Highways and Growth: Evidence from Brazil

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RESUMO

Um relatório recente da Confederação Nacional de Transportes (CNT, 2017) afirmou que os investimentos na infraestrutura de transporte do Brasil estagnaram em níveis muito baixos desde a década de 1970. Isso é alarmante, pois soluções de transporte são essenciais para promover crescimento, especialmente para um país de tamanho continental como o Brasil. Entre os estudos sobre os determinantes do crescimento das cidades realizados para o Brasil, poucos tratam especificamente o impacto da infraestrutura de transporte. Portanto, utilizando dados do Censo e análise de regressão com variável instrumental, buscamos identificar como a proximidade de uma rodovia afeta de forma causal o crescimento do emprego urbano e migração pendular entre 2000 a 2010. Os resultados indicam que as rodovias podem promover o crescimento do emprego de trabalhadores pouco qualificados, mas prejudicam os níveis de emprego de nível superior. Em relação à migração pendular, encontramos uma relação causal positiva entre a proximidade das rodovias e o deslocamento diário para uma cidade diferente, o que implica que a infraestrutura de transporte pode oferecer aos trabalhadores acesso a um mercado de trabalho mais amplo.

Palavras-chave: Rodovias, migração pendular, Emprego

Área de submissão: Infra-estrutura, transporte, energia, mobilidade e comunicação

Códigos JEL: R11, R41

ABSTRACT

A recent report from the National Confederation of Transport (CNT, 2017) stated that investments in Brazil's transportation infrastructure have stagnated at deficient levels since the 1970s. This is alarming, as transportation solutions are essential for promoting growth, especially for a continental country like Brazil. Among studies that consider the determinants of city growth for Brazil, few treat the impact of transportation infrastructure specifically. Therefore, using Census data and regression analysis with instrumental variable, we investigate how proximity to a highway causally affects urban employment growth and travel to work from 2000 to 2010. We found that highways can promote employment growth for low-skilled workers, but harms jobs for tertiary education level. Regarding travel to work, we specifically analyze workers who commute daily to a different city than the one where they live. We found a positive causal relationship between proximity to highways and daily commuting to a different city, which implies that transportation infrastructure can offer workers access to a broader labor market.

Keywords: Highways, Travel to work, Employment

JEL codes: R11, R41

INTRODUCTION

A recent report from the National Confederation of Transport (CNT, 2017) stated that investments in transportation infrastructure in Brazil have stagnated at very low levels since the 1970s. This is an alarming fact. A transportation infrastructure is important for the development of any nation, but it becomes crucial for a continental country as large as Brazil. A great territory makes transport connections essential for exploring the country's internal market, promoting agglomeration gains, reducing exportation costs, and promoting better national resources allocation, thus producing higher economic efficiency.

The relation between transport and growth is well known in the literature. The intra-urban model proposed by Alonso (1964) and Muth (1969) shows that transportation costs affect land-use and land prices of a city. By extending this model, Baum-Snow (2007) finds a reduction in population when a new highway is constructed passing through a city, arguing that roads may be responsible for suburbanization. Morten and Oliveira (2018), by extending the standard spatial equilibrium model (Roback, 1982; Moretti, 2011) with migration costs, finds that high transport costs cause wages to vary greatly across space, hindering labor market integration and welfare increase. Andrade, Maia, and Neto (2015) argued that better-connected cities generate more opportunities for development.

Lucas (1988) stated that spillover dynamics found in cities make them ideal for studying economic growth, while (Glaeser; Gottlieb, 2009) showed that transport costs are crucial to explaining agglomeration economies, which is a growth factor. In this context, several empirical studies considered the effects of transportation directly on urban growth. Duranton and Turner (2012) estimate a significant employment growth in American cities after highways were built: over a period of 20 years, a 10% increase in the stock of roads causes a 1.5% rise in city employment. In Europe (HOLL, 2004a, 2004b), studied the impact of improvements in the motorway network of Portugal and Spain. For both countries, she found empirical evidence that the new roads changed firm birth dynamics, raising agglomeration in some sectors while dispersing firms in others. On the other hand, Holtz-Eakin and Schwartz (1995) found no productivity spillovers across American states because of highways. Studying the Paris Metropolitan Area, Garcia-López, Hémet, and Viladecans-Marsal (2017) found no long-term impact of train expansion on population growth or short-term increase in employment growth but found that employment eventually raised in later periods.

