Transport Infrastructure, Urbanization and Shipping Costs: An analysis of the effects of an exogenous transport cost reduction on regional development*

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Abstract

This paper investigates the role of infrastructure improvements, especially those related to transport network, on regional development. It aims to verify that the greater proximity to markets, by reducing transportation costs, provides greater regional development, causing urbanization and changes in local labor markets, that leads to improvements in the living conditions of the population. We adopt an emprical strategy based on a *difference-in-difference* approach, taking into account four different investments in Brazilian transport network, the *Belém-Teresina* (BR 010/316); the *Cuiabá-Porto Velho* (BR 364); the *Cuiabá-Santarém* (BR 163/230) and the *Highway of Coffee* (BR 376). Our analysis is carried on using data from Brazilian Census Demographic (IBGE) for the years 1970 to 2000. The main results show that construction of new limited access highways has contributed to the development of those municipalities directed and indirected benefited by the highway, improving well-being of those living in the countryside.

Keywords: transport infrastructure;roads; shipping costs; regional development.

JEL Classification: J31, O15, O18, R42.

Introduction

The history of regional economic is based on the existence of transport costs as an instrument to form economic agglomeration and improve trade, in particular exports and imports. The economic decisions are built and limited by the transport costs of goods and commodities from one place to another (Christaller, 1966; Lösch, 1954; Isard, 1960; Fujita *et al.*,1999; Glaeser & Kohlase, 2003).

*This project received funds from Swiss Program for Research on Global Issues for Development (r4d program) under the thematic research module "Employment in the context of sustainable development" and the research project "Trade and Labor Market Outcomes in Developing Countries". We are also thankful to CNPq and Fapemig for financial support. We are grateful to Yan Vianna for outstanding research assistant.

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Many empirical works have pointed to a strong relationship between access to sea, percent of population living in coastal areas, urbanization and economic growth (Gallup, Sachs & Mellinger,1998). The development of areas far from the sea depends on the investments in infrastructure, despite the existence of natural resources. These investments are related to specific production and trade patterns imposed by high transport costs. As documented recently, major roads affect the distribution of the population (Baum-Snow 2007a, 2007b; Duranton & Turner 2007) and labor markets (Michaels 2008). Based on these evidences we propose to investigate the impacts of transport cost reduction on income or wages premium, human capital formation and labor markets.

In fact, our aim is to analyze the relationship between urbanization or urban growth and development by exploring the role of transport costs in the process of urbanization. The urbanization process, or more generally, the creation of urban agglomeration, and its relation to economic growth have been deeply discussed by the empirical and theoretical regional and urban economics literature (Lewis, 1954; Hoselitz, 1953; Christaller, 1966; Lösch, 1954; Pred, 1966; Jacobs, 1969; Henderson, 1999; 2003; Glaeser *et al.*, 1992; Glaeser, Scheinkman e Shleifer, 1995; Glaeser, 1999; Fujita & Thisse, 2002; Fujita *et al.*,1999; Black & Henderson, 1999, and others). The urban economists and development economic literature recognize the positive relation between urbanization and income (Kuznets, 1966; Jacobs, 1969; Bairoch, 1988; Glaeser & Maré, 2001; Acemoglu et al., 2002; Berry & Glaeser, 2005).

Empirically, Acemoglu *et al.* (2002) show that a country with an urbanization rate of 10 percent points above the average presents a per capita income 43% higher. Glaeser & Maré (2001) found an average urban wage premium that ranges from 24,9% to 10,9 % for those who lives in densely populated areas, controlling by individual characteristics.

Despite these empirical results, there are still few studies that deal with urbanization not only from the point of view of the change from agricultural sector to the industrial sector, but consider, in fact, the existence of cities, as in Henderson & Wang (2005). Actually there is still two main gaps in the literature: how to identify the relation between urbanization and economic growth and once we identify transport costs as one possible channel to urbanization, how to measure it.

According to Kuznets (1966), the population migration from countryside to the city, or from rural to urban areas, is afforded by population growth and structural changes that generate productivity gains per worker and per capita income increase associated with economic development. Hence, as agricultural surplus are generated and the transport network are improved, it become possible to trade the surplus and consequently new urban centers are created (Bairoch, 1988).

Historically, taking the American example, in the eighteenth century, when transportation costs were very high, and goods transported, basically, by water, the structure and location of these cities reflect high transportation costs. As roads and railways were expensive and rare, every major city was located along waterways, such as Boston, Chicago, New York, New Orleans, among others. Small towns were inside the country and were specialized in the provision of basic services to those living in production for self-consumption (Glaeser & Kohlhase, 2003).

In Brazil, a large fraction of old municipalities are settled along the coastline or in riverbeds, while the more recent cities have their headquarters along the national highway network. Figure 1 shows some examples of this phenomenon.

[Place Figure 1 - Transport Network in Amazon and State of Maranhão – Brazil]

The black points represent the oldest municipalities while the white points with black contour mark the newest ones. A quickly view point that the oldest municipalities in the Amazon Region are

settled along the riverside. In Maranhão, that has an earliest settlement process, the urbanization begins in the coastal and comes to interior following the implantation of highway network. In the late 70's, Brazilian Government introduces a regional policy based on the creation and development of a highway network that aimed to link the poorest country regions to the richest ones. Due to this experience, the majority of the cities in the Rondonia State, in the North region, were settled down just along *Porto Velho-Cuiabá* highway (BR 364).

Chein *et al.* (2009) have already studied some effects of transport infrastructure development in Brazil. The authors investigate the relationship between urbanization and individual incomes by exploring the role of transport costs in the Brazilian process of urbanization. They find that, although this relationship exists, it is not, necessarily, direct. Productive structure and local labor market are important channels which relate urbanization to individual income in emerging towns around the roads. Their empirical results show that there is no statistically significant relationship between the accumulation of human capital in those towns and the individual incomes, differently from the findings for large and medium-sized cities.

