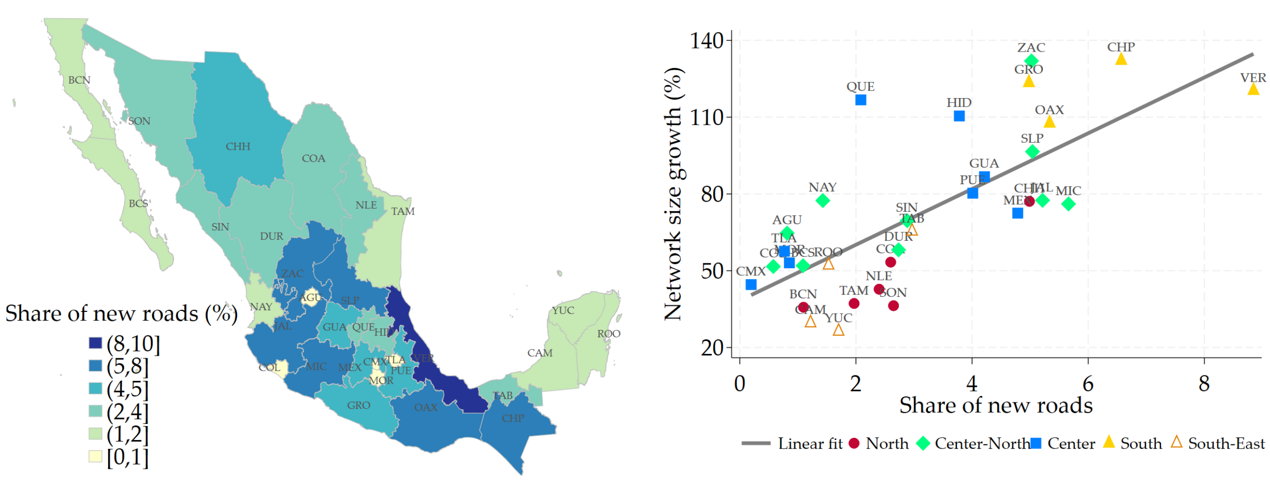
Figure 2. Paved roads and highways network in Mexico, 2004-2019



(a) 2004 (115,000 km) **(b)** 2019 (201,000 km)

Notes: The maps show the complete network of paved roads and highways in 2004 and 2019. Federal highways are highlighted in bold black segments, while red segments represent state and municipal paved roads.

Figure 3. Expansion of the paved road and highways network, 2004-2019



(a) Share of new roads (2004-2019) **(b)** Corr. share of new roads and growth (2004-2019)

Notes: From 2004 to 2019, 86 thousand kilometers of new roads were built in Mexico. Table 9 in the Appendix show the exact numbers by state.

2.3. Types of highways

Although more than one-fourth of the 86 thousand new segments of paved roads and highways were built in the South, the characteristics of these roads differed fundamentally from those constructed in the rest of the country.[11] Table 2 shows that the South region was consistently less likely to receive new paved roads and highways that were under federal jurisdiction, made of concrete, had four lanes, or had speed limits of $\geq 80km/h$, compared to the rest of the country. For instance, while the South received 20% of the 12.3 thousand kilometers of new federal roads, it received 28% of the 74 thousand kilometers of new local (municipal and state) roads. Similarly, it received only 17% of the 19 thousand kilometers of new roads with speed limits above $80km/h$, but 29% of those with speed limits below that threshold.[12] In contrast, the bias in the characteristics of new segments was reversed in the North. Table 2 shows that the region was more likely to receive federal highways and those with speed limits above $80km/h$.

Table 2. Share of new highways by type and region

Region	Federal		Concrete		4-lanes		Toll		$\geq 80\frac{km}{h}$	
	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
North	13	21	14	12	14	17	14	13	12	20
Center-North	30	30	30	29	30	29	30	29	30	30
Center	21	25	21	38	22	28	20	42	20	28
South	28	20	27	18	27	14	27	13	29	17
South-East	8	4	8	3	8	12	8	3	9	5
All	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Total in	74.0	12.3	82.8	3.5	85.2	1.2	80.3	6.0	67.4	19.0
('000 km)	**86**		**86**		**86**		**86**		**86**	

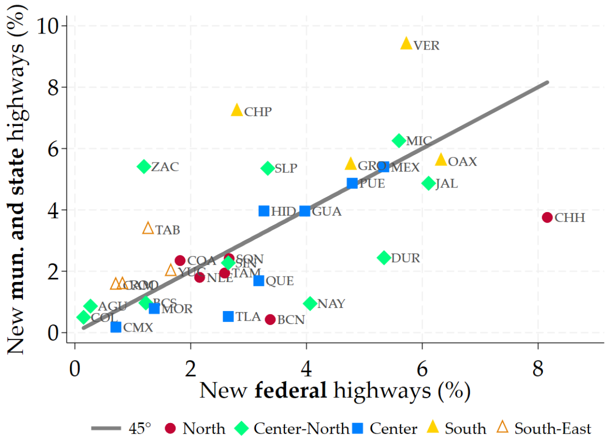
Notes: Data corresponds to new segments built between 2004 and 2019.

Figure 4 illustrates the patterns shown in Table 2 at the state level.[13] Panel 4a shows, for instance, that Chiapas received 7.2% of all new segments under local jurisdiction but only 2.8% of those under federal jurisdiction. In other words, relative to the national level, Chiapas was 2.5 times more likely to receive a local segment than a federal one. Alternatively, while the national ratio of new kilometers of local to federal segments was 6 to 1, in Chiapas it was 15 to 1.

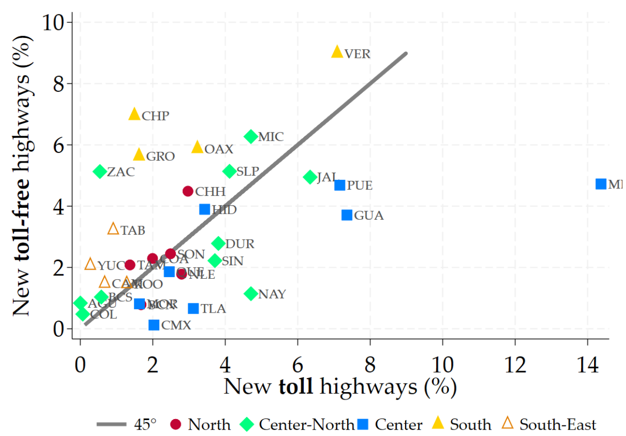
A similar pattern is observed across all other characteristics of new segments of paved roads and highways. Southern states appear most frequently above the 45-degree line in all panels of Figure 4, reflecting once again their higher likelihood of receiving local, toll-free, asphalt-surfaced roads with fewer than four lanes and speed limits below $\geq 80\frac{km}{h}$.

[11] Figures 15 and 16 in the Appendix show the geographical location of these new segments by characteristic.
[12] Table 12 shows that federal, concrete, four-lane, and toll roads and highways are positively correlated with higher top speeds.
[13] Table 10 in the Appendix reports the total kilometers by category, and Table 11 provides the corresponding shares shown in the figures.

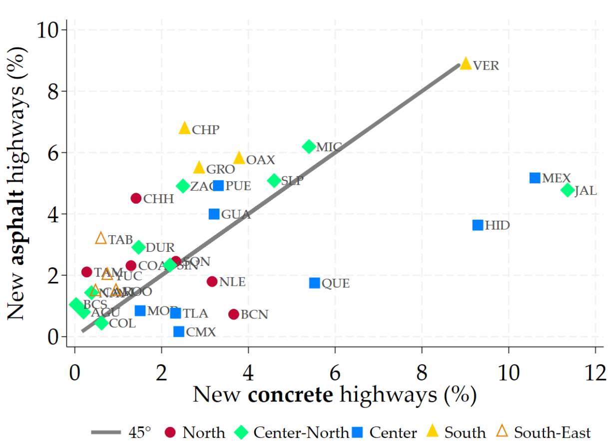
Figure 4. Share of Km of new highways by state and characteristics



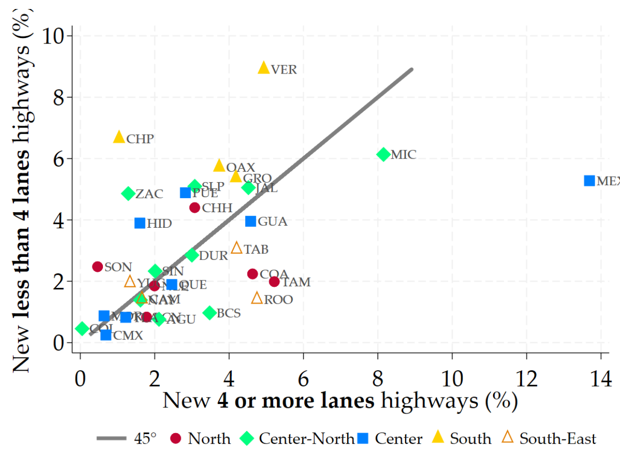
(a) New highways by jurisdiction



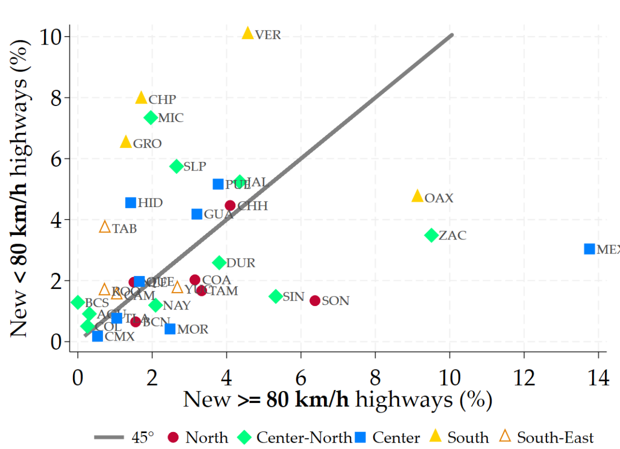
(b) New highways by toll status



(c) New highways by pavement material



(d) New highways by number of lanes



(e) New highways by speed

Notes: In all figures, axes show the share of total roads allocated to each state by characteristic, with x-axis characteristic and y-axis characteristic each summing independently to 100% across states.

3. Connectivity Gains

What were the consequences of building predominantly locally-administered, toll-free, asphalt, and less-than-four-lane roads for the integration of the South? To answer this question, we use two approaches to measure improvements in connectivity: *market access* and *network centrality*. These measures have the advantage of capturing changes in connectivity resulting from both nearby and distant infrastructure, as well as from completely new segments or improvements to existing ones.