Another issue related to transport costs is the dynamics of commuting. Even with the proliferation of teleworking opportunities, daily commuting still is a central part of the daily life of many workers (Sandow, 2011). The possibility to commute long distances can be a valuable alternative to out-migration (Green et al., 1999, Lück and Ruppenthal, 2010; van Ham, 2002), especially in rural areas characterized by a limited range of jobs. Advances in transportation, thus, can offer workers access to larger labor market (BJARNASON, 2014).

Among studies that consider the determinants of city growth for Brazil, few of them treat the impact of transportation infrastructure specifically or with enough detail. Da Matta et al. (2007) found that improvements in interregional transportation can stimulate city growth, but they lack detailed data on city level characteristics. Silva et al. (2016) show that, when spillover effects are ignored, the impact of growth policies is underestimated; however, they do not take into account transportation factors. Chein and Pinto (2017) studied the impact of roads expansion and found mixed results, concluding that investment in highways does not always produce positive effects. Their strategy, nonetheless, relies heavily on the strong assumption that the indicators of development in 1970 did not affect urbanization.

It is evident that more studies are necessary, as we currently know very little about the role of transportation infrastructure in the urbanization process of Brazil. If the connection between cities is indeed significant for growth, it can be argued that the lack of investment in transportation infrastructure has been one of the obstacles to the development of Brazil and many other developing countries. When transport infrastructures are underdeveloped, small expansions should promote big gains in terms of growth and development. In addition, the Brazilian case is relevant to the Urban Economic literature in general. Brazil is an important developing country as it is the 6th largest economy in the world (IMF, 2017). The country is known by the high density of its urban areas (Ingram and Carrol, 1981; Da Mata et al., 2007; Fernandez-Maldonado et al., 2014), which can be partially explained by its historical context. The Portuguese colonization resulted in a country with isolated cities across a great territory, which later hindered the development of transportation infrastructures (Natal, 1991).

With this in view, we intend to study the impact of highways in the cities of Brazil. More specifically, we will investigate how the proximity of a highway affects the growth of urban employment and travel to work from 2000 to 2010. We plan to use Census data to obtain socioeconomic characteristics and digital maps to account for the localization of highways.

We expect to find statistical evidence that highways increase employment growth in Brazil. When cities are better connected, labor market frictions decrease, which can lead to better job allocation and less unemployment (MORTEN; OLIVEIRA, 2018). An improved transportation infrastructure also reduces commute time, allowing workers to travel longer distances to work.

Works that measure the impact of investments in transportation also frequently lack identification strategies. Naïve estimations of the impact of transportation investment can suffer from reverse causality. While the creation of infrastructure can affect employment growth, it is also true that cities that present expected growth in jobs are likely candidates for receiving transport investments. These estimations are also prone to suffer from omitted variable bias, as there can be unobservable characteristics affecting the provision of infrastructure that caused growth in the future. To solve these endogeneity problems, several identification strategies have been proposed in the literature. Duranton and Turner (2012) use the Interstate Highway System, railway networks from the 19th century and expedition routes in the United States in past centuries as instruments for current highways' location in the USA. Morten and Oliveira (2018) uses a Minimum Spanning Tree Network connecting all five big regions to the capital (Brasília). We will follow Morten and Oliveira's (2018) approach.

HISTORICAL CONTEXT

Natal (1991) wrote that there is often a relationship between the occupation of a country and its transportation infrastructure. Although historical facts are not completely responsible for the current conditions of the country, understanding its initial circumstances can shed some light on the state of a country's transport system. In this regard, Brazil's occupation process is an interesting case.

A common occupation strategy was to first occupy the coast and then move to the interior regions, as the colonizers of North America did. After arriving in Brazil in 1500, the Portuguese logic, however, was to rapidly penetrate the interior of the country to take profit from its abundant natural resources (Natal, 1991). Throughout the colonial period, Brazilian spatial occupation was based on exploration of primary exportation products (basically: sugar cane, gold, and coffee). This approach generated Brazil’s first important cities, but also produced “economic islands”: highly specialized cities isolated and distant from each other (Furtado, 1968). The were no economic connections between Brazilian cities or regions as the transport infrastructure was poorly developed.

