Transport infrastructure and regional development in Brazil

Araújo, Maria da Piedade and Guilhoto, Joaquim José Martins

Universidade de São Paulo

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Maria da Piedade Araújo[2]
Joaquim José Martins Guilhoto[3]

Abstract
This paper analyses the impacts of the implementation of a transportation infrastructure project over the regional and national economic growth and its contribution to the decrease of the regional disparities in Brazil, as far as accessibility is concerned. This paper takes, as an illustrative case, the impact of the partial duplication of the highway BR–116, which is the main route between the Northeast region and the Center-South of the country. The methodological framework consists in the integration of a transportation model with the MIBRA model, an interregional applied equilibrium model of the Brazilian economy. The transportation model measures the change in the interregional distance and the accessibility to transport investment, while the MIBRA model estimates the spatial economic effects of the projects on the variables described above. The benchmark year is 1999. The model was constructed for six Brazilian regions, North, Northeast, Southeast, Center-West, South and São Paulo, and has details for twenty nine industries. In the simulation, the BR-116 highway has being duplicated by a total of 1,724 km. Overall the results show an increase in Brazilian GDP. In the short run, the change of the main economics indicators (GDP, demand of families and employment) is positive to almost all of the regions, with the Northeast region, the poorest one, being the more beneficiated, considering the GDP change. However, in the long run, in spite of positive changes in the GDP, the negative change in the employment level in the Northeast region persists. Despite the employment result, it is possible to verify that the duplication of BR-116 is capable of generate a propitious trade flow to the poorest regions of the country and to contribute to an increase in the production level, mainly in the Northeast region. As far as accessibility is concerned, it is possible not only to have access to cheaper inputs, but also to expand the production of more competitive products either to the domestic or to the external market.
KEY WORDS: applied general equilibrium model, transport infrastructure, regional development, BR-116 highway.

Introduction

In a historical perspective, the economic infrastructure, in general way, and of transport in particular, always it was seen as necessary condition for the economic growth. When the matter is the economic infrastructure, the sector transport occupies paper of prominence due to its clear importance in reinforce sources of economic efficiency of a Country. In the case of Brazil, for being a Country of continental dimensions, the transport

[1] This paper is part of the dissertation of the first author.
[2] Department of Economics, UNIOESTE; and Ph.D. Candidate, University of São Paulo, Brazil.
[3] Department of Economics, University of São Paulo, Brazil; REAL, University of Illinois; CNPq Scholar.

sector more has accented its importance due to function to transfer inputs and final goods to regions with not worthless distances. In this sense, the multiplier effect of the performance of the transport sector influences directly the competitiveness of all other sectors of the economy. The interest in to access the impacts of the availability of infrastructure of transport in the regional economic development falls into the influence that it has on the decisions of localization of investments by firms, as also in the decision of production and consumption. Thus, the availability of infrastructure of transport tends to influence the commerce flows, determining the costs of the commercial relations between firms and consumers in the diverse Brazilian regions. Lavinas et al. (1997) said that the existence of a different distribution in the spatial infrastructure can continue being an impeditive for the necessary growth of long run. This infrastructure is necessary in facing economic opening in order to reduce costs inefficiency in the use of the time. In Brazil, the solution of the infrastructure conditions and welfare remains, therefore, in the roll of the demands of first necessity. They are they that can lead to a new model of regional development not only balanced, but also substantiate in endogenous solid bases of long term.

Thus, the existence of appropriate infrastructure is a determinative factor in the incentive to the production and the job, and conditions the investment decisions when becoming related it the waited return of the capital inversions (CNI, 2002, p.23). It does not have doubt that a consensus around this affirmation. However, it is difficult to evaluate the empirical evidence due to the difficulties to analyze cause and effect of the investments in infrastructure of transport when product and job are determined by many other factors. With the objective of summarize the possible relations between infrastructure of transport and regional inequality in Brazil, Figure 1 presents the regional data of the per capita GDP, density of transport and territorial participation of each region. The infrastructure density is an index that measures the infrastructure availability as being the number of kilometers of available infrastructure for each km^2 of area of the Country. In the figure the density of transport is presented only for the modal road. The per capita GDP is measured in R$ of 2000. The availability of road infrastructure was measured from the total of kilometers of highway paved of each region. In terms of Brazil, the density of road transport is considered low (19,3 km/1000 km^2) when compared the countries of similar territorial extension, as Canada (39,6 km/1000 km^2) and Mexico (45,3 km/1000 km2), for example. There is a relative concentration of the wealth of the Country in the Southeast region. This reality is strengthened by the data of the per capita GDP. Comparing the regions Southeast and Northeast, the per capita GPD of the first one was, in 2000, almost three times of second. Despite the region Northeast almost having the double of the area of the region Southeast, the second has a transport density almost twice bigger. This situation demonstrates that in spite of the conditions of the road infrastructure, the region Southeast has an availability of highways better than Northeast region. It must also be highlight the considerable difference between the data of the South and Northeast region. The per capita northeast GDP was only 39% of the value of the South region, having this a density of transport bigger, with an area almost three times lesser. On the order hand, the Center-West region in territorial terms is similar to the Northeast region, but with lesser density of transport, and with the per capita GPD twice bigger. The North region can be considered an exception; therefore great part of its territorial area is covered by the Amazonian forest. In this direction, it was waited low transport density, but it calls the attention for the GPD bigger than the Northeast region.