The idea behind our paper is very similar to the experiment designed in Chein *et al.* (2009), but we will make some advances in the identification of the relation between urbanization and economic growth or development. In fact the results present in Chein *et al.* (2009) refer to a simple correlation between urbanization and income; we want to identify a cause relationship between urbanization and some indicators of development using a reduction in transportation cost as an instrument to urbanization. Following Michaels (2008) and Baum-Snow (2007), instead of using a measure of transportation costs we will associate the development of highway networks with a transportation cost reduction. But, contrary to Baum-Snow (2007) and differently from Michaels (2008) experiment we are interested in identifying the impact of urbanization caused by the roads investments on labor markets and income, that is, we use the highway improvement to identify urban growth and not a suburbanization (Baum-Snow, 2007) or necessarily and increase in international trade (Michaels, 2008).

Our empirical framework will be built on the importance of the transport networks, especially roads, in increasing urbanization and changing regional economies. In this context, some emphasis was given to the role of roads paving and expansion of transport network to increase agricultural productivity and consequently to induce the recent process of urbanization in the Center-west and North region.

The main idea is to implement an empirical exercise based on a difference-in-difference approach considering Brazilian municipalities, which the basic difference over the time relies on the development of a highway network that mainly reduces transport costs. We will compare the economic development in these municipalities before and after the improvement in a highway network. Our analysis will be carried on based on Census Demographic Database (IBGE) and on secondary data concerning the date of creation or improvement of roads infrastructure and their spatial information, which is provided by a geo-referenced database (Brazilian Ministery of Planning). We basically analyze the case of investment in four different Brazilian roads: the *Belém-Teresina* (BR 010/316), in North/Northeast Regions, the *Cuiabá-Porto Velho* (BR-364), in Center-West/North Regions, the *Cuiabá-Santarém* (BR-163), also in Center West/North Regions and the Highway of Coffee (BR-376), in the South Region.

Our main results point that construction of new limited access highways in Brazil has contributed to the development of those municipalities directed and indirected benefited by the highway, improving well-being of those living in the countryside. To illustrate, the estimate of the difference in population growth comparing municipalities benefited by the *Cuiabá-Santarém* highway and the rest of the

country reaches 62%. Concerning the human capital formation, those areas benfited by *Cuiabá-Santarém* highway and by Highway of Coffee had an increase of 1.8 years of education comparing to the others Brazilian municipalities. We also find positive effects of highways improvements on employment rate, high-qualified occupation rates, service occupation rate, familar *per capita* income and others.

The remainder of the paper is organized as following. Section 1 presents the history of the four roads analyzed. Section 2 describes the database and methodology. Section 3 presents the impacts estimates of the transport network investments on regional development. Section 4 discusses some limitations and caveats. Section 5 concludes.

1 The choice and history of the analyzed roads

We must emphasize that there is no consolidated database with information about the implementation dates, paving or duplication of highways. Alternatively, the strategy adopted was the choice of some stretches of major highways, local, regional or national level, from the information of the national highway network (Ministry of Transport). First, we identify highways located in different regional areas in terms of stage / level of development. There were selected, preliminarily, about 30 highway sections. The next step was to determine which of these had stretches deployment or suffered some significant improvements such as paving or duplication in one of three inter-census periods considered. From the information available to state agencies for transportation, the internet address of municipalities and documents on regional development (Sant'Anna, 1998; Margulis, 1991; GTI, 2005), it was possible to identify four highway sections with works impact between 1970-2000, BR-163/BR-230 (*Cuiabá-Santarém*), BR-364 (*Cuiabá-Porto Velho*); BR-316/BR-010 (*Belém-Teresina*) and BR-376 (*Highway of Coffee* -PR).

The *Belém-Teresina* (BR 010/316) highway was built in the 1970s as a part of the national policy for integration and development of the country as a whole. The highway, which comprises stretches of BR-316 and BR-010, is an important link between the north and northeast regions of the country. It was opened to traffic in 1976, with 1,087 kilometers paved. Along with the Belém-Brasilia highway, the Belém-Teresina highway was the main access route to East Amazônia at that time. It also provides access by land from coast municipalities in the northeast to waterways in the north (Sant'Anna, 1988).

[Place Figure 2 - Area of *Belém-Teresina* highway (BR 010/316]

Figure 2 depicts the Belém-Teresina highway and the focus of our analysis. The highway crosses a very poor region, where a large percentage of the municipalities was mostly rural until the 1990s; 58% of the population over 10 years of age was living in rural areas in 1980. Note that we have excluded from our sample the state capitals (Belém, Teresina, and São Luis) The construction of the Belém-Teresina highway has increased the population density along its path. This change can be seen in two dimensions - creation of new cities and migration flows (Chein & Assunção, 2012).

On the other hand, the *Cuiabá-Porto Velho* (BR 364) has 1090 quilometers paved, connecting Porto Velho (State of Rondônia) to Cuiabá (State of Mato Grosso) and Rio Branco (State of Acre). It is worth mentioning that the focus of this article will take as a reference one particular stretch of paving from Cuiabá to Porto Velho. This stretch was delivered to traffic from 1983 being completed in September 1984 (Fearnside, 1987).

The paving of the Cuiabá-Porto Velho was just one component of *Polonoroeste,* program co-financed by the World Bank, whose main objective was to organize de occupation of the region and provide the necessary infrastructure for the use of local agricultural potencial. Besides the highway investments, the *Polonoroeste* encompassed: i) agricultural development and environmental project, ii) health projects, and ii) the design of new settlements. The total loans was US$ 434.4 million between December 1981 and October 1983 (Margulis, 1991).

Despite the existence of ohter components in Polonoroeste, the investment of BR 364 account for 57% of the total value of US$ 1.6 billion (37% of the World Bank and 66% of the Brazilian government) budget of project (Fearnside, 1987; World Bank, 1999; Magulis, 1991).

The area *surrounding Cuiabá-Porto Velho* (BR 364) highway are represented in Figure 3.

[Place Figure 3 - Area of *Cuiabá-Porto Velho* (BR 364)]

The BR-163/BR-230 has a total length of 1,743 km, of which 760 km cross over the state of Mato Grosso and 983 km the State of Pará (Figure 4). This highway, whose construction started in 1970, aimed to provide a link between the Midwest Region and the Port of *Santarém* and increase the development of a part of the Brazilian *cerrado*. The highway was part of a plan that intends to occupy demographic gaps along the Tapajós and Xingu rivers (Sant'Anna, 1998). Importantly, the Cuiabá-Santarém is only a part of the BR-163, a longitudinal highway, which runs from north to south of the country. It is worth noting that one of the barriers to our experiment relies on the fact that it is possible to identify which municipalities between Cuiabá and Santarém benefited from the highway after 1978, however, there is no precise information about the BR-163 at south of Cuiabá, or better still, the specific period of time this stretch was built.