With the Industrial Revolution came a demand for faster transportation in western countries, which in the 19th century was solved by the construction of railways. The dispersed occupation of Brazil, however, imposed a challenge, as it was difficult and expensive to build an integrated system throughout its great territory. Natal (1991) writes that the answer was to build a radial railway system connecting the main cities in the interior to ports in the coast. The railroads in this system were rarely interconnected, which was not a problem initially as the Brazilian economy was export-oriented. However, as the internal markets started to develop in the later 19th century, the limited transportation structure turned out to be insufficient due to the lack of interregional connections.

It was in this context that highways started to emerge, often near important railways (Nazareth, 1978). These paved roads were a cheaper way to connect different regions of the country and provide transportation from the train stations to cities nearby. In spite of that, highway construction developed slowly until the mid-20th century, when it became the most important mode of transportation in Brazil (Natal, 1991). The inflection point occurred when the Brazilian capital was transferred to a new city in the center of the country built solely for this purpose: Brasilia. As a result, a new highway system was constructed to connect the new capital with all the other capitals of the country (Morten and Oliveira, 2018). According to Nazareth (1978), because of increased investments in road systems and lack of maintenance of railways and navigation infrastructure, the 1960s ended with 95% of passengers and 73% of goods being transported by roads. In spite of that, the investments were not able to follow the transportation demands. Because of increasing industrialization and massive migration of rural farmers to cities looking for better working conditions, the urban centers expanded faster than its transport infrastructures could handle.

In the 1970s came a world oil crisis which severely damaged the Brazilian economy. As transportation infrastructure was mainly financed with public money, the Brazilian transportation system started to deteriorate (Natal, 1991). Since then, investments in the transportation infrastructure have stagnated at extremely low levels (CNT, 2017). Because of poor public transportation infrastructure and low-income population, Brazilian cities today are dense and present remarkably high commuting costs (Ingrad and Carrol 1981, Fernandez-Maldonado et al. 2014, Silveira Neto et al. 2015).

EMPIRICAL STRATEGY

Specification

In this subsection, we propose an empirical model that depicts how highways affect employment growth and daily commute. Our specification is cross-section model that describes how the city's distance to the nearest highway affect the variation of the dependent variable from 2000 to 2010.

Let i be the index of cities and j the index of states. The model is:

$$y_{ij} = \alpha + \beta \times 2000\ dist\ Highways_i + \Gamma \times Controls_i + \lambda_j + \varepsilon_{ij} \tag{1}$$

in which y_i is either the change log of employment or the change log of workers who work in a city different than the one they live for the 2000-2010 period. $2000\ dist\ Highways_i$ is the distance of the centroid of the city i to the nearest highway (in kilometers) in the year 2000.

$Controls_i$ is a vector of fifteen variables. Three variables are related to geography and space (distance and squared distance to the nearest capital city and city area), three measure historical characteristics of the city (distance to the nearest city related to Brazilian historical sugar, gold and coffee business cycles), four variables come from the 2000 Census (log population, share of population with tertiary education, log GDP per capita, and log rural GDP per capita), two binary variables identify if the person is a recipient of government subsidies, a binary variable for cities that are part of metropolitan regions, a binary variable for cities that have railways and, finally, a binary variable for cities that have a federal educational institution or a federal university.

Every variable was measured at the municipality level, which is the lowest administrative level in Brazil. From 2000 to 2010, the number of municipalities went from 5,507 to 5,565. As many municipalities had their borders modified, using municipality as the unit of study could lead to bias. Instead, we use MCAs (Minimum Comparable Areas), an aggregation of municipalities developed by IPEA (Reis, Pimentel, Alvarenga; 2007). This aggregation strategy allows us to compare the same spatial units throughout time. We also exclude the MCAs with capital cities from the sample. The final dataset is comprised of 5,431 MCAs.

The model will be estimated with state fixed effects. The country has 26 states and one federal district. As we are working only with federal highways, the state fixed effects can help to partial out the effect caused by state highways.

For dealing with possible endogeneity problems, we use an instrumental variable approach, which is described in the next section.

Endogeneity

The literature has shown that naïve OLS estimations of the impact of transportation investment can suffer from endogeneity problems (Baum-Snow and Ferreira, 2015). While new infrastructure may promote education accessibility, it is also true that cities expected to grow in education and school attendance are likely candidates for receiving transport investments. These estimations are also prone to suffer from omitted variable bias, as there can be unobservable characteristics affecting the provision of infrastructure that caused accessibility in the future.