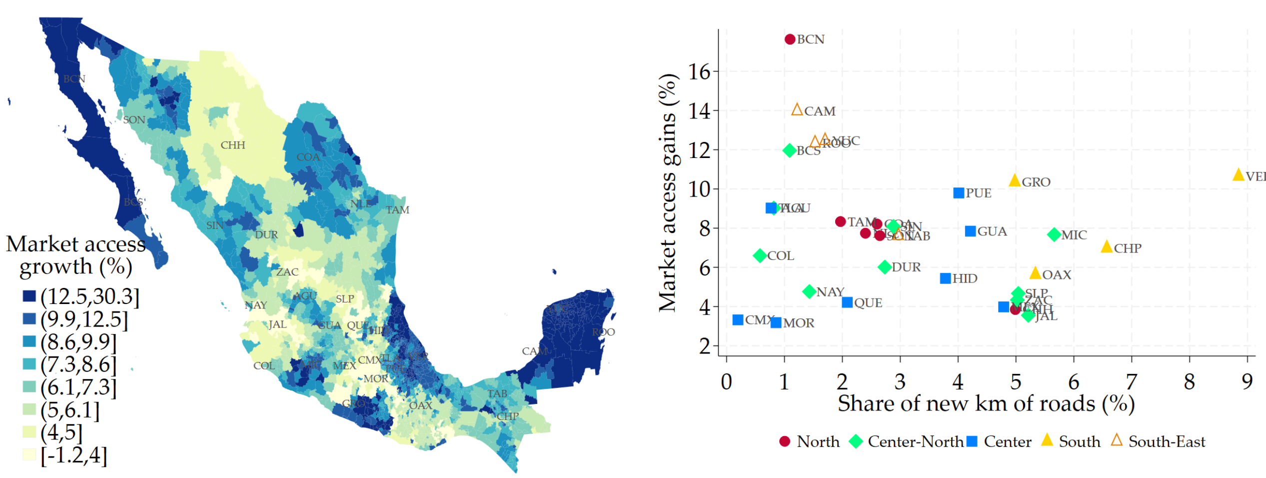
3.1. Market access

Market access measures spatial accessibility, which refers to how easily a municipality can connect with other markets. It assigns greater weight to nearby locations or larger economies. The market access index for municipality $i \in J$ is given by:

$$MA_i = \sum_{j \in J, j \neq i} \frac{L_j}{\tau_{i,j}^{\theta}}, \tag{1}$$

where J is the number of municipalities, L_j is the market size of municipality j measured as the number of workers in the census, $\tau_{i,j}$ is iceberg trade cost from municipality i to j (as defined below in Equation 12) and θ is the elasticity which measures the sensitivity of trade flows to trade costs. We compute MA_i separately for the Economic Censuses 2004 and 2019 keeping the market size constant at 2004 levels, therefore, attributing all changes in market access to trade costs reductions. Following the meta estimates in Simonovska and Waugh (2014) and Redding (2016), we set $\theta = 4$.[14]

Figure 5. Market access growth, 2004-2019



(a) Market access growth **(b)** Average market access growth by state

Notes: Market access is defined as in Equation 1. Market access is computed keeping market size constant in 2004 levels and letting only the highways network change from 2004 to 2019. State-level average market access growth is the population-weighted average across growth rates by municipality.

Figure 5 illustrates the changes in market access resulting from the construction and improvements of highways between 2004 and 2019. Figure 5a highlights that the municipalities experiencing the greatest increases in market access belong to three main groups (shown in darker shades). First, municipalities along the

[14] This implies that goods are highly differentiated across locations. Depending on the context, this elasticity ranges in the literature from 4 (Head and Mayer, 2014) to 9 (Allen and Arkolakis, 2014).

northern border with the United States, particularly those near California and Texas. Second, municipalities near the coastal cities of Tuxpan, Veracruz and Acapulco, Guerrero. And third, municipalities in the Yucatán Peninsula.

Figure 5b shows the share of new kilometers of paved roads and highways alongside the corresponding average market access gains. Despite receiving only about 1% of the new infrastructure, Baja California experienced a market access increase of over 15%. Three of the four states in the Southeast were also among the top gainers in market access, despite each receiving less than 1.5% of the new roads. In contrast, states in the South—despite receiving the largest shares of new infrastructure—had mixed outcomes. For example, Veracruz, the largest recipient of new infrastructure, achieved market access gains similar to those of Puebla, which received less than half as much. Likewise, Chiapas and Oaxaca had market access improvements comparable to Colima's, despite receiving more than ten times the kilometers of new paved roads and highways.

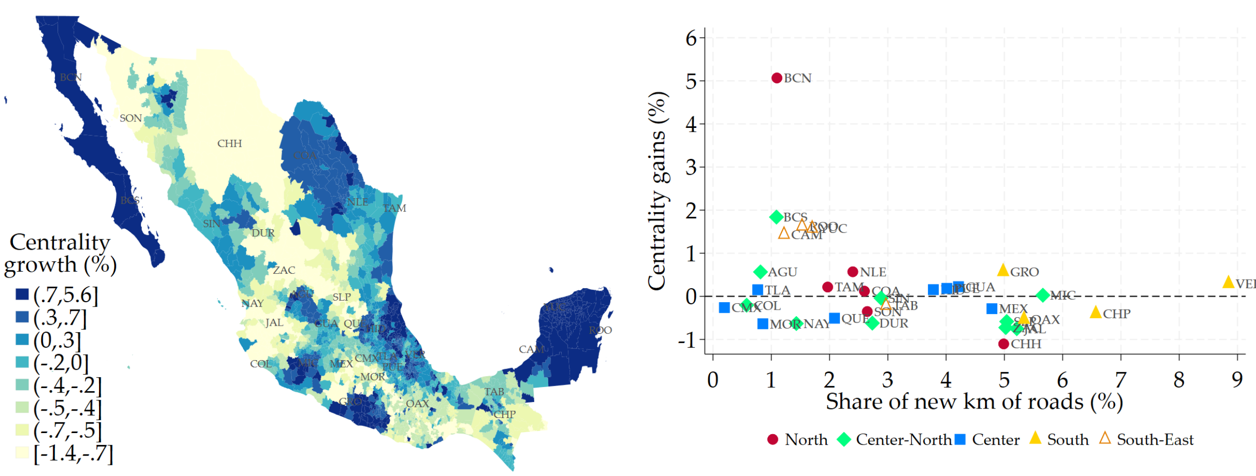
3.2. Network centrality

Our second measure of connectivity is the network centrality coefficient. This measure identifies which municipalities are most influential within the road transportation network, regardless of their market size. A high centrality coefficient indicates that a municipality is either highly connected to many others or connected to a few highly influential municipalities (those with high centrality scores). The centrality coefficient of municipality i is defined as:

$$c_i = \frac{1}{\lambda} \sum_{j \in J} \frac{1}{\tau_{i,j}} c_j, \tag{2}$$

where $\tau_{i,j}$ represents, again, the iceberg trade costs between municipality i and j, λ is the largest eigenvalue of the adjacency matrix of inverse trade costs $\frac{1}{\tau_{i,j}}$, and c_i the i-th entry of the eigenvector associated to λ.[15]

Figure 6. Network centrality growth, 2004-2019



(a) Network centrality growth **(b)** State average centrality growth

Notes: Municipality network centrality is the weighted sum of the entries of the eigenvector associated to the largest eigenvalue of the inverse trade costs matrix. Centrality is normalized to 1 for Mexico City (Delegación Cuauhtémoc) in both 2004 and 2019. State-level network centrality growth in panel (b) is the population-weighted average of the growth rates by municipality.

[15] The adjacency matrix summarizes the trade relationships between municipalities, with larger trade costs between i and j corresponding to lower weights in the matrix.

Figure 6 presents the changes in the centrality coefficient resulting from the construction and improvement of paved roads and highways between 2004 and 2019. The map in Figure 6a shows that municipalities in the Baja California and Yucatán peninsulas became more important within the national network, along with those near the coastal cities of Manzanillo (Colima), Acapulco (Guerrero), and Veracruz (Veracruz). In contrast, municipalities in the interior of the country and in the southernmost regions became less central to the network.

Figure 6b displays the share of new kilometers of paved roads and highways alongside the corresponding network centrality gains. As with market access, Baja California is the state with the largest improvement in relative centrality. Once again, states in the South experienced limited gains. While Guerrero and Veracruz saw modest increases in their relative importance within the network, the states of Oaxaca and Chiapas actually became less central.

3.3. Discussion

In summary, the Mexican governments (both federal and local) built a substantial share of new paved roads and highways between 2004 and 2019 in the South—a region with a large share of the population but lagging economic development. However, this infrastructure was mostly under local jurisdiction, toll-free, paved with asphalt, and had fewer than four lanes. These roads were likely intended to connect municipalities within individual states rather than link them to the broader national network. As a result, gains in market access and network centrality in the South were modest. The opposite pattern was observed in the North and, to some extent, the South-East. Two key questions arise: First, why did the South receive a disproportionately large share of new infrastructure kilometers? And second, why was this infrastructure so different?

One reason the South received a large share of newly paved roads relates to equity and regional development goals. Figure 7a shows a positive correlation between the poverty index in 2005 and the share of new infrastructure built from 2004 to 2019.[16] All southern states are clustered among those with the highest poverty rates and also received the largest shares of new infrastructure. In contrast, all northern states are clustered among those with the lowest poverty rates and received the smallest shares of new paved roads and highways. By building more highways in the South, governments may aim to boost both short- and long-term economic activity while also promoting social inclusion—such as access to education and health services—thereby reducing poverty.

Large infrastructure investments, however, can also be explained by clientelism (Luca et al., 2023) and vote buying (Boudot-Reddy and Butler, 2024). In states with weak institutions, infrastructure projects can serve as visible signs of government action. In line with this explanation, Figure 7b shows a negative correlation between the democracy index in 2019 and the share of new kilometers of paved roads and highways built between 2004 and 2019.[17] All southern states are clustered among the least democratic and received the largest shares of new infrastructure. The pattern is less clear for states in other regions of the country.

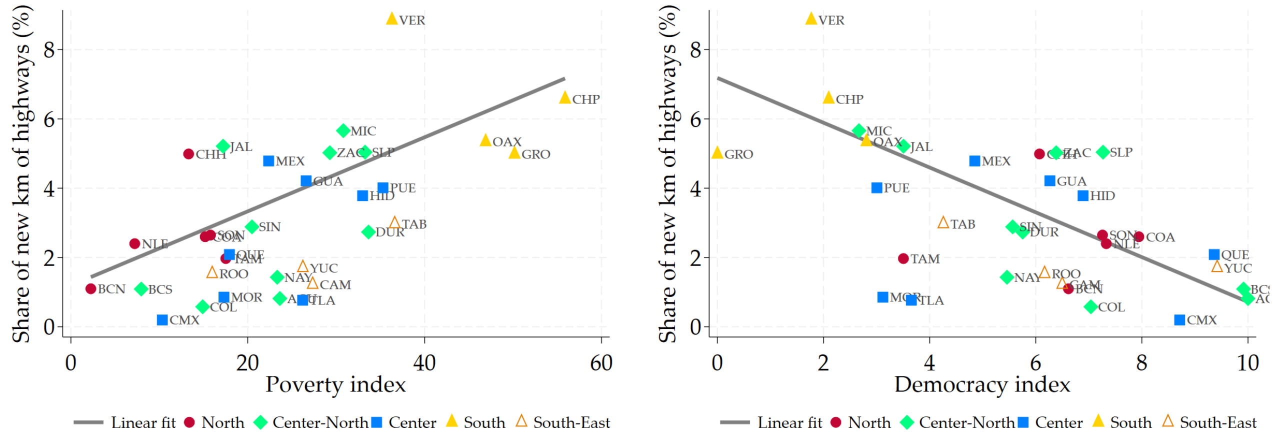
Similarly, the fact that new infrastructure in the South consisted disproportionately of local, toll-free, asphalt roads with fewer than four lanes suggests that governments prioritized accessibility over connectivity—that is, ensuring basic mobility to reach local public services such as health and education, rather than promoting economic integration to access distant markets. However, once again, the type of infrastructure built in the South may also reflect clientelist strategies, as local, toll-free roads with fewer lanes are cheaper to build and allow governments to deliver quick and highly visible results.

While identifying the precise motivations behind the scale and characteristics of transport infrastructure

[16] The poverty index (2005) represents the share of households unable to meet basic needs in education and health, in addition to food (CONEVAL, 2005).

[17] The democracy index is calculated by the National Electoral Institute and the Konrad-Adenauer-Stiftung Foundation (Adenauer, 2021).

Figure 7. New roads, poverty and democracy, 2004-2019



(a) Share of new roads and poverty index (2005)

(b) Share of new roads and democracy index (2010)

Notes: In panel (a), the poverty index (2005) is the share of households with inability to meet basic needs in education and health, in addition to food (CONEVAL, 2005). In panel (b), the democracy index is sourced from Adenauer (2021) and the National Electoral Institute of Mexico. The earliest available index is 2010.

built between 2004 and 2019 lies beyond the scope of this paper, it is nonetheless essential to assess the economic implications of the observed policy. In the next section, we calibrate a standard economic geography model to quantify the impact of these infrastructure investments on aggregate welfare and the distribution of income across municipalities and states.