[Place Figure 4 - Area of *Cuiabá-Santarém* (BR 163/230)]

Finally, the BR 376, in the State of Paraná, known as *Highway of Coffee*, links the coffee producing region in Paraná with the port of Paranaguá. The relevant phenomenon in terms of improving the highway, occurred between 1980 and 1991, refers to the doubling of a stretch with 66,7 km, between Sprea (Apucarana) and Ponta Grossa, in 1986 (DER-PR). Figure 5 shows the State of Parana and the Highway of Coffee, municipalities in green are those crossed by the highway while the blue ones are in the highway neighborhood.

[Place Figure 5 - Area of *Highway of Coffee* (BR 376)]

2 Data and Methodology

We use data from the Demographic Censuses of 1970, 1980, 1991 and 2000, collected by the Brazilian Institute of Geography and Statistics (IBGE). Along with the basic information collected for the Census, IBGE also used an extended questionnaire to obtain more detailed socioeconomic information. This extended questionnaire is applied to a sample of 10 to 20% of the population of each municipality, depending on its size. Our data come from this longer survey. Table 1 brings some descriptive statistics.

[Place Table 1- Descriptive Statistics]

The initial idea was to get some inferences about the impacts generated by improvements in transport infrastructure identified in the previous section on some municipal development indicators, specifically on the variables of income, education, occupational and productive structure. The first step, therefore, was the definition of the coverage area of the highway to define the group of municipalities benefited. To that end, we made the intersection (spatial join line-point) between the national highway network and the comparison areas grid, resulting from compatibility of existing municipalities in 1970 and 2000 (see Chein et al. 2007). Thus, there were defined the comparison areas directly benefited by the construction of the highway, or those whose seats are closest to each of the stretches of highway, in almost all cases, municipalities crossed by the highway. Then, we defined the direct and indirect neighbors of these areas in order to obtain the total area covered highway.

Importantly, in the case of municipalities in the North and some in the Midwest, the compatibility generates comparison areas of large territory, which enlarges the area surrounding the highway. Then, the inclusion of all neighbors may overestimates indirect beneficiaries, while take into account only the direct neighbors can cause some sort of underestimation. The choice was to estimate a DID model (differences in difference) considering first neighbors and second neighbors, as follows:

$$Y_{i,t} - Y_{i,t-1} = \alpha + \delta_1^C(D_{i,t}^{364C} - D_{i,t-1}^{364C}) + \delta_2^C(D_{i,t}^{163C} - D_{i,t-1}^{163C}) + \delta_3^C(D_{i,t}^{316C} - D_{i,t-1}^{316C}) + \delta_4^C(D_{i,t}^{376C} - D_{i,t-1}^{376C}) + \delta_1^{FN}(D_{i,t}^{364FN} - D_{i,t-1}^{364FN}) + \delta_2^{FN}(D_{i,t}^{163FN} - D_{i,t-1}^{163FN}) + \delta_3^{FN}(D_{i,t}^{316FN} - D_{i,t-1}^{316FN}) + \delta_4^{FN}(D_{i,t}^{376FN} - D_{i,t-1}^{376FN}) + \delta_1^{SN}(D_{i,t}^{364SN} - D_{i,t-1}^{364SN}) + \delta_2^{SN}(D_{i,t}^{163SN} - D_{i,t-1}^{163SN}) + \delta_3^{SN}(D_{i,t}^{316SN} - D_{i,t-1}^{316SN}) + \delta_4^{SN}(D_{i,t}^{376SN} - D_{i,t-1}^{376SN}) + \epsilon_{i,t}$$

where $Y_{i,t}$ refers to a municipal development indicator, or the outcome variable, $D_{i,t}^{C}$ is a dummy variable that is equal to one if the observation refers to a municipality or comparison area that is crossed by the highway at a time t after its construction or improvement; $D_{i,t}^{FN}$ is a dummy variable that is equal to one if the observation refers to a municipality or comparison area that is a direct (or first) neighbor of the highway at a time t after its construction or improvement; $D_{i,t}^{SN}$ is a dummy variable that is equal to one if the observation refers to a municipality or comparison area that is an indirect (or second) neighbor of the highway at a time t after its construction or improvement.

Thus, δ coefficients give us the difference-in-difference estimator, that is $\Delta Y_{Treat} - \Delta Y_{Control}$, which means the difference between the change of the indicator occurred in the areas benefited by the opening or improvement of the highway and that of the control group, in these case, municipalities or comparison areas not benefited by highways improvement between 1970-2000.

3 Empirical Results

Tables 2a and 2b bring the estimate effects of highways improvements on development indicators. Generally, we find evidences of a positive impact of the highways on the area benefited by the transport network investments. The results point to a positive and highly significant effect on *per capita* income in the case of *Cuiabá-Santarém* (179%)[1] and *Belém-Teresina* (115%) highway. In terms of population growth, the effect was around 62%. This result could be understood as a positive effect on migration flows, that is, the new economic perspectives generated by the highway affect the population distribution in the neighborhoods of highways as a consequence o lower migration costs.

We should also emphasize positive impacts of highways on human capital formation in all cases. The comparison areas benfited by *Cuiabá-Santarém* highway and by Highway of Coffee had an increase

[1] (exp(1.026)-1)*100

of 1.8 years of education comparing to the others Brazilian municipalities. Moreover, the analysis of market labor indicators shows that there was a change from an agricultural economy to an urban one in surrounding areas of the highways, or better, it is possible to observe an increase in the employment rates in industry, trade and services as well as in high-qualified occupation rates.

[Place Table 2a and Table 2b - Effects of Highways' Improvements on Income and Labor Market]

In spite of the positive effects of highways presented in Table 2a and Table 2b, it is important to remember that there is a few difficulties in measuring the impact of a reduction in shipping costs. On one side, a good transport network allows access to less expensive markets, which corresponds to the best business opportunities. On the other hand, it is the more developed regions and the richest ones that can afford the high costs of construction and maintenance of transport infrastructure. Naturally, the construction of a road or highway is strongly influenced by the characteristics of the cities that are at its ends. However, that link is much weaker for those that are located in more intermediate positions. At first, the population of these cities experienced an exogenous reduction in shipping costs.