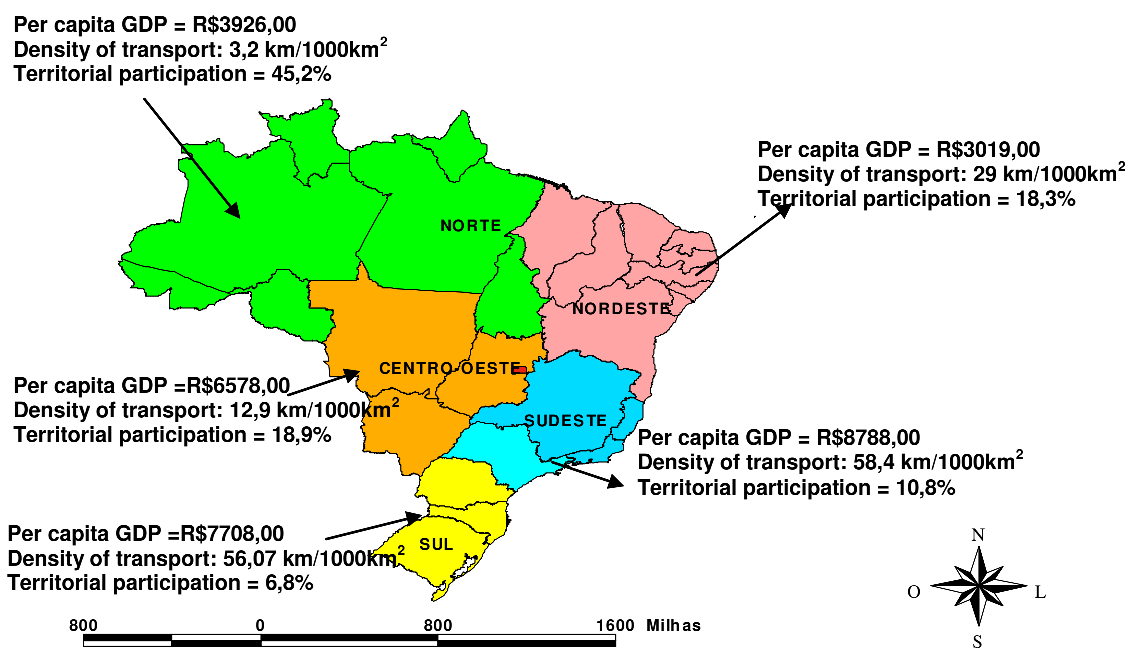

Figure 1 - Regional distribution of the per capita GDP, density of road transport and territorial participation, 2000
Source: elaborated by author from data of IPEADATA and GEIPOT.

In this interim, the transport, as furthermore segments of the economic infrastructure should be part of a strategy of public planning of long term. The long of the time, Brazil attended, in the some Plans of Government, proposals to improve the economic infrastructure. In this sense, the infrastructure of transport always had the function to short the distances between the regions and to increase the access the goods and services by population. Considering the necessity of reduction of the regional inequalities, it can be inferred that the competitive integration of the domestic territory passes for the coordination and investment in transport infrastructure, searching to minimize the bottlenecks in the infrastructure that can be considered obstacles to the valuation of the interregional complementary. Considering the necessity of investments and the scarcity of resources for this purpose, becomes important to develop studies that allow assisting in the identification of priorities of the different projects of improvements in transport infrastructure, taking in consideration the impact on the economic growth and the regional equity. In this direction, the interregional applied equilibrium model present as an important tool to evaluate the spatial economic effect these investments. These models can be used to assist in the identification of priorities projects considering its impact on the economic growth, regional distribution of the wages and population, among others. With this modeling is possible to evaluate the effect of overflow of the investment in infrastructure of transport for beyond the borders of the region where such investment was implemented, as also to hierarchical the projects of investment ahead of its impacts in the economy. One expects, with this work, to give a contribution to methodological framework as to the analysis of the infrastructure of transport and its relation with the regional development in Brazil. In this paper the objective it is to evaluate the impacts of the implementation of projects of investment in transport infrastructure on the growth of the Brazilian economy and its contribution in the reduction of the regional inequalities when improvements in the accessibility are implemented.