4. Model

In the previous section, we documented that Mexico's highway network expanded by 75% between 2004 and 2019, with over one-third of this growth concentrated in six southern states. However, these states did not experience the largest gains in market access or network centrality. To fully capture the aggregate and distributional effects of this uneven expansion—and to understand the mechanisms driving them—we calibrate a standard new economic geography model. Following Allen and Arkolakis (2014), the model features a large number of municipalities, each heterogeneous in terms of local productivity and amenities, and incorporates spatial interactions through worker migration and trade in goods.

4.1. Setup

The country is composed by J municipalities inhabited by $\bar{L}$ fully mobile workers. Workers are homogeneous and have preferences over a basket of J municipality-specific varieties denoted by Y_j. The welfare of a worker living in municipality i is then:

$$W_i = \left(\sum_{j \in J} Y_j^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \cdot u_i, \tag{3}$$

where u_i represents local amenities, encompassing all characteristics that make a municipality desirable to live in, such as housing, the natural environment, public goods and services, or social ties. We assume:

$$u_i = \bar{u}_i L_i^{\beta}, \tag{4}$$

where $\bar{u}_i$ is the fundamental component of local amenities and $\beta < 0$ governs congestion externalities. This functional form captures the idea that more congested municipalities become less attractive due to higher housing costs, increased pollution, longer commuting times, and greater degradation of public goods. Once workers choose where to live, they inelastically supply a unit of labor at no utility cost.

Municipalities demand labor L_i and produce a tradable variety Y_i according a constant returns to scale production function:

$$Y_i = A_i L_i, \tag{5}$$

where A_i is the municipality's productivity and captures the average efficiency of a worker living there. It includes differences in capital stock, industrial composition, institutional quality or access to local public infrastructure.[18] We assume:

$$A_i = \bar{A}_i L_i^{\alpha}, \tag{6}$$

where $\bar{A}_i$ is the fundamental productivity of the municipality and $\alpha > 0$ captures the fact that workers and firms are more productive in large and dense urban environments (Puga, 2010; Combes et al., 2012).[19]

The good Y_i produced in municipality i is sold at municipality j subject to an iceberg trade cost $\tau_{i,j} > 1$.[20] That is, for every unit sold at destination j, $\tau_{i,j}$ units of that good have to be shipped from origin i. Assuming perfect competition, the price of a variety produced at i and sold at j is simply the marginal cost:

$$P_{i,j} = \frac{w_i \tau_{i,j}}{A_i}, \tag{7}$$

where w_i is the endogenous wage at municipality i. Since workers are fully mobile, they will optimally migrate to the location that maximizes their welfare, given by the indirect utility function:

$$W_i = \frac{w_i}{P_i} u_i \tag{8}$$

In Equation 8, P_i is the price index given by the geometric average of all imported municipality variety prices $P_{j,i}$:

$$P_i = \left(\sum_{j \in J} P_{j,i}^{1-\sigma} \right)^{\frac{1}{1-\sigma}} \tag{9}$$

Notice that the real wage of a worker living in municipality i is $\frac{w_i}{P_i}$ and local real income is given by $\frac{w_i L_i}{P_i}$.

In equilibrium, for a given geography characterized by $J, \bar{A}_i, \bar{u}_i, \tau_{i,j}\ \forall i, j \in J$ and national population $\bar{L}$:

1. Municipal total income is equal to municipal expenditures on all varieties

$$w_i L_i = \sum_{j \in J} P_j^{1-\sigma} w_j L_j \qquad \forall i$$

2. Workers allocate across municipalities until welfare is equalized

$$W = W_i \qquad \forall i$$

[18] All of which are assumed to be exogenous, beyond their effect through agglomeration externalities.
[19] We don't explicitly model skill heterogeneity of workers. If a worker migrates, it inherits the efficiency of the city of destination.
[20] Some of this final good is sold to itself at no trade cost.

3. The vector of wages, w_i, clears all municipal and aggregate labor markets

$$\sum_{i \in J} L_i = \bar{L}$$

Allen and Arkolakis (2014) show that if $\alpha + \beta \leq 0$ the equilibrium vectors w_i and L_i exist; are unique and stable; and can be computed iteratively by solving the following system of J equations and $2J$ variables L_i, w_i:[21]

$$w_i^{1-\sigma} L_i^{\beta(1-\sigma)} = W^{1-\sigma} \sum_{j \in J} \tau_{i,j}^{1-\sigma} \bar{A}_j^{\sigma-1} \bar{u}_i^{\sigma-1} w_j^{1-\sigma} L_j^{\alpha(\sigma-1)} \quad (10)$$

The system can be reduced to J equations and J variables by using the fact that:[22]

$$L_i A_i^{1-\sigma} w^{\sigma} = \phi w_i^{1-\sigma} u_i^{1-\sigma}, \quad (11)$$

where W and ϕ are welfare and amenities normalization constants, respectively.

Intuitively, this model predicts that municipalities with higher productivity, better amenities, or better integration into the trade network will attract more workers through migration. Two forces will determine the optimal size of municipalities. On the one hand, highly productive places offer higher wages and attract people, becoming even more productive through agglomeration externalities. On the other hand, amenities congestion acts as a repulsive force, as more people living in the same location reduces utility for all inhabitants in the municipality. The interplay between these two forces determines the effects of place-based policies, such as new transport infrastructure reducing trade costs, cash transfers to poor regions, or attracting large firms that increase municipal productivity.

4.2. Calibration

Our model calibration consists of three steps. First, we parameterize σ, α and β.[23] Second, we determine the geography of trade costs by directly mapping travel times $T_{i,j}$ to iceberg trade costs $\tau_{i,j}$. Third, we recover municipal-level fundamental amenities $\bar{u}_i$ and productivities $\bar{A}_i$ by inverting the model so that it exactly matches the geographical distribution of observed labor L_i and wages w_i in the 2019 Economic Census. We explain these three steps in detail below and Table 3 summarizes this calibration.[24]

Table 3. Table of Parameters, Values, and Sources

Param.	**Value**	**Description**	**Source**
σ	5	Elasticity of subst.	Simonovska and Waugh (2014)
α	0.1	Agglomeration	Rosenthal and Strange (2004)
β	-0.3	Congestion	Rosenthal and Strange (2004)

Notes: Baseline parameterization. Notice that $\theta = \sigma - 1$, where $\theta = 4$ (see Redding (2016)). Sensitivity analysis is provided below.

For our baseline specification we choose $\sigma = 5$, $\alpha = 0.1$ and $\beta = -0.3$.[25] These values follow a standard parameterization in the literature to ensure the comparability of our results. Second, we obtain the bilateral

[21] Equation 10 is obtained by replacing Equations 4, 6, 7, 8 and 9 in equilibrium condition 1.

[22] See proof in Allen and Arkolakis (2014).

[23] In Armington-type models, the trade elasticity θ, which is used in our market access measure, is related to the elasticity of substitution σ by $\theta = \sigma - 1$.

[24] Although there are 2,400 municipalities in Mexico, we keep only around 2,000 for the calibration. The rest are excluded because they have less than 2,500 inhabitants, the minimum municipality size to appear in the Economic Census.

[25] Our baseline α is on the higher end. Ahlfeldt et al. (2015) estimate $\alpha = 0.07$ for Berlin, Germany.

trade costs matrix $\{\tau_{i,j}\}_{i,j\in J}$ by using the mapping in Allen and Arkolakis (2022), which implies a travel time elasticity of negative one:[26]

$$\tau_{i,j} = T_{i,j}^{\frac{1}{\sigma-1}} \tag{12}$$

Third, we invert Equation 10 to retrieve fundamental amenities $\bar{u}_i$ and fundamental productivity $\bar{A}_i$. The $J \times J$ system becomes:

$$u_i^{1-\sigma} = \frac{W^{1-\sigma}}{\phi} \sum_{i\in J} \tau_{ij}^{1-\sigma} w_i^{\sigma-1} w_j^{\sigma} L_j u_j^{\sigma-1} \qquad \forall i \in J, \tag{13}$$

where $\phi \equiv 1$ is a normalization constant and $\bar{u}_i = u_i L_i^{-\beta}$. Solving this system requires observed municipal levels of labor (L_i) and wages (w_i), which are assumed to be the exact equilibrium outcomes of the model. Once u_i is recovered, Equation 11 is used to recover A_i and $\bar{A}_i = A_i L_i^{-\alpha}$. Intuitively, amenities are identified from differences in municipal population while holding local productivity and trade costs constant. Municipal productivity is identified from differences in wages while holding municipal population and trade costs constant.

4.3. Estimated amenities and productivity

In this section, we discuss the estimated local amenities and productivity across Mexico in 2019. Understanding geographical differences in these two features is key for analyzing the effects of changes in transportation infrastructure. While these characteristics are estimated at the municipal level, we present them at the state level and with respect to Mexico City for clarity of exposition.

Figure 8 maps the average state amenities (weighted by municipal population). Figure 8a shows that states in the South are twice as desirable to live in compared to Mexico City or northern states when factoring in negative congestion externalities. This helps explain why people continue to live in the South despite low wages, as they may benefit from lower rent prices, better air quality, and strong cultural and family ties. However, Figure 8b reveals that before accounting for negative congestion externalities, the desirability gap between the North and south is less pronounced, which highlights the importance that people put on congestion when they choose where to live.

Figure 9 maps the average state productivity weighted by municipal population. Figure 9a shows that most states are half as productive as Mexico City, with the exception of those along the northern border. Southern states are, on average, three times less productive than Mexico City. Figure 9b displays the states' productivity before accounting for agglomeration externalities. While Mexico City remains more productive than most states, the gap narrows, highlighting the significant positive externalities the city derives from its high population density.

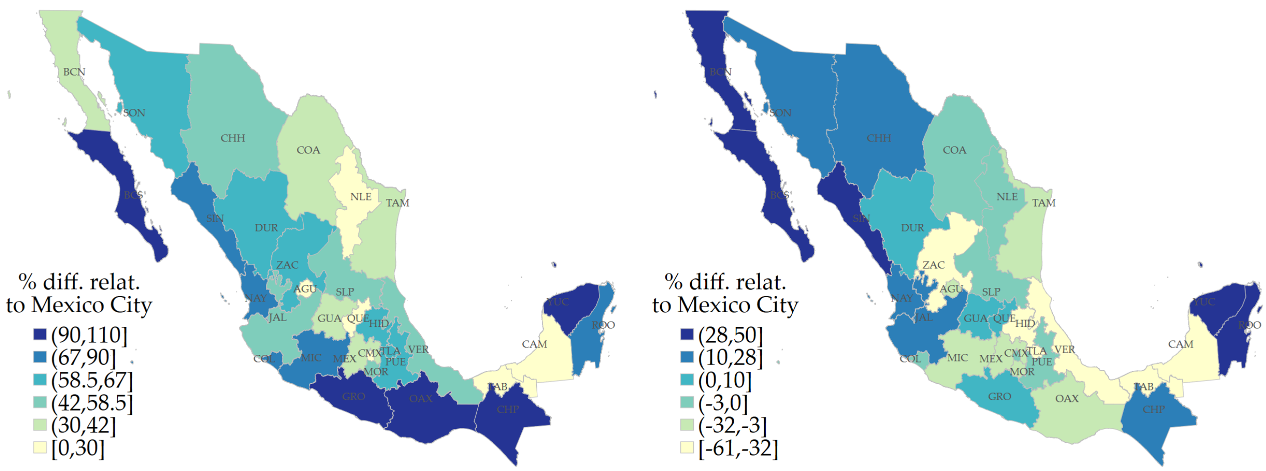
Will new transport infrastructure have the same effect when connecting two high-productivity states as opposed to two high-amenity states? Intuitively, the answer is no. Building a highway between two high-productivity (low-amenity) areas increases real wages (w_i/P_i) through two main channels. First, it reduces the price index (P_i), making goods cheaper and thereby attracting people to the municipality. This population influx, in turn, boosts productivity through agglomeration externalities, raising nominal wages (w_i). If these effects are sufficiently strong, they may offset the negative impact of congestion externalities on local amenities. This scenario is, for instance, more likely when connecting two northern states.