In order to mitigate this identification problem (simultaneous correlation), i.e., to consider just the first relation or the impact of transport network on new ecoomic perspectives, the models of Table 2a and 2b were reestimate without the extremities of the highways and the capitals in their neighborhoods. Table 3a and Table 3b report the new estimates. The results are very similar to those found on Table 2a and 2b.

[Place Table 3a and Table 3b - Effects of Highways' Improvements on Income and Labor Market without extremities]

In summary, we find some evidence that lower shipping costs changes the regional economy surrounding the highways and leads to a new distribution of humam and physical capital. In generally, it is possible to observe that investments in transport networks induce a change from rural to urban activities, an increase on wages or incomes and higher levels of human capital.

4 Caveats and Limitations

It is worth mentioning that our results are still very preliminary. The analysis of the previous section is based on the assumption that the investments in transport network were the only event that has affected differently comparison areas benefited by them.

In this sense, it is important to emphasize some of the underlying assumptions and characteristics of the experiment designed here to test whether different highways improvements cause economic growth:

1. Characteristics of the cities not constant over time were not considered in our analysis, so that effects of the construction of highways might be underestimated or overestimated, if there is something besides the highway built that could affect the regional/local development.

2. The definition of highways' beneficiaries has a margin of error, since it was not possible to clearly identify the date of construction of each sections of the national highway network,i.e.,

in Cuiabá-Porto Velho area were also considered as beneficiaries, in 1980s, the municipalities at north of Porto Velho and south of Cuiabá. Similar problems were encountered in the definition of the coverage area of the others highways.

3. Is is difficult to isolate the effect of the construction of highway, since the transport issue should be considered in an integrated way, that is, the positive effect of a particular road can be canceled if it is built in the same period of the construction of a road with a lower cost or better route, connecting, for exemple, isolate areas to a more modern port. Moreover, in general, investments in network transport infrastructure are took together with others ones, like fiscal incentives, agricultural programs, cash transfers and more.

In order to mitigate such kind of limitations and make some robustness checks, the next steps of this research include new definitions of the groups of beneficiaries and not beneficiaries, as the comparison between the municipalities crossed by the road and the first and second neighbors. Besides, we intend to estimate similar models to the previous ones considering data at micro or individual instead of municipal one.

5 Conclusion

This paper investigates the impact of improvements in the transport network on economic development. We have shown that investments in highways seem to changed the human and physical capital distribution - economies near the highways increases population, income and schooling as well as reduces the participation of agricultural sector. Our results bring new evidence of the role of highways in promoting urbanization, better living conditions and economic expansion of new areas.

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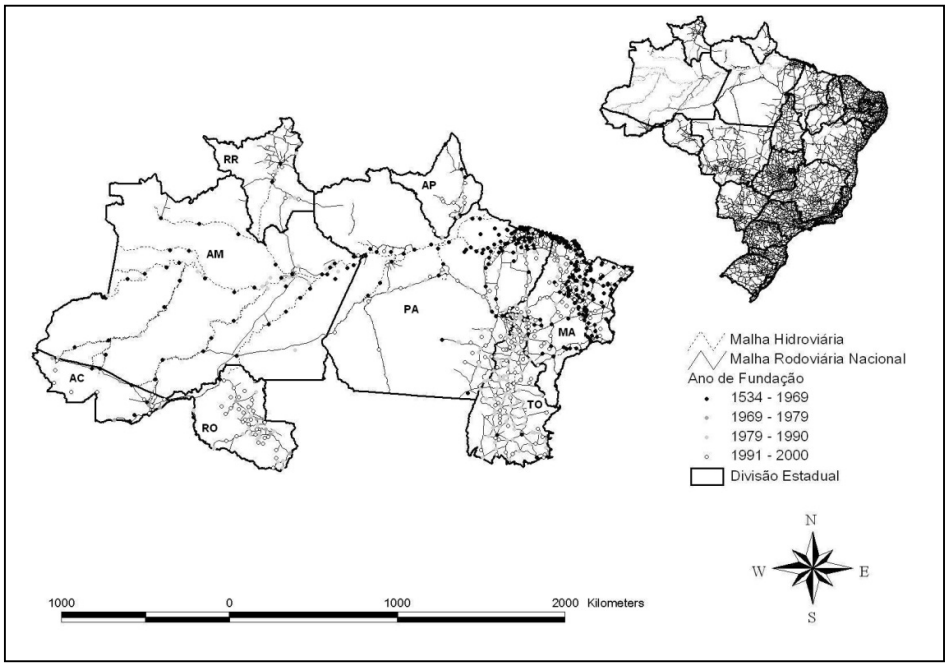
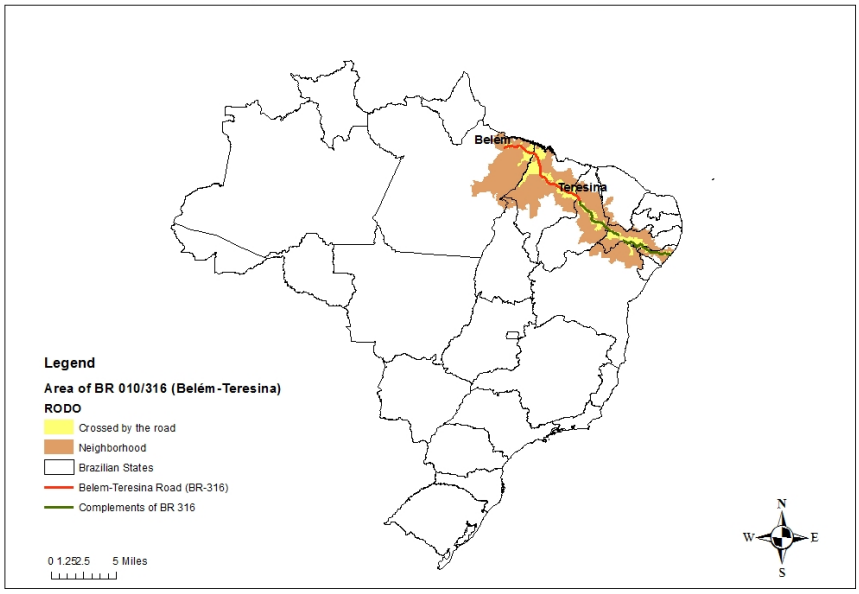
Figure 1: Transport Network in Amazon and State of *Maranhão* – Brazil