To deal with these issues, several identification strategies have been proposed in the literature. Baum-Snow (2007) used 1947 plans of the Interstate Highway System as an instrument for the network that was built later, being the first work to use construction plans to instrument for realized infrastructure. Duranton and Turner (2012) use the same plans, along with railway networks from the 19th century and expedition routes in past centuries as instruments for current highways' location in the USA. Garcia-López et al. (2017) use Roman roads and 1870 railways as instruments for the Regional Express Rail (RER) infrastructure in Paris metropolitan area.

Besides planned routes and ancient roads, other works have used the inconsequential units approach (Redding and Turner, 2014). In this form of identification, straight lines connecting important cities serve as an instrument for highways or railways that were built between them. Smaller cities that conveniently lie in these paths are said to have received a road "accidentally," as if in a random assignment. This method was used by Banerjee, Duflo, and Qian (2012) as an instrument for China's railway system. More recently, Minimum Spanning Tree algorithms have been used for generating these artificial networks. These algorithms connect a set of nodes with straight lines minimizing the total length of the segments, thus emulating the job of road planners: connect many cities with a single network minimizing the cost (Faber, 2014). Faber (2014) used this method while studying the impact of China's highway system, and Morten and Oliveira (2018) produced a Spanning Tree network to predict the Brazilian highway network.

Following previous literature, our identification strategy will rely on a minimum spanning tree network borrowed from Morten and Oliveira (2018).

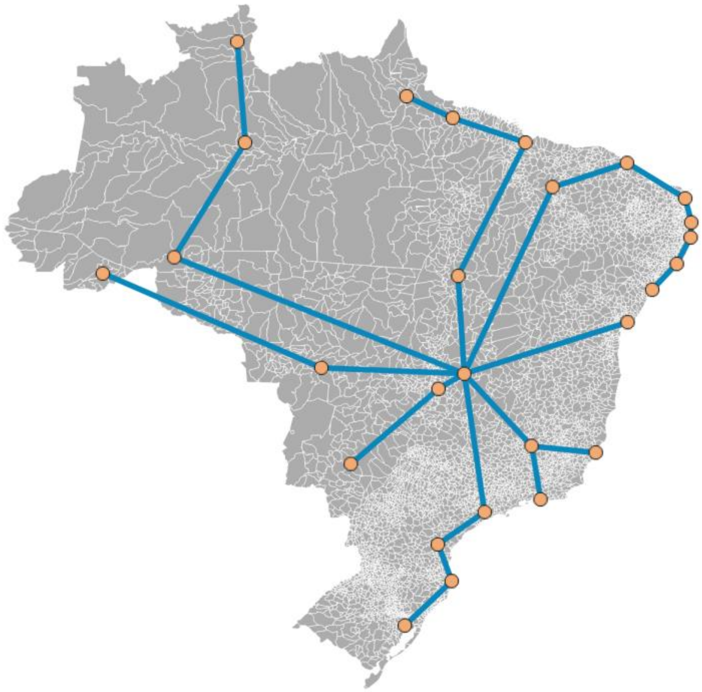
The instrument: A Minimum Spanning Tree Network

As explained above, the inconsequential units approach is already consolidated in the literature as a strategy to instrument for transportation systems (Redding and Turner, 2014). Morten and Oliveira (2018) make use of this strategy, tailoring their network to mimic the Brazilian government plans in the 1950s. With the construction of the capital (named "Brasília") in a central region of the country, the government simultaneously started building a national highway system connecting the capital to all state capitals. Along with longitudinal, transversal and diagonal roads, they built eight radial highways starting in Brasilia and expanding to the rest of the country. Based on that, the authors divide Brazil into eight segments and build a minimum spanning tree network that connects Brasília to all state capitals within each segment. We follow Morten and Oliveira (2018) in their approach. The generated network is shown in figure 1. Correlation analysis shows that the number of kilometers of highways in each municipality becomes more correlated with the artificial network along the decades.

Therefore, our first stage regression is:

$$2000\, dist\ Highways_{it} = \delta + \mu \text{ dist } MST_{it} + \nu_{it} \tag{4}$$

Figure 1. Minimum Spanning Tree network connecting all capital cities



Data

In this subsection, we describe the data used in the analysis.