On the other hand, connecting two high-amenity (low-productivity) states might have a weaker impact. While new highways will still increase real wages in these areas, the effect is likely to be smaller. This is

[26]Consistent with the gravity literature (Disdier and Head, 2008; Chaney, 2018; Allen and Arkolakis, 2022).

because price indices in less productive regions remain high, and agglomeration externalities are less pronounced in low-productivity areas. This scenario is particularly relevant to southern states. In Section 6, we present two quantitative exercises that illustrate these mechanisms by comparing the effects of a hypothetical new highway in the North to one of similar length and features in the South.

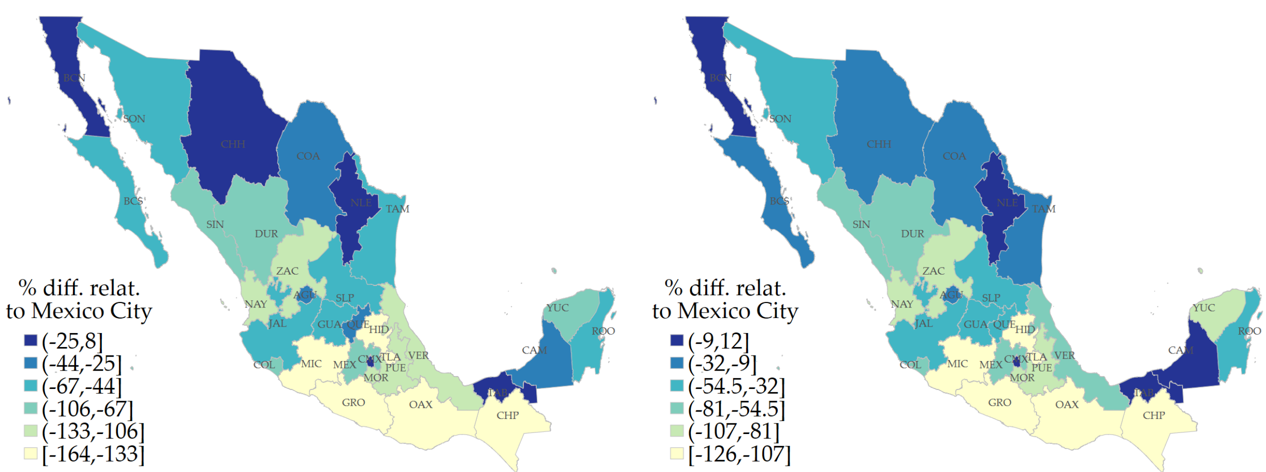
Figure 8. Average amenities by state in 2019



(a) Composite amenities $u_i = \bar{u}_i L_i^{\beta}$ **(b)** Exogenous amenities $\bar{u}_i$

Notes: State averages are weighted by municipal population. Values are shown with respect to Mexico City (CMX).

Figure 9. Average productivity by state in 2019



(a) Composite productivity $A_i = \bar{A}_i L_i^{\alpha}$ **(b)** Exogenous productivity $\bar{A}_i$

Notes: State averages are weighted by municipal population. Values are shown with respect to Mexico City (CMX).

5. Results

5.1. Aggregate gains

In our main counterfactual exercise, we analyze the output and welfare gains resulting from improvements in the highway network between 2004 and 2019. To do this, we focus on the economy in 2019 and remove all highway improvements, then we interpret the distance from this counterfactual economy to the one observed in the data as total *long-run* gains, that is, once migration happened and wages adjusted to clear local labor markets.

Table 4 presents the results. The first row shows that the welfare gains from new transport infrastructure amount to 1.7%. Notice that there is no dispersion in welfare gains, as migration continues until the congestion of municipal amenities exactly offsets higher real wages, implying that utility is equalized across all municipalities.

Table 4. Aggregate gains from new highways, 2004-2019

Gains (%)	Aggregate	p5	p50	p95
Welfare	1.7	-	-	-
Real income	1.0	-2.3	2.8	11.9
Labor	-	-3.1	0.9	7.6

Notes: Percentiles correspond to the distribution across the 2,062 municipalities we keep for the model.

The second row shows the real income gains, measured as $\frac{w_i L_i}{P_i}$. In aggregate, Mexico's real income is 1.0% higher than it would have been without the new infrastructure. For reference, these gains are comparable to the share of GDP of states such as Aguascalientes (1.3%), Durango (1.2%), or Morelos (1.1%).[27] Note that these gains are *permanent*, meaning that if all other economic conditions remain constant in future periods, the economy will continue to benefit from a real aggregate income that is 1% higher than it would be without the new highways. However, these gains are not evenly distributed across municipalities. While the median municipality in the distribution of gains experiences a real income increase of 2.8%, the municipality at the 5th percentile loses 2.3% of its real income, whereas the one at the 95th percentile gains 11.9%.

The third row shows that aggregate labor gains are zero by definition, as the national population remains constant. However, new transport infrastructure induces internal migration, reallocating the population across regions. While the median municipality in the labor gains distribution grows by 0.9%, the municipality at the 5th percentile loses 3.1% of its workers, while the one at the 95th percentile gains 7.6%.

All in all, the new highways built between 2004 and 2019 contributed positively to aggregate real income and welfare. Although there were overall real income gains, the new infrastructure also prompted a significant relocation of economic activity. These gains, however, represent a raw measure. To determine whether they are net positive, it is necessary to account for associated costs—not only construction costs, but also social, cultural, environmental, and maintenance costs (Asher et al., 2020). Estimating these monetary and utility costs is beyond the scope of this paper. Nonetheless, the benefits will be net positive as long as the total costs remain below 1.0% of GDP annually.[28]

[27] Source: GDP per state in 2019, INEGI.

[28] For reference, Mexico invests less than 0.5% of its GDP annually to expand and maintain its road network.

5.2. Regional distribution of gains

Although aggregate real income gains from highways built between 2004 and 2019 amount to 1.0%, not all states and regions benefited equally. Table 5 summarizes the real income gains by region and reports the implied elasticity of real income with respect to network growth. The region that benefited the most was the South-East. Despite receiving the lowest share of new roads and experiencing the smallest implied network growth, the South-East saw a 6.7% increase in aggregate real income—an implied elasticity of 0.16 (= 0.067 / 0.41).

While the South received 25.7% of all newly constructed road kilometers, its real income gains were 4.4%, not very different from those observed in the North (4%), despite the North receiving only 15.7% of the new road segments. In fact, the implied elasticity in the North was twice that of the South. Finally, states in the Center would have had economies 1.2% larger had the new infrastructure not been built, as economic activity reallocated to the North, South, and South-East. Taking into account both the expansion of the network and the associated income gains, the implied elasticity at the national level was 0.013; that is, doubling the size of the road network would have generated a 1.3% increase in GDP.

Table 5. Decomposition of gains from new highways by region, 2004-2019

	(1)	(2)	(3)	(4)
	Real income gains (%)	**Share of new KM of roads (%)**	**Network growth (%)**	**Implied Elasticity**
North	4.0	15.7	48.2	0.08
Center North	0.4	30.5	79.4	0.00
Center	-1.2	20.7	82.6	-0.01
South	4.4	25.7	120.7	0.04
South-East	6.7	7.4	41.0	0.16
Aggregate	1.0	100	73.9	0.01

Notes: The elasticity of real income with respect to highway network expansion is calculated as column (1) divided by column (3). Columns (2) and (3) refer to changes in segments that existed in 2004, along with new segments added between 2004 and 2019.

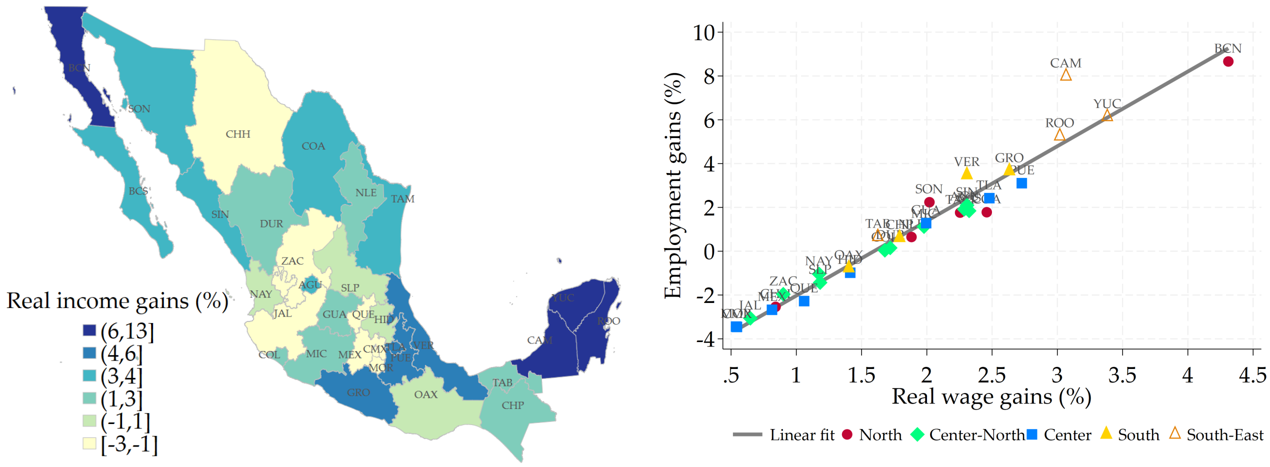
Figure 10a focuses on state-level real income gains.[29] The biggest winner was Baja California, which experienced significant gains (13%) due to the construction of a few—but highly important—segments that enhanced national connectivity. The states in the Yucatán Peninsula also saw substantial improvements, primarily because numerous local roads increased the connectivity of the oil-producing states of Tabasco and Campeche with the rest of the peninsula. Within the region, real income rose by 8.3% in Quintana Roo and 9.5% in Yucatán.

To a lesser extent, but still notably, the southern states of Guerrero and Veracruz also benefited (with gains of 6%), as two key coastal cities—Acapulco in Guerrero and the port of Tuxpan in Veracruz—were better connected to Mexico City via high-speed highways. The fact that the South exhibited a lower elasticity of real income gains to new infrastructure compared to the North (see Table 5) is largely driven by Chiapas, which saw aggregate real income gains of 2.5%, and Oaxaca, with only 0.6%.

Finally, Figure 10b plots real wage gains against employment gains by state to illustrate the sources of aggregate real income gains. While real wages ($\frac{w_i}{P_i}$) increased in all states—thanks to a reduction in trade costs and, consequently, local prices (P_i)—total employment varied across states due to migration. For instance, although wages in Oaxaca rose by 1.4%, 0.8% of the labor force left the state, resulting in a net increase in local real income of only 0.6%. States in the North and Southeast generally experienced both real

[29] See exact numbers in Table 13 in the Appendix.

Figure 10. Real income, employment and real wage gains by state



(a) Real income gains $\left(\frac{w_i L_i}{P_i}\right)$ **(b)** Employment (L_i) and real wage gains $(\frac{w_i}{P_i})$

Notes: State-level values are population weighted averages.

wage and employment gains, whereas highly congested central states—such as Mexico City and the State of Mexico—saw the lowest real wage gains and the largest losses in local employment.