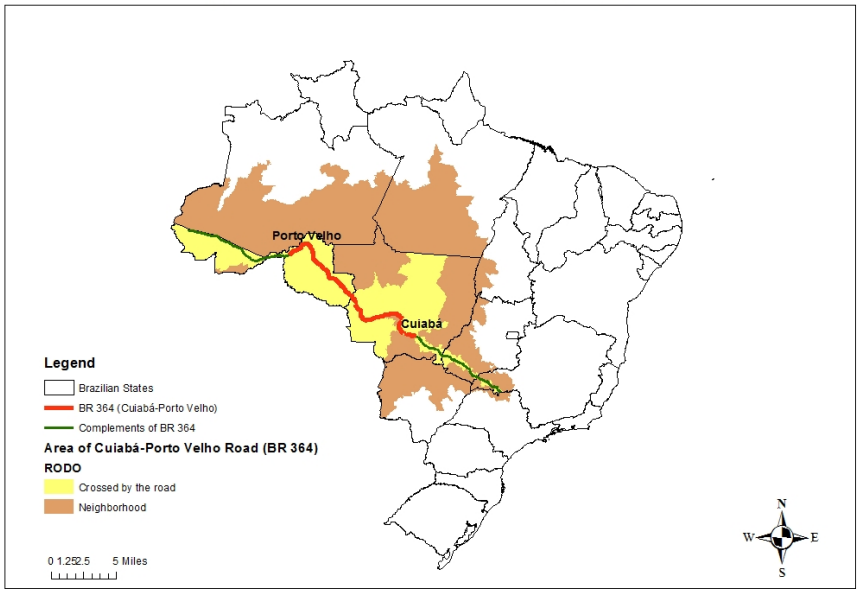
Source: Authors' Elaboration (based on INGEO, Brazilian Planning Ministry 2002)

Figure 2: Area of Belém-Teresina Road (BR 316)



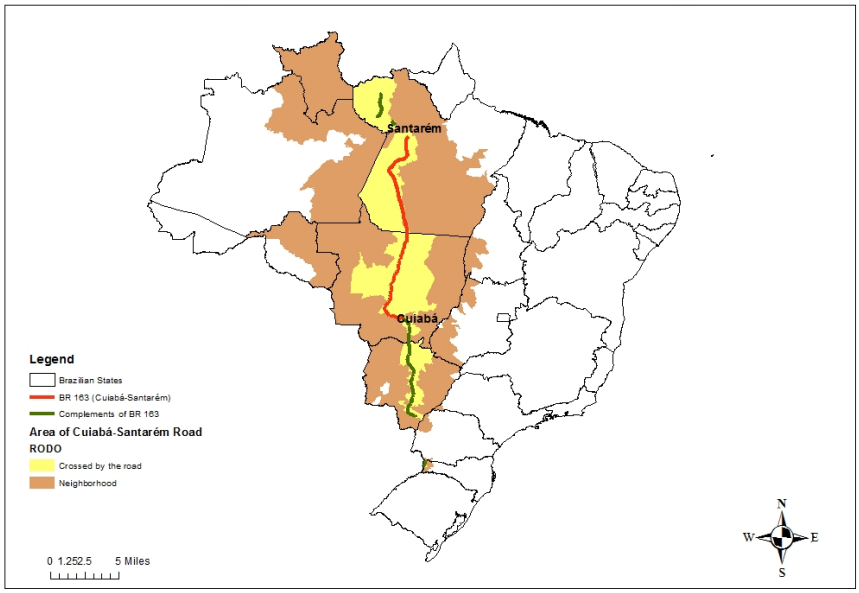
Source: Authors' Elaboration

Figure 3: Area of Cuiabá-Porto Velho Highway (BR 364)



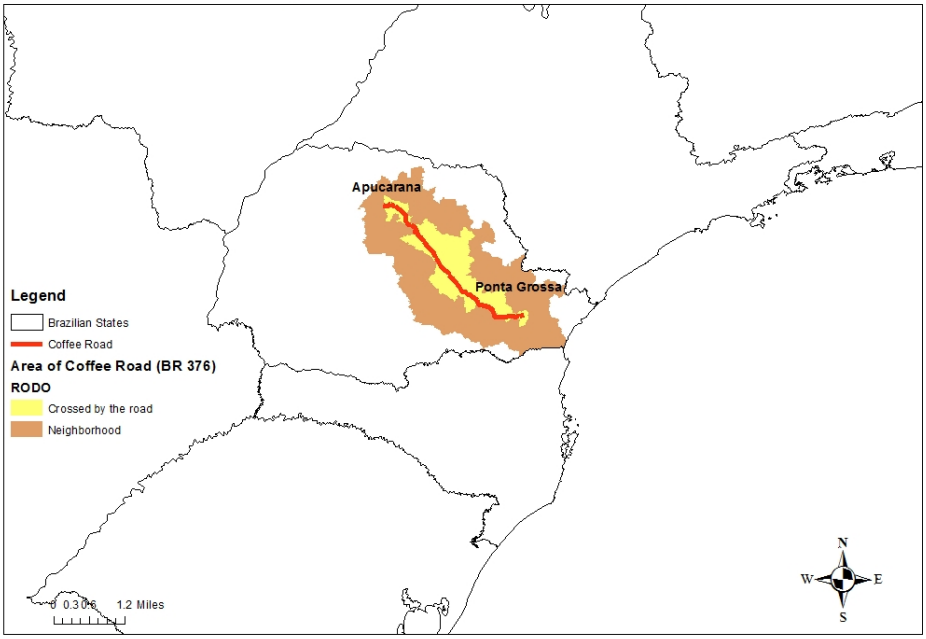
Source: Authors' Elaboration

Figure 4: Area of Cuiabá-Santarém Highway (BR 163)



Source: Authors' Elaboration

Figure 5: Area of Highway of Coffee (BR 376)