The Brazilian Demographic Census is performed by the Brazilian Institute of Geography and Statistics (IBGE) every ten years. We use Census data from 1980, 1991, 2000, and 2010 to obtain school attendance information and education level of the population at the municipality level for each decade. For all years, except in 1991, information is provided on which municipality the student attends school. From the Census, we also computed control variables, such as qualified population, and mean age for each decade.

Additionally, we use data from the Brazilian Institute for Applied Economic Research (IPEA) to obtain information on the area, density, GDP per capita of each municipality for each decade. Finally, from data provided by the Ministry of Social Development (MDS) we obtained two control variables for the share of residents who receive government subsidies in each city. The subsidies were the Continuous Benefit Programme (BPC) and the Family Allowance (Bolsa Família).

The Ministry of Transport, Ports and Civil Aviation provides digital maps and pictures of the highways of Brazil for each decade from 1960 to 2010, and the Brazilian Institute of Geography and Statistics (IBGE) provides digital maps for the Brazilian municipalities. From these data, we were able to compute the explanatory variable using GIS techniques. We also used GIS and Python libraries to produce the instrument, which is based on Morten and Oliveira's (2018) work.

We also used a set of geographical and historical controls. The distance to the nearest capital was computed by the authors. As historical controls, we used three indexes that measure the proximity of each municipality to the central locations of three critical moments of Brazilian economic history: the sugar boom, the gold rush, and the coffee boom. These indexes were produced by (Naritomi; Soares; Assunção, 2012).

ESTIMATION RESULTS AND DISCUSSION

In this section, we report the results of the estimations. Table 1 reports that the instrument is significant, with a first-stage F well above the threshold of 10, even when several control variables are taken into account. Given that we have a strong first-stage, we can move on to explore the impact of highways on our variables of interest. We start by exploring the effect of highways on employment; in the following subsection, we analyze how roads affect travel to work.

Table 1. First stage regressions results

	(1) Distance to nearest highway
Distance to MST	0.0519***
	(0.00844)
Distance to nearest capital city	-0.323***
	(0.0449)
Distance to nearest capital city sqrd	0.00641***
	(0.000836)
area	1.052***
	(0.0716)
Metropolitan region	-0.769***
	(0.161)
sugar cycle	0.0747
	(0.280)
coffee cycle	0.533***
	(0.170)
gold cycle	-0.687***
	(0.206)
log population 2000	-0.676***

	(0.0614)
tertiary education share 2000	1.735
	(2.217)
log GPD per capita 2000	-0.203
	(0.126)
log rural GDP per capita 2000	-0.354***
	(0.0845)
Federal educational instution 2000	0.134
	(0.376)
Subsidy BPC	-18.78***
	(4.673)
Subsidy Bolsa Família	-1.490
	(2.364)
Railway	-0.240***
	(0.0654)
State FE	Yes
Observations	5431
R2	0.627
First stage F	37.90

Notes: Robust standard errors in parentheses. The symbols *, **, *** indicate significant at the 10%, 5% and 1% levels, respectively.

Employment

Table 2 reports IV estimation results for the effect of highways on employment for different education levels. Specifically, we estimated how a longer distance to the nearest highway affect the employment for all workers, workers without education, workers with primary education only, workers with up to secondary education, and workers with at least tertiary education (columns 1 to 5, respectively). We obtained significant coefficients for the general case, for the non-qualified, and for those with up to secondary education. All significant coefficients were negative. As our explanatory variable is distance to the nearest highway, the results were according to our expectation: shorter distances to a highway means more employment growth. The numbers imply that roads bring employment benefit only to the less educated, while those with at least secondary education seem not to be affect by it.

Table 2. IV regressions for employment

	Employment growth				
	(1)	(2)	(3)	(4)	(5)
	All qualifications	Non-qualified	Primary education	Secondary education	Tertiary education
Distance to highway$_{2000}$	-0.00332**	-0.00322**	-0.00676***	-0.00429	-0.00107
	(0.00134)	(0.00164)	(0.00222)	(0.00375)	(0.00209)
Control variables	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes
Observations	5431	5431	5431	5431	5431
First Stage F	37.90	37.90	37.90	37.90	37.90

Notes: Robust standard errors in parentheses. The symbols *, **, *** indicate significant at the 10%, 5% and 1% levels, respectively.