5.3. *Sensitivity analysis*

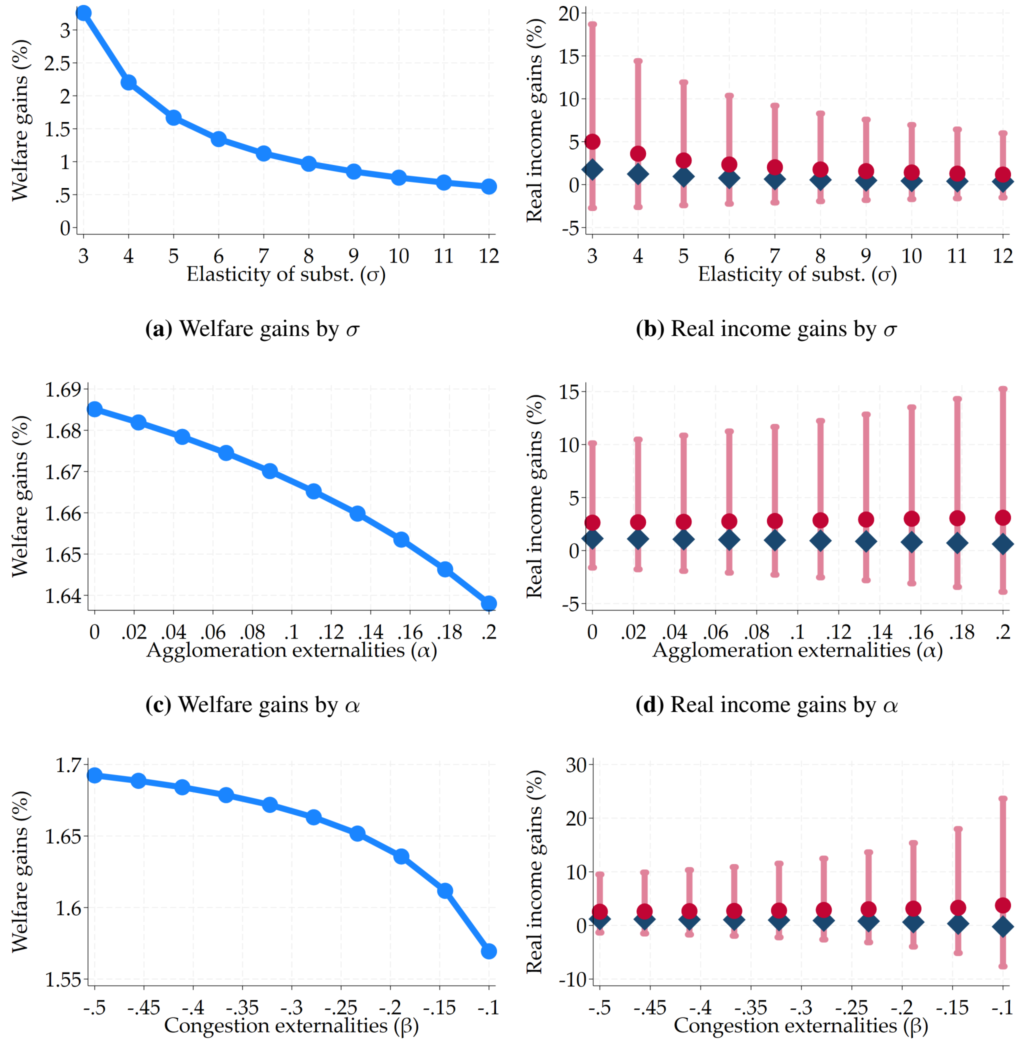
Our results on the gains from new road infrastructure built between 2004 and 2019 are based on a specific parameterization. In this section, we conduct a sensitivity analysis to show that our findings on welfare and real income gains are robust. Specifically, we vary the elasticity of substitution (σ), agglomeration externalities (α), and congestion externalities (β). Figure 11 presents the results: the left column shows the welfare gains, while the right column displays real income gains, including both the national aggregate and the municipal distribution, as represented by the 5th, 50th, and 95th percentiles.

Figure 11a shows that higher trade elasticity (σ) corresponds to smaller welfare gains from reductions in trade costs. Most empirical estimates in the literature place σ between 5 and 9 (Simonovska and Waugh, 2014). Within this range, aggregate welfare gains for Mexico are estimated to fall between 0.9% and 1.6%, assuming all other parameters remain constant. Similarly, as show in Figure 11b, aggregate real income gains decrease with σ and range from 0.5% to 1%. Furthermore, the dispersion of gains across municipalities narrows as σ increases, with the difference between the 5th and 95th percentiles shrinking from 14 percentage points under the baseline parameterization to 9.5 percentage points at the higher end of σ.

Figure 11c illustrates that welfare gains decrease slightly as the agglomeration externalities elasticity (α) increases; however, the magnitude of this change is minimal. For instance, increasing α by an order of magnitude—from 0.02 to 0.2—results in only a marginal reduction in welfare gains, from 1.68% to 1.64%. In the literature, values for α range from 0.015 to 0.039 (Donovan et al., 2024), so our parameterization is likely a lower bound for welfare gains. Figure 11d shows that stronger productivity responses to agglomeration lead to greater dispersion in real income gains. However, the difference between the 5th and 95th percentiles remains relatively stable, increasing modestly from 13 percentage points when $\alpha = 0.06$ to 16.5 percentage points when $\alpha = 0.15$, which is not substantially different from our preferred parameterization.

Finally, Figure 11e shows that welfare gains increase as the strength of congestion externalities grows (i.e., as β decreases). Although the results are more sensitive to this parameter than to α, the range of variation

Figure 11. Sensitivity analysis



(a) Welfare gains by σ **(b)** Real income gains by σ

(c) Welfare gains by α **(d)** Real income gains by α

(e) Welfare gains by β **(f)** Real income gains by β

Notes: Gains from newly paved roads (2004–2019). Left column displays aggregate welfare gains. Right column shows the aggregate and municipal dispersion of real income gains. Baseline parameterization is $\sigma = 4, \alpha = 0.1, \beta = -0.3$. Marker ♦ represents the aggregate level, ● represents the 50th percentile municipality, and the vertical lines | correspond to the 95th and 5th percentile municipalities.

remains narrow. For example, changing our preferred parameterization from $\beta = -0.3$ to $\beta = -0.5$ increases the implied welfare gains by only 0.02%. Moreover, Figure 11e indicates that the dispersion of municipal real income gains is smaller when congestion externalities are stronger. However, as with welfare gains, the difference between the 5th and 95th percentiles remains relatively stable, decreasing slightly from 13 percentage points under our preferred parameterization to 11 percentage points when $\beta = -0.5$.

Unfortunately, estimating the exact values of these elasticities for Mexico is beyond the scope of this paper. Estimating σ would require data on bilateral trade flows across Mexican municipalities, which, to the best of our knowledge, is not currently available. Similarly, estimating α and β would involve specifying and estimating a regression model where changes in population density are instrumented using a variable that influences productivity and amenities solely through its effect on population flows, while also accounting for spillover effects. Both tasks are left for future research.

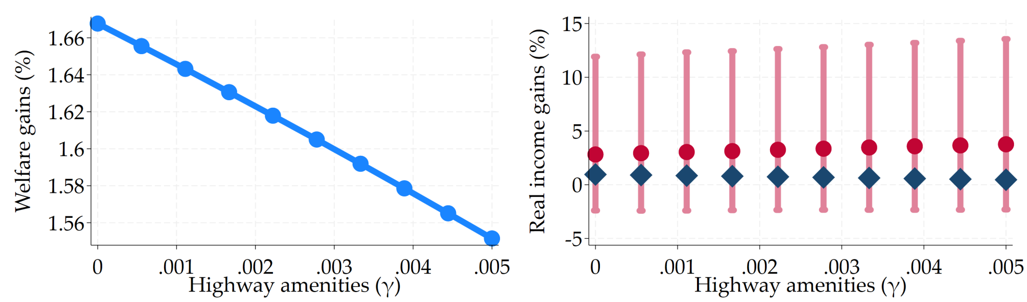
5.4. *Highways as amenities*

The fact that southern states such as Chiapas and Oaxaca received a large amount of new infrastructure but did not benefit accordingly in terms of real income gains hides the fact that new roads might be valued in these areas as public goods. One way to account for this in the model is to include the kilometers of highways (H_i) in a municipality as part of the local amenities. Lets now assume that:

$$u_i = \bar{u}_i L_i^{\beta} H_i^{\gamma}, \tag{14}$$

where $\beta < 0$ and $\gamma \geq 0$, which allows for both congestion externalities and consumption of roads as local amenities. Figure 12 shows the effects of new transport infrastructure from 2004 to 2019 on aggregate welfare and real income for different parameterization of γ.

Figure 12. Gains when highways are valued as amenities



(a) Welfare gains by γ **(b)** Real income gains by γ

Notes: Gains from newly paved roads (2004–2019). Left column displays aggregate welfare gains. Right column shows the aggregate and municipal dispersion of real income gains. Baseline parameterization is $\sigma = 4, \alpha = 0.1, \beta = -0.3$. Marker ♦ represents the aggregate level, ● represents the 50th percentile municipality, and the vertical lines | correspond to the 95th and 5th percentile municipalities.

Figure 12a shows that aggregate welfare gains decrease as the weight of highways in municipal amenities increases. This is because improving amenities in low-productivity areas through, for instance, locally administered, toll-free roads discourages workers from migrating to more productive, better-connected areas. Figure 12b shows that the stronger the valuation of highways as amenities, the smaller the real income gains. However, the variation is small, and the distribution of gains across municipalities is not sensitive to the valuation of roads as amenities. Although it is plausible that southern states value new roads beyond their effects on trade costs and market access, introducing this valuation into the model does not significantly affect our results.

6. What is the best infrastructure policy for the South?

Throughout this paper, we have shown empirical and quantitative evidence that the substantial increase in transport infrastructure in southern Mexico has not necessarily translated into significant improvements in market access, network centrality, or real income for the states in that region. In this section, we examine whether a different approach to infrastructure policy would achieve better outcomes. To explore this, we conduct four exercises using our baseline model. The first two illustrate how similar infrastructure investments produce different results in the South compared to the North, while the latter two demonstrate that combining infrastructure with productivity-enhancing policies offers a more effective solution for the South.

We begin by proposing the addition of a new highway to the 2019 highway network, with a total length of 2,200 kilometers and an average speed of 120 km/h. In practice, this would be a 12-meter-wide highway with four lanes in total (approximately 3–3.5 meters per lane). Two potential routes are considered. The first option is in the North, connecting Monterrey, Nuevo León, to Tijuana, Baja California, and traversing five of the six border states: Nuevo León, Coahuila, Chihuahua, Sonora, and Baja California. The second option is in the South, linking Tapachula, Chiapas, to Manzanillo, Colima, and passing through four southern states—Chiapas, Veracruz, Oaxaca, and Guerrero—one in the Southeast (Tabasco), and one in the Center-North (Colima).[30] Figures 13a and 13c show the exact locations of the two proposed highways.

The welfare and real income effects of the two proposed highways are presented in columns (1) and (2) of Table 6.[31] Constructing the highway in the North results in welfare gains that are three times greater than those from building it in the South (0.3% versus 0.1%). Moreover, the northern highway generates aggregate real income gains of 0.2%, which could potentially offset its costs, while the southern highway leads to aggregate real income losses of 0.1%.

Table 6. Welfare and real income gains from a new 2,200 km and 120 km/h highway in 2019

Gains (%)	(1) **North highway**	(2) **South highway**	(3) **South highway and productivity**	(4) **South only productivity**
		Welfare gains		
Aggregate	0.31	0.10	0.31	0.20
		Real Income gains		
North	3.78	-0.39	-1.01	-0.58
Center North	-0.35	-0.17	-0.24	-0.06
Center	-1.135	-0.27	-0.76	-0.465
South	-1.005	2.57	8.44	5.65
South-East	-1.08	0.79	1.20	0.42
Aggregate	0.18	-0.04	0.002	0.036

Notes: Gains from adding the new highways shown in Figure 13 relative to the baseline economy and the highway network in 2019. Welfare gains are calculated at the national level. Real income gains are computed as the sum of $w_i L_i / P_i$. The southern highway counterfactual (2) considers the addition of a new highway in the South. The southern highway counterfactual (3) involves the same highway addition as in (2) but also increases the exogenous productivity $\bar{A}_i$ of the 90 municipalities crossed by the highway by 5.5%. Counterfactual (4) only introduces the productivity boost.