Source: Authors' Elaboration

Table 1: Descriptive Statistics

		Cuiabá-Porto Velho (BR 364)				*Cuiabá-Santarém (BR 163)*				Belém-Teresina (BR 010/316)				*Highway of Coffee (BR 376)*			
		0	1	Diff		0	1	Diff		0	1	Diff		0	1	Diff	
Employment Rate																	
	1970	0.44	0.45	0.01	***	0.44	0.46	0.02	***	0.44	0.46	0.02	***	0.44	0.46	0.02	**
	1980	0.98	0.98	0.00		0.98	0.98	0.00		0.98	0.98	0.00		0.98	0.99	0.01	**
	1991	0.96	0.96	0.00		0.96	0.96	0.00	*	0.96	0.95	-0.01	*	0.96	0.97	0.01	**
	2000	0.89	0.87	-0.01	***	0.88	0.88	-0.01	*	0.88	0.90	0.01	***	0.88	0.88	0.00	
Average Familiar Per Capita Income																	
	1970	45.23	54.63	9.40	***	45.37	52.44	7.07	***	47.18	29.07	-18.11	***	45.39	58.58	13.19	**
	1980	114.03	149.04	35.01	***	114.93	131.32	16.39	***	120.99	57.36	-63.63	***	115.28	130.40	15.12	**
	1991	108.25	142.11	33.86	***	109.03	127.48	18.45	***	114.85	54.87	-59.99	***	109.30	132.31	23.01	**
	2000	175.47	213.50	38.03	***	176.41	195.52	19.11	***	185.89	83.22	-102.67	***	176.46	212.80	36.35	**
Years of Education																	
	1970	1.39	1.37	-0.02		1.40	1.22	-0.17	***	1.46	0.67	-0.78	***	1.38	1.71	0.32	**
	1980	1.88	1.93	0.05		1.89	1.79	-0.10	**	1.97	0.96	-1.01	***	1.88	2.22	0.35	**
	1991	3.44	3.66	0.22	***	3.44	3.61	0.17	***	3.56	2.24	-1.32	***	3.43	4.05	0.62	**
	2000	4.60	4.82	0.22	***	4.60	4.79	0.19	***	4.73	3.33	-1.39	***	4.60	5.29	0.70	**
Earnings per Worker																	
	1970	145.51	177.43	31.91	***	145.91	172.18	26.27	***	151.87	93.76	-58.10	***	146.26	181.06	34.80	**
	1980	334.16	443.35	109.19	***	336.20	407.96	71.76	***	352.62	192.27	-160.34	***	338.43	365.61	27.18	*
	1991	286.60	379.23	92.62	***	287.99	357.88	69.89	***	301.20	177.59	-123.61	***	289.84	333.36	43.51	**
	2000	441.64	542.72	101.08	***	443.58	508.50	64.92	***	464.44	249.01	-215.42	***	444.70	517.47	72.77	**
Agricultural Employment Rate																	
	1970	0.70	0.63	-0.07	***	0.70	0.69	-0.01		0.69	0.79	0.10	***	0.70	0.67	-0.03	
	1980	0.56	0.51	-0.05	***	0.56	0.56	0.01		0.55	0.67	0.12	***	0.56	0.54	-0.01	
	1991	0.48	0.41	-0.07	***	0.48	0.44	-0.04	***	0.47	0.62	0.15	***	0.48	0.44	-0.04	
	2000	0.38	0.34	-0.04	***	0.38	0.36	-0.02	**	0.37	0.51	0.14	***	0.38	0.33	-0.05	**
Industry Employment Rate																	
	1970	0.09	0.06	-0.03	***	0.09	0.06	-0.03	***	0.09	0.05	-0.07	***	0.08	0.10	0.02	
	1980	0.14	0.10	-0.04	***	0.14	0.10	-0.03	***	0.14	0.07	-0.07	***	0.13	0.15	0.02	

	1991	0.14	0.11	-0.04	***	0.14	0.10	-0.04	***	0.15	0.07	-0.07	***	0.14	0.17	0.03	**
	2000	0.14	0.12	-0.02	***	0.14	0.11	-0.03	***	0.15	0.09	-0.06	***	0.14	0.18	0.04	**
Total Income																	
	1970	44.53	55.68	11.15	***	44.68	53.55	8.87	***	46.57	28.39	-18.17	***	44.78	57.51	12.73	**
	1980	115.00	152.10	37.10	***	115.89	135.12	19.22	***	122.09	58.05	-64.04	***	116.36	130.61	14.25	**
	1991	108.40	142.73	34.32	***	109.17	128.40	19.23	***	115.03	54.98	-60.05	***	109.48	132.14	22.66	**
	2000	175.40	213.53	38.13	***	176.32	195.84	19.52	***	185.81	83.30	-102.51	***	176.38	212.79	36.41	**

* significant at 10%; ** significant at 5%; *** significant at 1%.

Source: Authors' Elaboration based on Demographic Census (IBGE)