In Table 3, we break the estimations down by industry. Column 1 show the results for agriculture. We found a negative coefficient for those with primary education, but no significant results for those with no education or with secondary education. This is expected, as agriculture mostly employs low-skilled labor. The results also point out that cities with more roads drove out qualified jobs in the years that followed. Something similar happened with manufacturing: the only significant relationship we obtained was a positive one for the workers with secondary education. Cities with a better access to roads seem to have suffered a loss of these educated workers during the 2000s. For service and mineral extraction workers, being near to roads had a causal relationship with low-skilled employment growth: non-qualified for services, educated at the primary level for mineral extraction.

Table 3. Employment growth by industry and education level

	Employment growth			
	(1)	(2)	(3)	(4)
	Agriculture	Manufacturing	Services	Mineral Extraction
Non-qualified	0.000376	-0.00483	-0.00101	-0.0103**
	(0.00302)	(0.00393)	(0.00207)	(0.00462)
Primary education	-0.0100**	-0.00319	-0.00450**	-0.00145
	(0.00412)	(0.00402)	(0.00226)	(0.00339)
Secondary education	-0.000797	0.0114**	-0.00103	-0.00477
	(0.00365)	(0.00486)	(0.00374)	(0.00374)

Tertiary education	0.00592*	-0.000951	-0.000747	0.00150
	(0.00335)	(0.00350)	(0.00217)	(0.00237)

Notes: Robust standard errors in parentheses. The symbols *, **, *** indicate significant at the 10%, 5% and 1% levels, respectively.

In Table 4 and 5, we break down services and manufacturing results by subsectors to further explore which industries were most affected by improved access to transportation infrastructure. Table 4 reports results for manufacturing. Among several industries, the results show that being close to roads only helped the chemical products industry. No significant results were found for food and drinks, textiles and clothing, and machines an equipment industry. Table 5 shows estimation results for service subsectors. We found a causal effect of proximity to roads on employment growth in the trade sector, but a negative relationship between being close to a road and employment in the financial intermediation industry.

In summary, the results show that better access to roads have a positive impact on the growth of low-skilled jobs. This is consistent with our initial hypothesis, given that better transportation infrastructure gives the worker a larger pool of jobs to choose, as discussed in length in the introduction section. However, contrary to our expectations, proximity to roads seem to hinder high-skilled work. The reasons for this effect are not clear and more investigation is required to understand this finding.

Table 4. Regression results for some manufacturing subsectors

	Employment growth				
	(1)	(2)	(3)	(4)	(5)
	All	Food and drinks	Textiles and clothing	Chemical products	Machines and equipment
Distance to highway$_{2000}$	-0.00129	0.00786	0.00299	-0.0160***	0.00135
	(0.00329)	(0.00505)	(0.00478)	(0.00467)	(0.00376)
Control variables	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes
Observations	5431	5431	5431	5431	5431
First Stage F	37.90	37.90	37.90	37.90	37.90

Notes: Robust standard errors in parentheses. The symbols *, **, *** indicate significant at the 10%, 5% and 1% levels, respectively.

Table 5. Regression results for some service subsectors

	Employment growth			
	(1)	(2)	(3)	(4)
	All	Trade	Education and Health	Financial Intermediation
Distance to $highway_{2000}$	-0.00161	-0.0108***	0.00199	0.0102**
	(0.00150)	(0.00312)	(0.00264)	(0.00424)
Control variables	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Observations	5431	5431	5431	5431
First Stage F	37.90	37.90	37.90	37.90

Notes: Robust standard errors in parentheses. The symbols *, **, *** indicate significant at the 10%, 5% and 1% levels, respectively.

Travel to work

The transportation infrastructure of a city deeply affects the dynamics of commuting that, in turn, affects the labor market. As discussed in the introduction section, better access to long distances can offer workers access to larger labor market (BJARNASON, 2014). If we find a positive impact of proximity to roads on long-distance commuting to work, we will have further evidence that roads help employment by promoting a better job allocation in space.