The real income gains from these highways vary across the country. The highway in the North increases the aggregate real income of northern states by 3.8%, at the expense of the South and the rest of the country, which each experience a 1% decline in their aggregate real income. In contrast, the highway in the South raises the aggregate real income of southern states by 2.6%, primarily at the expense of northern states, which are too distant from the new infrastructure to benefit.

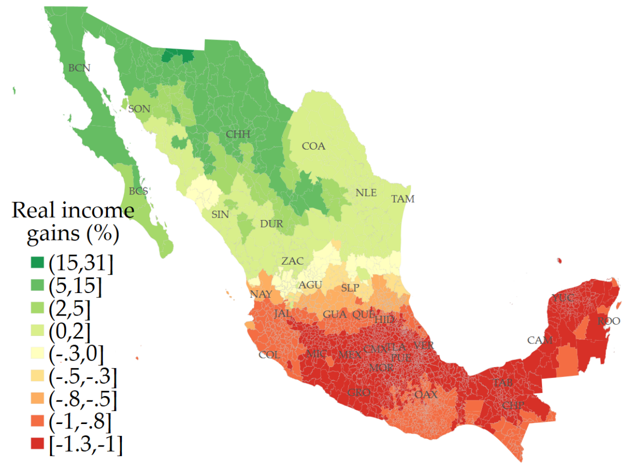
Figure 13b shows the real income gains from the northern highway at the municipal level. Municipalities directly crossed by this highway benefit the most, with real income gains ranging from 5 to 30%. However, there are important spillover effects reaching as far south as municipalities in Zacatecas, in the geographical center of Mexico. Part of the gains experienced by northern municipalities is due, in large part, to losses in the center and south of the country, especially in the congested areas of Mexico City and the State of Mexico,

[30] As of 2025, the average speed on the northern route is 80 km/h, while on the southern route it is 60 km/h (Google Maps). A version of the southern hypothetical road was first proposed in Dávila et al. (2002). The 2025–2030 National Infrastructure Plan includes a 500-kilometer section that largely overlaps with this proposed route.

[31] These estimates do not account for financial, environmental, cultural, or maintenance costs. We discuss in the conclusion how the omission of these factors might affect the results.

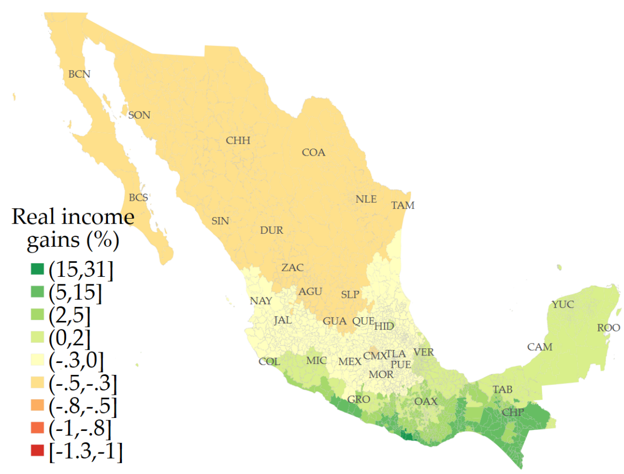
Figure 13. Proposed new highways (2,200 km long and 120 km/h each one)

(a) Northern highway (Monterrey-Tijuana)



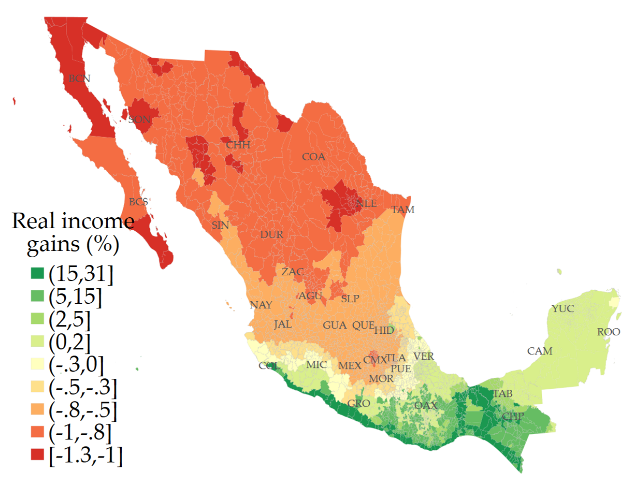
(b) Real income gains from northern highway

(c) Southern highway (Tapachula-Manzanillo)



(d) Real income gains from southern highway

(e) Municipalities with productivity ($\bar{A}_i$) increase of 5.5%



(f) Real income gains from southern highway and productivity increase

Notes: Highways in panels (a) and (b) are both 2,200 km long with an average speed of 120 km/h. Both highways are separately added to the existing network in 2019. Real income is $\frac{w_i L_i}{P_i}$.

where losses exceed 1%.

Similarly, Figure 13d illustrates the real income gains resulting from the southern highway. Once again, the municipalities directly traversed by the highway benefit the most, with real income gains above 5%. However, the spillover effects to nearby municipalities are weaker than with the northern highway, and the relocation of economic activity from the north and center is less pronounced, with municipalities in the center-north and north only reducing their real income by at most 0.5%.

The southern highway yields lower aggregate welfare and real income gains compared to the northern highway because the North is more productive (see Figure 9). With the new highway, the market access of northern municipalities increases significantly, as they can trade at a lower cost with other large and productive economies. This improves economic activity and attracts workers from the center and south to the North. In contrast, this effect is weaker in the South, where the new highway primarily connects smaller, less productive municipalities.

To highlight the importance of productivity in determining the effects of new transport infrastructure, we combine the Southern highway from Figure 13c with a 5.5% productivity boost for the 90 municipalities it crosses (as shown in Figure 13e). This increase is precisely the amount required to match the 0.3% aggregate welfare gains achieved by the northern highway. Column (3) in Table 6 shows the results of this experiment.

Although combining the southern highway with a productivity boost yields the same welfare gains as the northern highway, it does not generate any aggregate real income gains. However, the real income gains for the South are more than three times larger than in the scenario with the new highway alone (8.4% versus 2.6%). This difference is entirely driven by a greater reallocation of economic activity from the North and the rest of the country, where real income declines by 1% and 0.6%, respectively. Figure 13f confirms this pattern, showing that municipalities along the new southern highway with the productivity boost experience real income gains of 15% to 30%, with substantial positive spillovers to nearby areas.

But are these larger gains driven primarily by the highway or by the productivity boost? Column (4) of Table 6 isolates the effects of the productivity boost alone—without the southern highway. In this case, the productivity boost generates welfare gains amounting to two-thirds of those produced by either the northern highway or the combined southern highway and productivity scenario. Notably, the productivity boost alone still does not result in aggregate real income gains. However, it does lead to a 4.5% increase in real income in the South—again, roughly two-thirds of the gains observed when the highway is included. These regional gains are entirely explained by relocation effects from the North and the rest of the country.

7. Conclusions

In this paper, we showed that the size of Mexico's paved road and highway network grew by 75% from 2004 to 2019. However, this new infrastructure was unequally distributed across regions. Four southern states—Guerrero, Chiapas, Oaxaca and Veracruz—together received more than one-fourth of all newly constructed road kilometers. Contrary to expectations, these roads in the South did not significantly improved market access or network centrality for the region. We provide evidence to explain this outcome. In the South, most new roads were low-speed, locally administered, toll-free, paved with asphalt, and had fewer than four lanes. These roads were likely intended to connect municipalities within individual states rather than integrate these states into the broader national network. In contrast, an opposite pattern was observed in the North of the country.

We then calibrate a standard economic geography model (Allen and Arkolakis, 2014) and find that the welfare gains from all new roads constructed between 2004 and 2019 amounted to 1.7%. Real income gains were 1.0%, comparable to the GDP shares of states such as Aguascalientes, Durango, or Morelos. However, the South—despite receiving the largest amount of new road meters per capita and experiencing the highest network growth rate—had an implied elasticity of real income to network size growth of just 0.4, which is half that of the North and one-fourth that of the South-East.

To better understand why the South experienced lower real income gains—beyond the predominantly local nature of its new roads—we use our calibrated model to perform a counterfactual exercise. Specifically, we simulate the construction of a hypothetical 2,200-kilometer highway with a speed limit of 120 km/h in two alternative locations. The results show that if the highway is built in the North, its welfare effects are three times greater than if the same highway is built in the South. For the Southern highway to match the welfare impact of the Northern one, the 90 municipalities it crosses would require an average productivity increase of 5.5%. With this boost, real income gains in the South would rise to 8.4%, compared to just 2.6% if only the highway is constructed without accompanying productivity improvements.

These findings highlight an important policy implication: simply building more kilometers of roads is not sufficient to stimulate economic activity in lagging regions. To fully realize the benefits of new infrastructure, two key conditions must be met. First, new roads must enhance connectivity to the broader national network rather than merely improving intra-state access. Second, they should link productive municipalities or be paired with productivity-enhancing policies. The specific strategies to boost productivity in the South are varied and may include attracting large, formal, and productive firms (Levy, 2018; Fentanes and Levy, 2024); removing barriers to skilled migration (Bryan and Morten, 2019); creating special economic zones (Hausmann and Rodrik, 2003); improving regional governance (Rodrik, 2004); or increasing international trade between the South of Mexico and Central American countries (Anderson and Van Wincoop, 2001).

While this paper focuses on the economic effects of new road infrastructure at the municipal level, it is important to recognize broader impacts beyond this scope. A substantial body of literature, reviewed in Kaiser and Barstow (2022), highlights significant transportation-related barriers to healthcare, education, and labor market access in rural areas—particularly for women and youth. Improved road access has been associated with positive health outcomes, such as reductions in child and maternal mortality (Dasgupta et al., 2024) and better access to vaccines and emergency services (Hierink et al., 2021). However, infrastructure expansion can also lead to negative effects, including increased exposure to air and noise pollution (Welch et al., 2023), higher rates of traffic fatalities (Profillidis et al., 2014), and elevated crime rates (Calamunci and Lonsky, 2025). Similarly, while better roads reduce travel time to schools and can increase enrollment (Maparu and Mazumder, 2017), they may also contribute to school dropout rates as improved access to urban labor markets incentivizes youth to join the workforce prematurely (Aggarwal, 2018). Given this complex set of offsetting effects, the exclusion of health and education outcomes from this analysis is unlikely to introduce systematic bias in the estimated economic impacts—especially as improved infrastructure may also accelerate migration away from rural areas, potentially reducing local human capital.

Beyond agglomeration externalities, the model calibration used in this paper does not account for several key drivers of municipal and regional productivity differences—particularly when these are endogenous to new transport infrastructure. These factors include firm sorting (Gaubert, 2018), firm selection and agglomeration effects (Combes et al., 2012), and skill-based worker sorting (Lindenlaub, 2017). As noted by Busso and Fentanes (2024), when productivity adjusts endogenously to infrastructure—through firm dynamics, for example—the welfare and spatial gains estimated by standard economic geography models likely represent a lower bound. If anything, Figure 17 in the Appendix shows that model-implied exogenous productivity in southern states declined between 2004 and 2019.[32]

Finally, the welfare gains reported in this paper are gross figures: they do not account for construction

[32]This exogenous productivity was computed by calibrating the model using Economic Census and highways data from 2004, following the procedure described in Section 4.

costs, which are likely to increase over time (Brooks and Liscow, 2023), nor for non-monetary costs such as environmental degradation (Asher et al., 2020), displacement of populations, or cultural and social disruption (Valenzuela-Casasempere, 2024). To the extent that these costs are lower in the South than in other regions, the net gains for the South may, in fact, be underestimated. However, data from the Ministry of Transportation (SCT) indicate that federal roads cost 45% more per kilometer than local roads. Based on this, while the North received 13.8% of the new road segments, it accounted for 14.3% of total national infrastructure spending; by contrast, the South received 26.5% of the new segments and 26.1% of the spending. These figures suggest that regional cost differences are unlikely to introduce systematic bias into our estimates.[33] Moreover, because the South contains a larger share of the country's forests and Indigenous communities, the environmental and social disruption costs may have been particularly significant there. These impacts are rarely quantified in the literature and represent a promising direction for future research.