Table 2a - Effect of Highways' Improvements on Income and Labor Market

	BR 364 *Cuiabá-Porto Velho*			BR 163 *Cuiabá-Santarém*				
	C	FN	SN	C	FN	SN	Observations	R-squared
Per Capita Income (in log)	0.036	-0.114	-0.083	1.026***	0.870***	0.940***	11853	0.06
	(0.117)	(0.080)	(0.073)	(0.131)	(0.087)	(0.076)		
Total Population (in log)	0.339***	0.190***	0.185***	0.482***	0.326***	0.201***	11853	0.06
	(0.044)	(0.030)	(0.027)	(0.049)	(0.032)	(0.028)		
Years of Education	1.840***	1.718***	1.700***	0.527**	0.571***	0.576***	11853	0.05
	(0.215)	(0.146)	(0.133)	(0.240)	(0.159)	(0.139)		
Years of Education - Population aged 25 or more	1.160***	1.089***	1.052***	1.155***	1.150***	1.136***	11853	0.05
	(0.196)	(0.133)	(0.121)	(0.219)	(0.145)	(0.126)		
Agricultural Employment Rate	-0.104***	-0.096***	-0.099***	-0.179***	-0.122***	-0.109***	11853	0.03
	(0.028)	(0.019)	(0.017)	(0.031)	(0.021)	(0.018)		
Service Employment Rate	0.088***	0.086***	0.077***	0.094***	0.076***	0.075***	11853	0.04
	(0.014)	(0.009)	(0.009)	(0.015)	(0.010)	(0.009)		
Trade Employment Rate	0.048***	0.027***	0.029***	0.038***	0.025***	0.020***	11853	0.03
	(0.006)	(0.004)	(0.004)	(0.007)	(0.005)	(0.004)		
Industry Employment Rate	0	0.003	0.009	0.056***	0.044***	0.051***	11853	0.01
	(0.012)	(0.008)	(0.008)	(0.014)	(0.009)	(0.008)		
Mining, Quarrying and Forestry Employment Rate	-0.019***	-0.013***	-0.013***	-0.016**	-0.027***	-0.037***	11853	0.01
	(0.007)	(0.005)	(0.005)	(0.008)	(0.005)	(0.005)		
Familiar per capita Income	8.46	-11.759	-8.825	98.472***	73.408***	76.195***	11853	0.02
	(12.852)	(8.731)	(7.970)	(14.369)	(9.492)	(8.296)		
Superior Education Rate	0.013***	0.009***	0.009***	0.007***	0.004***	0.003***	11853	0.02
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)		
High-School Education Rate	0.270***	0.282***	0.271***	0.127**	0.108***	0.116***	11853	0.02
	(0.055)	(0.038)	(0.034)	(0.062)	(0.041)	(0.036)		
Employment Rate	-0.022	-0.026	-0.023	0.527***	0.510***	0.517***	11853	0.11
	(0.055)	(0.037)	(0.034)	(0.061)	(0.040)	(0.035)		
Economic Activity Rate	0.033**	0.019**	0.023***	0.027*	0.019**	0.019**	11853	0
	(0.013)	(0.009)	(0.008)	(0.015)	(0.010)	(0.008)		
High-qualified occupations Rate	0.017***	0.017***	0.013***	0.012***	0.011***	0.010***	11853	0.02
	(0.004)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)		

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%. Note: C=Crossed by the road, FN=First Neighborhood, SN=Second Neighborhood.

Table 2b - Effect of Highways' Improvements on Income and Labor Market

	BR 010/316 *Belém-Teresina*			BR 376 Highway of Coffee				
	C	FN	SN	C	FN	SN	Observations	R-squared
Per Capita Income (in log)	0.767***	0.672***	0.668***	-0.019	0.046	-0.007	11853	0.06
	(0.084)	(0.054)	(0.054)	(0.194)	(0.121)	(0.109)		
Total Population (in log)	0.279***	0.210***	0.230***	0.046	0.136***	0.076*	11853	0.06
	(0.031)	(0.020)	(0.020)	(0.072)	(0.045)	(0.041)		
Years of Education	0.290*	0.280***	0.273***	1.839***	1.864***	1.805***	11853	0.05
	(0.153)	(0.100)	(0.100)	(0.355)	(0.222)	(0.199)		
Years of Education - Population aged 25 or more	0.709***	0.655***	0.626***	1.109***	1.168***	1.124***	11853	0.05
	(0.140)	(0.091)	(0.091)	(0.323)	(0.203)	(0.181)		
Agricultural Employment Rate	-0.131***	-0.111***	-0.118***	-0.085*	-0.111***	-0.104***	11853	0.03
	(0.020)	(0.013)	(0.013)	(0.046)	(0.029)	(0.026)		
Service Employment Rate	0.040***	0.029***	0.023***	0.049**	0.068***	0.059***	11853	0.04
	(0.010)	(0.006)	(0.006)	(0.023)	(0.014)	(0.013)		
Trade Employment Rate	0.016***	0.007**	0.007**	0.025**	0.030***	0.028***	11853	0.03
	(0.005)	(0.003)	(0.003)	(0.011)	(0.007)	(0.006)		
Industry Employment Rate	0.032***	0.017***	0.019***	0.01	0.015	0.017	11853	0.01
	(0.009)	(0.006)	(0.006)	(0.020)	(0.013)	(0.011)		
Mining, Quarrying and Forestry Employment Rate	0.003	0.007**	0.007*	0.005	0	-0.001	11853	0.01
	(0.005)	(0.003)	(0.003)	(0.012)	(0.008)	(0.007)		
Familiar per capita Income	34.492***	28.274***	25.126***	-3.009	4.948	1.038	11853	0.02
	(9.164)	(5.971)	(5.971)	(21.224)	(13.303)	(11.898)		
Superior Education Rate	0.002	0.001	0.001	0.018***	0.013***	0.012***	11853	0.02
	(0.001)	(0.001)	(0.001)	(0.003)	(0.002)	(0.002)		
High-School Education Rate	0.089**	0.062**	0.052**	0.357***	0.298***	0.292***	11853	0.02
	(0.039)	(0.026)	(0.026)	(0.091)	(0.057)	(0.051)		
Employment Rate	0.530***	0.510***	0.518***	-0.017	-0.018	-0.019	11853	0.11
	(0.039)	(0.025)	(0.025)	(0.090)	(0.057)	(0.051)		
Economic Activity Rate	0.004	0.001	0.013**	0.031	0.042***	0.028**	11853	0
	(0.009)	(0.006)	(0.006)	(0.021)	(0.013)	(0.012)		
High-qualified occupations Rate	0.012***	0.012***	0.011***	0.011	0.009**	0.008**	11853	0.02
	(0.003)	(0.002)	(0.002)	(0.007)	(0.004)	(0.004)		

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%. Note: C=Crossed by the road, FN=First Neighborhood, SN=Second Neighborhood.