In this section, we are interested in those workers who live and work in different cities, and thus rely on long-distance transportation infrastructure (in the case of Brazil, this means heavy use of roads) for their daily commute. For this reason, we will refer to “travel to work” as those commuting trips that are done to and from a different city than where the worker lives. We will call “inbound commuters” those workers who live in city *i* but travels daily to a different city for work reasons, and “outbound commuters” those who live in city *i*, but travels daily to a different city for work reasons.

In Table 6, we report general results for the impact of distance to the nearest highway in 2000 on travel to work growth in the 2000-2010 period. In the first column, the dependent variable is the total amount of workers who daily travels in or out the city *i*. This measures the total flow of commuting that takes place between city *i* and its neighbors. We then divide the travel to work into two categories: inbound commuting and outbound commuting. This disaggregation can help us to find differences in the dynamics of travel to work; as a higher inbound commuting should be related to richer cities, while larger levels of outbound commuting should be found in poorer localities. The results show that proximity to highways induces travel to work for all cases. The larger coefficient for inbound than for outbound commuting indicate that, on average, for the Brazilian case, being close to a highway causes more workers to commute to city *i* for work than to commute outward to other cities.

Table 6. IV regressions for commuting

	(1) Total commuting	(2) Inbound commuting	(3) Outbound commuting
Distance to $highway_{2000}$	-0.0787**	-0.00940**	-0.00798**
	(0.0342)	(0.00409)	(0.00371)
Control variables	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Observations	5431	5431	5431
First Stage F	37.90	37.90	37.90

Notes: Robust standard errors in parentheses. The symbols *, **, *** indicate significant at the 10%, 5% and 1% levels, respectively.

In Table 7 and 8, we analyze the education level of the commuters, breaking the sample down into the same four education categories as in the previous subsection. In Table 7, the results show that those cities that were closer to highways in 2000 saw a rise of non-qualified and low-skilled workers commuting inward to work. Table 8, on the other hand, did not show significant results for non-qualified workers commuting outward. However, it presented significant coefficients for workers with primary and secondary education levels. In summary, proximity to highways had a positive impact on both inbound and outbound travel to work. The effect is primarily on low-skilled labor, as we found no significant result for workers with tertiary education level. Also, workers with a secondary level of education are commuting outward because of highways, but those roads are not bringing much inward commuting.

Table 7. IV regressions for inbound commuting by education levels

	Travel to work growth: inbound commuting			
	(1) Non-qualified	(2) Primary education	(3) Secondary education	(4) Tertiary education
Distance to $highway_{2000}$	-0.00897**	-0.00995**	-0.00609	-0.00186
	(0.00448)	(0.00462)	(0.00421)	(0.00377)
Control variables	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Observations	5431	5431	5431	5431
First Stage F	37.90	37.90	37.90	37.90

Notes: Robust standard errors in parentheses. The symbols *, **, *** indicate significant at the 10%, 5% and 1% levels, respectively.

Table 8. IV regressions for outbound commuting by education levels

	Travel to work growth: outbound commuting			
	(1)	(2)	(3)	(4)
	Non-qualified	Primary education	Secondary education	Tertiary education
Distance to $highway_{2000}$	-0.00284	-0.00939**	-0.0106**	-0.000562
	(0.00406)	(0.00424)	(0.00449)	(0.00347)
Control variables	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Observations	5431	5431	5431	5431
First Stage F	37.90	37.90	37.90	37.90

Notes: Robust standard errors in parentheses. The symbols *, **, *** indicate significant at the 10%, 5% and 1% levels, respectively.

CONCLUSION

In this study, we investigated whether the improvement of transportation infrastructure can promote employment and ease access to a larger labor market, thus promoting growth. To our knowledge, there are no published empirical works that study the connection between highways and both employment and travel to work for a developing country.

To explore the relationship between highways and employment and travel to work, we analyzed data for 2000 and 2010 for all municipalities of Brazil through log-difference models with instrumental variables. We have evidence that highways can promote employment growth, specifically for low-skilled workers. We also found that higher-skilled labor seems to be negatively related to proximity to highways in some cases, which will require further investigation.

We also found evidence that highways promote better access to a larger labor market, as proximity to highways are causally related to workers daily commuting to a different city. This result implies that even a city with a limited labor market can see an improvement in its employment levels if the city is well connected to municipalities that offer more jobs. Hence, the expansion of highways can be seen as a policy for increasing employment and promoting growth.

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