[33] See Table 14 in the Appendix for further details.

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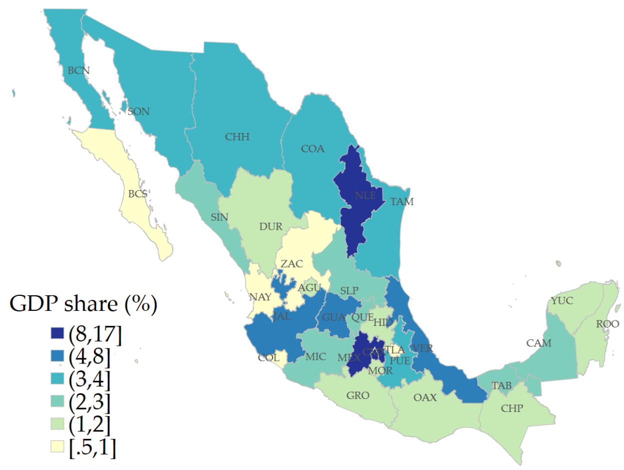
Appendix

A. Data

Figure 14. GDP share by state, 2019



Notes: Data from INEGI's national accounts. GDP includes oil production.

Table 7. Economic Census coverage by 2-digit industry (NAICS)

		2004		**2019**	
Code	**Sector**	**Estab.**	**Empl.**	**Estab.**	**Empl.**
11	Agriculture, Forestry, Fishing and Hunting	21,252	196,481	24,372	233,554
21	Mining, Quarrying, and Oil and Gas Extraction	3,077	122,640	3,123	190,685
22	Utilities	2,437	221,335	2,961	216,300
23	Construction	13,444	652,387	19,501	676,301
31-33	Manufacturing	328,718	4,198,579	579,828	6,493,020
42	Wholesale Trade	86,997	962,143	155,545	1,582,933
44-45	Retail Trade	1,493,590	4,035,223	2,092,770	5,899,054
48-49	Transportation and Warehousing	41,899	634,940	22,245	997,000
51	Information	7,586	244,679	8,828	363,805
52	Finance and Insurance	10,417	275,830	26,593	662,239
53	Real Estate and Rental and Leasing	45,579	179,146	68,010	327,129
54	Professional, Scientific, and Technical Services	68,589	472,348	100,098	848,651
55	Management of Companies and Enterprises	349	51,690	366	138,987
56	Administrative and Support	43,152	815,388	76,059	2,407,276
61	Educational Services	30,891	517,958	53,524	817,536
62	Health Care and Social Assistance	102,940	355,169	196,089	763,881
71	Arts, Entertainment, and Recreation	31,790	143,589	51,352	267,775
72	Accommodation and Food Services	277,436	1,218,262	637,124	2,668,898
81	Other Services (except Public Administration)	395,014	941,749	681,769	1,577,903
	Total	**3,005,157**	**16,239,536**	**4,800,157**	**27,132,927**

Table 8. Economic Census coverage by state

		2004		2019	
Code	**State**	**Estab.**	**Empl.**	**Estab.**	**Empl.**
1	Aguascalientes	33,630	202,009	53,939	369,945
2	Baja California	61,812	557,515	105,215	1,034,332
3	Baja California Sur	16,930	92,224	30,601	225,017
4	Campeche	22,970	128,920	35,275	187,898
5	Coahuila de Zaragoza	66,469	551,108	95,230	962,912
6	Colima	20,484	93,621	33,566	178,059
7	Chiapas	94,021	302,120	186,996	554,589
8	Chihuahua	79,249	707,514	106,430	1,049,247
9	Ciudad de México	342,475	2,842,874	427,959	4,297,134
10	Durango	37,911	216,591	56,236	329,975
11	Guanajuato	150,800	731,350	242,534	1,379,427
12	Guerrero	95,254	305,650	149,114	435,108
13	Hidalgo	62,612	243,974	118,821	432,299
14	Jalisco	214,768	1,219,494	335,120	2,004,175
15	México	364,921	1,533,201	624,472	2,527,280
16	Michoacán de Ocampo	141,543	466,512	230,966	779,733
17	Morelos	63,686	230,715	96,462	362,154
18	Nayarit	29,912	118,964	57,023	237,485
19	Nuevo León	110,163	1,008,854	151,448	1,803,965
20	Oaxaca	107,120	302,860	219,176	551,009
21	Puebla	165,237	649,927	298,183	1,117,993
22	Querétaro	42,524	277,336	81,224	689,199
23	Quintana Roo	29,114	216,564	53,642	486,636
24	San Luis Potosí	63,820	308,813	97,773	554,866
25	Sinaloa	64,635	370,192	107,567	626,365
26	Sonora	66,741	444,677	99,804	781,364
27	Tabasco	44,245	211,734	73,616	308,616
28	Tamaulipas	85,319	589,207	112,589	816,605
29	Tlaxcala	38,315	125,008	69,715	224,220
30	Veracruz de Ignacio de la Llave	184,668	738,647	278,230	1,064,138
31	Yucatán	62,799	313,892	112,503	516,924
32	Zacatecas	41,010	137,469	58,728	244,258
	Total	**3,005,157**	**16,239,536**	**4,800,157**	**27,132,927**

Table 9. New paved highways by state, 2004-2019

State	Roads (km) 2004	Roads (km) 2019	Diff. (km)	Growth (%)	Share of new roads
Aguascalientes	1,076	1,772	696	57.3	0.8
Baja California	2,622	3,559	937	31.3	1.1
Baja California Sur	1,789	2,719	930	48.1	1.1
Campeche	3,521	4,562	1,040	27.3	1.3
Coahuila	4,159	6,378	2,219	45.8	2.5
Colima	954	1,446	493	45.5	0.6
Chiapas	4,246	9,855	5,609	123.2	6.8
Chihuahua	5,525	9,785	4,260	70.9	5.1
Mexico City	374	541	167	5.8	0.0
Durango	4,014	6,349	2,334	54.0	2.8
Guanajuato	4,148	7,745	3,597	81.0	4.4
Guerrero	3,444	7,695	4,251	113.2	5.1
Hidalgo	2,923	6,152	3,229	101.8	3.9
Jalisco	5,744	10,195	4,451	66.1	5.0
Mexico	5,641	9,729	4,088	54.4	4.0
Michoacan	6,353	11,187	4,834	68.9	5.7
Morelos	1,375	2,105	730	37.6	0.7
Nayarit	1,577	2,798	1,221	73.2	1.5
Nuevo Leon	4,789	6,838	2,048	33.8	2.1
Oaxaca	4,233	8,789	4,556	98.6	5.4
Puebla	4,267	7,693	3,426	73.4	4.1
Queretaro	1,525	3,306	1,781	110.7	2.2
Quintana Roo	2,503	3,807	1,305	44.3	1.4
San Luis Potosi	4,458	8,762	4,304	90.8	5.3
Sinaloa	3,541	6,003	2,462	65.2	3.0
Sonora	6,223	8,483	2,261	31.3	2.5
Tabasco	3,875	6,408	2,533	62.5	3.2
Tamaulipas	4,518	6,199	1,681	32.2	1.9
Tlaxcala	1,139	1,794	656	34.0	0.5
Veracruz	6,277	13,831	7,554	112.6	9.2
Yucatan	5,529	6,982	1,453	19.4	1.4
Zacatecas	3,250	7,540	4,289	126.1	5.4
Total	**115,612**	**201,005**	**85,393**	**73.9**	**100**

Notes: Data from INEGI/SCT. The total length of new segments built between 2004 and 2019 differs from the net change in network length over the same period, as existing segments may have changed in length.

Table 10. New segments of paved roads and highways by state and type, 2004-2019

State	New km	Federal		Speed $>= 80\frac{km}{h}$		Toll		Concrete	
		No	Yes	No	Yes	No	Yes	No	Yes
Aguascalientes	673	639	33	614	59	673	0	666	7
Baja California	731	315	416	436	295	630	100	602	128
Baja California Sur	867	716	151	867	0	832	35	866	1
Campeche	1,227	1,140	87	1,028	198	1,186	40	1,210	17
Coahuila	1,962	1,738	224	1,365	598	1,843	120	1,917	45
Colima	389	370	18	340	49	385	4	367	22
Chiapas	5,676	5,332	345	5,353	324	5,587	90	5,588	89
Chihuahua	3,785	2,780	1,005	3,007	777	3,606	178	3,735	49
Mexico City	220	133	87	120	100	98	122	136	84
Durango	2,465	1,807	658	1,743	722	2,236	229	2,413	52
Guanajuato	3,423	2,934	489	2,816	607	2,982	441	3,310	112
Guerrero	4,622	4,035	587	4,377	245	4,525	97	4,522	100
Hidalgo	3,337	2,935	402	3,068	270	3,131	206	3,012	325
Jalisco	4,356	3,604	753	3,530	826	3,976	380	3,958	398
México	4,657	4,000	657	2,047	2,611	3,795	862	4,286	372
Michoacán	5,320	4,631	690	4,948	372	5,038	282	5,131	189
Morelos	751	582	169	281	470	653	98	698	53
Nayarit	1,201	701	500	805	397	919	282	1,188	13
Nuevo León	1,599	1,333	265	1,312	286	1,431	168	1,488	111
Oaxaca	4,914	4,135	779	3,181	1,733	4,720	194	4,782	133
Puebla	4,195	3,604	590	3,478	716	3,765	430	4,079	116
Querétaro	1,643	1,252	391	1,329	314	1,496	147	1,449	194
Quintana Roo	1,254	1,153	101	1,118	136	1,177	77	1,221	33
San Luis Potosí	4,374	3,964	410	3,871	504	4,127	247	4,213	161
Sinaloa	2,009	1,682	326	999	1,010	1,786	223	1,932	77
Sonora	2,114	1,786	328	904	1,210	1,965	149	2,033	82
Tabasco	2,640	2,484	156	2,502	138	2,586	54	2,619	21
Tamaulipas	1,755	1,437	319	1,123	632	1,673	82	1,746	10
Tlaxcala	716	390	326	518	199	529	187	635	81
Veracruz	7,645	6,940	705	6,778	867	7,220	425	7,329	316
Yucatán	1,673	1,469	204	1,166	508	1,657	16	1,647	26
Zacatecas	4,154	4,007	147	2,349	1,804	4,121	32	4,066	87
Total by cat.	**86,348**	**74,030**	**12,318**	**67,371**	**18,976**	**80,349**	**5,999**	**82,843**	**3,504**
Total	**86,348**	**86,348**		**86,348**		**86,348**		**86,348**	

Notes: Data from INEGI/SCT. The total length of new segments built between 2004 and 2019 differs from the net change in network length over the same period, as existing segments may have changed in length.