Table 3a - Effect of Highways' Improvements on Income and Labor Market (without extremities)

	BR 364 *Cuiabá-Porto Velho*			BR 163 *Cuiabá-Santarém*				
	C	FN	SN	C	FN	SN	Observations	R-squared
Per Capita Income (in log)	0.04	-0.114	-0.083	1.029***	0.870***	0.947***	11829	0.06
	(0.121)	(0.080)	(0.073)	(0.137)	(0.087)	(0.076)		
Total Population (in log)	0.309***	0.190***	0.185***	0.476***	0.326***	0.180***	11829	0.05
	(0.045)	(0.030)	(0.027)	(0.051)	(0.032)	(0.028)		
Years of Education	1.804***	1.718***	1.700***	0.532**	0.571***	0.582***	11829	0.05
	(0.222)	(0.146)	(0.133)	(0.251)	(0.159)	(0.140)		
Years of Education - Population aged 25 or more	1.148***	1.089***	1.052***	1.137***	1.150***	1.142***	11829	0.04
	(0.203)	(0.133)	(0.121)	(0.229)	(0.145)	(0.127)		
Agricultural Employment Rate	-0.105***	-0.096***	-0.099***	-0.182***	-0.122***	-0.114***	11829	0.03
	(0.029)	(0.019)	(0.017)	(0.033)	(0.021)	(0.018)		
Service Employment Rate	0.090***	0.086***	0.077***	0.095***	0.076***	0.076***	11829	0.04
	(0.014)	(0.009)	(0.009)	(0.016)	(0.010)	(0.009)		
Trade Employment Rate	0.047***	0.027***	0.029***	0.037***	0.025***	0.020***	11829	0.02
	(0.007)	(0.004)	(0.004)	(0.007)	(0.005)	(0.004)		
Industry Employment Rate	0	0.003	0.009	0.059***	0.044***	0.052***	11829	0.01
	(0.013)	(0.008)	(0.008)	(0.014)	(0.009)	(0.008)		
Mining, Quarrying and Forestry Employment Rate	-0.020**	-0.013***	-0.013***	-0.018**	-0.027***	-0.036***	11829	0.01
	(0.008)	(0.005)	(0.005)	(0.009)	(0.005)	(0.005)		
Familiar per capita Income	8.865	-11.759	-8.825	97.347***	73.408***	76.485***	11829	0.02
	(13.301)	(8.730)	(7.969)	(15.006)	(9.490)	(8.353)		
Superior Education Rate	0.013***	0.009***	0.009***	0.006**	0.004***	0.003***	11829	0.02
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)		
High-School Education Rate	0.261***	0.282***	0.271***	0.120*	0.108***	0.117***	11829	0.02
	(0.057)	(0.038)	(0.034)	(0.065)	(0.041)	(0.036)		
Employment Rate	-0.021	-0.026	-0.023	0.524***	0.510***	0.517***	11829	0.11
	(0.057)	(0.037)	(0.034)	(0.064)	(0.040)	(0.036)		
Economic Activity Rate	0.033**	0.019**	0.023***	0.026*	0.019**	0.019**	11829	0
	(0.013)	(0.009)	(0.008)	(0.015)	(0.010)	(0.008)		
High-qualified occupations Rate	0.017***	0.017***	0.013***	0.012**	0.011***	0.010***	11829	0.02
	(0.004)	(0.003)	(0.003)	(0.005)	(0.003)	(0.003)		

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%. Note: C=Crossed by the road, FN=First Neighborhood, SN=Second Neighborhood.

Table 3b - Effect of Highways' Improvements on Income and Labor Market (without extremities)

	BR 010/316 *Belém-Teresina*			BR 376 *Coffee Road*				
	C	FN	SN	C	FN	SN	Observations	R-squared
Per Capita Income (in log)	0.767***	0.670***	0.667***	-0.005	0.046	-0.007	11829	0.06
	(0.084)	(0.055)	(0.055)	(0.214)	(0.121)	(0.109)		
Total Population (in log)	0.279***	0.206***	0.230***	0.012	0.136***	0.076*	11829	0.05
	(0.031)	(0.020)	(0.020)	(0.080)	(0.045)	(0.041)		
Years of Education	0.290*	0.273***	0.273***	1.805***	1.864***	1.805***	11829	0.05
	(0.153)	(0.100)	(0.100)	(0.392)	(0.222)	(0.199)		
Years of Education - Population aged 25 or more	0.709***	0.642***	0.626***	1.127***	1.168***	1.124***	11829	0.04
	(0.140)	(0.092)	(0.091)	(0.358)	(0.203)	(0.181)		
Agricultural Employment Rate	-0.131***	-0.112***	-0.118***	-0.094*	-0.111***	-0.104***	11829	0.03
	(0.020)	(0.013)	(0.013)	(0.051)	(0.029)	(0.026)		
Service Employment Rate	0.040***	0.029***	0.023***	0.057**	0.068***	0.059***	11829	0.04
	(0.010)	(0.006)	(0.006)	(0.025)	(0.014)	(0.013)		
Trade Employment Rate	0.016***	0.007**	0.007**	0.027**	0.030***	0.028***	11829	0.02
	(0.005)	(0.003)	(0.003)	(0.012)	(0.007)	(0.006)		
Industry Employment Rate	0.032***	0.017***	0.019***	0.009	0.015	0.017	11829	0.01
	(0.009)	(0.006)	(0.006)	(0.022)	(0.013)	(0.011)		
Mining, Quarrying and Forestry Employment Rate	0.003	0.007**	0.007*	0.006	0	-0.001	11829	0.01
	(0.005)	(0.003)	(0.003)	(0.014)	(0.008)	(0.007)		
Familiar per capita Income	34.492***	27.379***	25.124***	0.424	4.948	1.038	11829	0.02
	(9.163)	(6.013)	(5.970)	(23.461)	(13.301)	(11.897)		
Superior Education Rate	0.002	0.001	0.001	0.015***	0.013***	0.012***	11829	0.02
	(0.001)	(0.001)	(0.001)	(0.004)	(0.002)	(0.002)		
High-School Education Rate	0.089**	0.058**	0.052**	0.348***	0.298***	0.292***	11829	0.02
	(0.039)	(0.026)	(0.026)	(0.101)	(0.057)	(0.051)		
Employment Rate	0.530***	0.509***	0.518***	-0.018	-0.018	-0.019	11829	0.11
	(0.039)	(0.026)	(0.025)	(0.100)	(0.057)	(0.051)		
Economic Activity Rate	0.004	0	0.013**	0.031	0.042***	0.028**	11829	0
	(0.009)	(0.006)	(0.006)	(0.024)	(0.013)	(0.012)		
High-qualified occupations Rate	0.012***	0.012***	0.011***	0.012	0.009**	0.008**	11829	0.02
	(0.003)	(0.002)	(0.002)	(0.008)	(0.004)	(0.004)		

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%. Note: C=Crossed by the road, FN=First Neighborhood, SN=Second Neighborhood.