Table 11. New segments of paved roads and highways by state and type, 2004-2019

State	Federal		Speed $>= 80\frac{km}{h}$		Toll		Concrete	
	No	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**	**Yes**
Aguascalientes	0.9	0.3	0.9	0.3	0.8	0.0	0.8	0.2
Baja California	0.4	3.4	0.6	1.6	0.8	1.7	0.7	3.7
Baja California Sur	1.0	1.2	1.3	0.0	1.0	0.6	1.0	0.0
Campeche	1.5	0.7	1.5	1.0	1.5	0.7	1.5	0.5
Coahuila	2.3	1.8	2.0	3.1	2.3	2.0	2.3	1.3
Colima	0.5	0.1	0.5	0.3	0.5	0.1	0.4	0.6
Chiapas	7.2	2.8	7.9	1.7	7.0	1.5	6.7	2.5
Chihuahua	3.8	8.2	4.5	4.1	4.5	3.0	4.5	1.4
Mexico City	0.2	0.7	0.2	0.5	0.1	2.0	0.2	2.4
Durango	2.4	5.3	2.6	3.8	2.8	3.8	2.9	1.5
Guanajuato	4.0	4.0	4.2	3.2	3.7	7.4	4.0	3.2
Guerrero	5.5	4.8	6.5	1.3	5.6	1.6	5.5	2.9
Hidalgo	4.0	3.3	4.6	1.4	3.9	3.4	3.6	9.3
Jalisco	4.9	6.1	5.2	4.4	4.9	6.3	4.8	11.4
México	5.4	5.3	3.0	13.8	4.7	14.4	5.2	10.6
Michoacán	6.3	5.6	7.3	2.0	6.3	4.7	6.2	5.4
Morelos	0.8	1.4	0.4	2.5	0.8	1.6	0.8	1.5
Nayarit	0.9	4.1	1.2	2.1	1.1	4.7	1.4	0.4
Nuevo León	1.8	2.2	1.9	1.5	1.8	2.8	1.8	3.2
Oaxaca	5.6	6.3	4.7	9.1	5.9	3.2	5.8	3.8
Puebla	4.9	4.8	5.2	3.8	4.7	7.2	4.9	3.3
Querétaro	1.7	3.2	2.0	1.7	1.9	2.5	1.7	5.5
Quintana Roo	1.6	0.8	1.7	0.7	1.5	1.3	1.5	0.9
San Luis Potosí	5.4	3.3	5.7	2.7	5.1	4.1	5.1	4.6
Sinaloa	2.3	2.6	1.5	5.3	2.2	3.7	2.3	2.2
Sonora	2.4	2.7	1.3	6.4	2.4	2.5	2.5	2.3
Tabasco	3.4	1.3	3.7	0.7	3.2	0.9	3.2	0.6
Tamaulipas	1.9	2.6	1.7	3.3	2.1	1.4	2.1	0.3
Tlaxcala	0.5	2.6	0.8	1.0	0.7	3.1	0.8	2.3
Veracruz	9.4	5.7	10.1	4.6	9.0	7.1	8.8	9.0
Yucatán	2.0	1.7	1.7	2.7	2.1	0.3	2.0	0.7
Zacatecas	5.4	1.2	3.5	9.5	5.1	0.5	4.9	2.5
Total by category	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Notes: Data from INEGI/SCT.

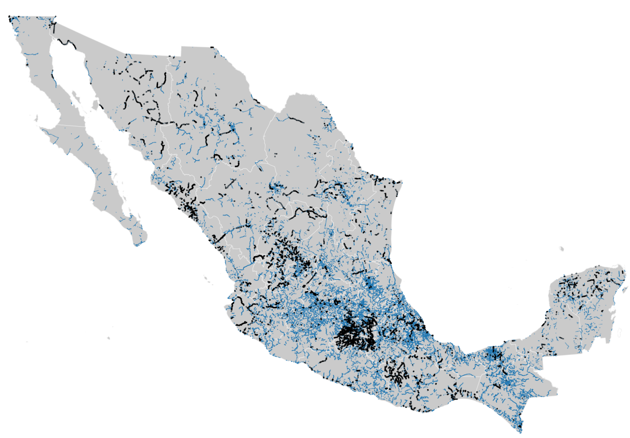
Figure 15. New segments of paved roads and highways by type, 2004-2019

(a) New federal highways

(b) New toll highways

(c) New concrete paved highways

(d) New 4-lanes highways

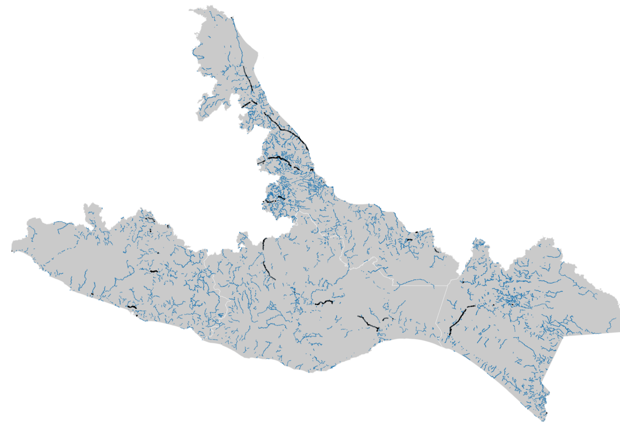


(e) New $>= 80km/h$ highways

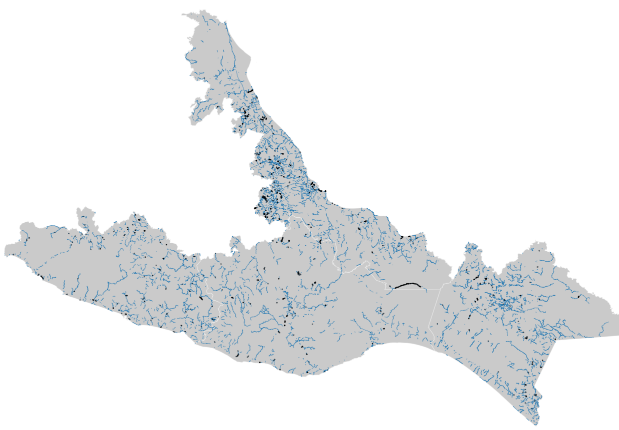
Notes: Maps show all new paved road and highway segments built between 2004 and 2019. Each panel highlights the corresponding characteristic (as indicated in the subtitle) with bold black lines.

Figure 16. New segments of paved roads and highways **in the South** by type, 2004-2019

(a) New federal highways



(b) New toll highways



(c) New concrete paved highways

(d) New 4-lanes highways

(e) New $>= 80km/h$ highways

Notes: Maps show all new paved road and highway segments built between 2004 and 2019. Each panel highlights the corresponding characteristic (as indicated in the subtitle) with bold black lines.

B. Correlation road characteristics and speed

The characteristics of highways affect their top speed. To understand how, we run the following regression at the segment of highway level, k:

$$Speed_k = \beta_0 + \beta_1 \cdot Federal_k + \beta_2 \cdot Toll_k + \beta_3 \cdot Concrete_k + \beta_4 \cdot Four\ Lanes_k + \beta_5 \cdot State_k + \varepsilon_k, \quad (15)$$

where $Federal,\ Toll,\ Concrete,\ Four\ Lanes$ are dummy variables that take the value of one if the segment corresponds to a highway administered by federal authorities, if it charges toll fees, if it is made of concrete, and if it has at least four lanes, respectively. We cluster standard errors at the state level to account for state-specific infrastructure shocks. Table 12 shows the coefficients of this regression, in the left column we use all highway segments in 2019 and the the right column only new segments built from 2004 to 2019.[34]

Table 12. Correlation of speed with highway's characteristics in 2019

	(1)	(2)
	All highways 2019	**Only new highways 2004-2019**
Dependent var.	**Speed (km/h)**	**Speed (km/h)**
Federal	14.79***	10.70***
	(1.049)	(1.198)
Toll	22.52***	26.47***
	(1.913)	(2.236)
Concrete	0.02	-1.0
	(2.259)	(1.83)
4 Lanes	3.52***	3.66*
	(0.938)	(1.666)
Constant	59.12***	59.40***
	(0.283)	(0.067)
State controls	Yes	Yes
Obs. ('000 km)	201	85
R^2	0.48	0.45

Notes: Observations in each regression are segments of highways as defined in the National Highways Network in 2019. Standard errors are clustered by state.

[34] Adding interactions of highway's characteristics yields similar results.

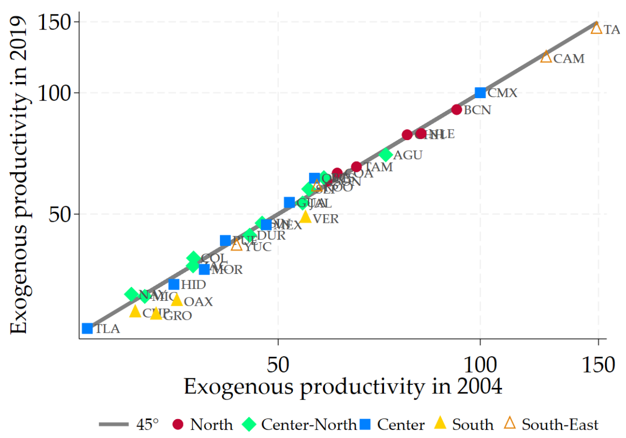
C. Model results

Table 13. Gains from new roads 2004-2019

State	Gains (%)		
	Wage	**Employment**	**Real income**
Aguascalientes	2.3	1.9	4.2
Baja California	4.3	8.7	13.0
Baja California Sur	2.3	1.8	4.2
Campeche	3.1	8.0	11.1
Coahuila	2.5	1.8	4.2
Colima	1.7	0.0	1.7
Chiapas	1.8	0.6	2.4
Chihuahua	0.8	-2.5	-1.7
Mexico City	0.5	-3.5	-2.9
Durango	1.7	0.2	1.9
Guanajuato	2.0	1.3	3.3
Guerrero	2.6	3.7	6.3
Hidalgo	1.4	-1.0	0.4
Jalisco	0.6	-3.1	-2.4
State of Mexico	0.8	-2.7	-1.9
Michoacan	2.0	1.1	3.1
Morelos	0.5	-3.4	-2.9
Nayarit	1.2	-1.0	0.1
Nuevo Leon	1.9	0.6	2.5
Oaxaca	1.4	-0.8	0.6
Puebla	2.7	3.1	5.8
Queretaro	1.1	-2.3	-1.2
Quintana Roo	3.0	5.3	8.3
San Luis Potosi	1.2	-1.4	-0.3
Sinaloa	2.3	2.1	4.4
Sonora	2.0	2.2	4.3
Tabasco	1.6	0.7	2.3
Tamaulipas	2.3	1.8	4.0
Tlaxcala	2.5	2.4	4.9
Veracruz	2.3	3.5	5.8
Yucatan	3.4	6.1	9.5
Zacatecas	0.9	-2.0	-1.1
Total	**1.6**	**0.0**	**1.0**

Notes: Gains from new roads 2004-2019.

Figure 17. Exogenous productivity relative to Mexico City in 2004 and 2019



Notes: Exogenous productivity relative to Mexico City.

Table 14. Costs of new segments of paved roads and highways by region

Region	(1) **Local (km)**	(2) **Federal (km)**	(3) **Costs Local**	(4) **Costs Federal**	(5) **Total costs**	(6) **Share of new roads**	(7) **Share of costs**
North	9,389	2,556	9,389	3,707	13,096	13.8	14.3
Center-North	22,122	3,686	22,122	5,345	27,467	29.9	29.9
Center	15,830	3,112	15,830	4,513	20,343	21.9	22.1
South	20,442	2,416	20,442	3,503	23,945	26.5	26.1
South-East	6,247	547	6,247	794	7,040	7.9	7.7
Total	**74,030**	**12,318**	**74,030**	**17,861**	**91,891**	**100**	**100**

Notes: Columns 1 and 2 refer to the length of new segments of paved roads and highways. Cost per kilometer of local roads is normalized to 1 (column 3). Cost per kilometer of federal roads is set to 1.45 (column 4), following the average costs reported by the Ministry of Transportation (SCT). Total costs (column 5) are the sum of local and federal costs. Columns 6 and 7 show the share (%) of new roads and costs by region, respectively.