This paper takes as an illustrative case, the impact of the partial duplication of BR-116 highway, the one of the most important routes between the Northeast region and Center-South of the country. The BR-116 is a federal highway, being considered strategic of the point of view of the MERCOSUL. This highway connects the State of the Rio Grande do Norte to Rio Grande do Sul, as traced presented in Figure 2.

Figure 2 - Tracing of BR-116 Highway

Source: Brazil (2003)

The BR-116 highway has 4586.7 km, of which only 766.1 km was duplicated in the year of 2000. Most of the highway still is of simple track, considered in unsatisfactory conditions for the traffic to a large extent of its stretch, mainly in the Northeast portion of the country. The duplication of part of the highway in the Northeast and South stretch of the country is part of the projects considered with priority in the Plurianual Plan 2004/2007. Of the total duplicate in the year of 2000, only 1.19% was in the Northeast region.

MODEL[4]

The methodological framework consists of the integration of a model of transport to a applied general equilibrium model. The starting point is the “Modelo Inter-regional para a Economia Brasileira” (MIBRA), which is a regional applied general equilibrium model for the Brazilian Economy developed by Guilhoto et al. (2002) basing on the Monash Multi-regional Forecast model (MMRF) formely developed for the Australian Economy by Peter et al. (1996). Since its implementation the model has been used to evaluate the impact of

[4] For a detailed description of the variables and equations of the general equilibrium model consults ARAÚJO (2006). It is highlighted that the dissertation is in final phase of elaboration, with forecast of defense in Fev. 2006.

different politics in an interregional approach. The transport model has for objective to measure the change in the interregional distance and the accessibility for transport project investment, while the applied general equilibrium model evaluates the spatial economic effect of these projects on Gross Domestic Product -GDP, regional distribution of the wage, population, among others. The year of reference is 1999. The model was constructed for six Brazilian regions (North, Northeast, Center-West, São Paulo, Southeast, South), and has details for 29 industries. The MIBRA model presents equations in five modules: core, governmental finance, capital and investment, debt accumulation and, labor market and regional migration. The absorption matrix (Figure 3) suggests the theoretical structure required by the central module of the general equilibrium model.

		1	2	3	4	5	6
		Production	Investment	Consumption	Exports	Regional Gov.	Federal Gov.
	Dimension	←JxQ→	←JxQ→	←Q→	←I→	←Q→	←Q→
Inputs	↑ IxS ↓	BAS1	BAS2	BAS3	BAS4	BAS5	BAS6
Margins	↑ IxSxR ↓	MAR1	MAR2	MAR3	MAR4	MAR5	MAR6
Taxes	↑ IxS ↓	TAX1	TAX2	TAX3	TAX4	TAX5	TAX6
Labor	↑ M ↓	LAB					
Capital	↑ I ↓	CAP					
Land	↑ I ↓	LAND					
Other Costs	↑ I ↓	OCTS					

I = Number of *Commodities* (i=29)

J= Number of Industries (j=29)

M= Labor Occupations (m=1)

Q= Number of Regions (q=6)

R = Number of Margins (r=6)

S= Regions + Imports (s=7)

Figure 3 - MIBRA's absorption matrix

Source: adapted of Peter et al. 1996.

The columns identify the following economic agents: 1) domestic producers divided into J industries and Q regions; 2) investors divided into J industries in Q regions; 3) a single representative household for each of the Q regions; 4) an aggregate foreign purchaser of exports; 5) an other demand category corresponding to Q regional governments; and 6) another demand category corresponding to federal government demands in the Q regions.

The rows show the structure of the purchases made by each of the agents indentified in the columns. Each of the I commodity types identified in the model can be obtained within the region, from other regions or imported from overseas. The source-specific commodities are used by industries as inputs to current production and capital formation, are consumed by households and governments and are exported. Only domestically produced goods appear in the export column. R of the domestically produced goods are used as margin services which are required to transfer commodities from their sources to their users. Commodity taxes are payable on the purchases. As well as intermediate inputs, current production requires inputs of three categories of primary factors: labor divided into M occupations, fixed capital and agricultural land. The other costs category covers various miscellaneous industry expenses. Each cell in the input-output table countains the name of the corresponding matrix of the values of flows of commodities, indirect taxes or primary factors to a group of users.

The absorption matrix suggest the theoretical structure required by AGE core. The theoretical structure includes: demand equations required for the six users; equations determining commodity and factor prices; market clearing equations; definitions of commodity tax rates. As the MMRF model, the equations of MIBRA's AGE core can be grouped according to the following classification: a) producer's demands for produced inputs and primary factors; b) demands for inputs to capital creation; c) households for inputs to capital creation; d) household demands; e) export demands; f) government demands; g) demands for margins; h) zero pure profits in production and distribution; i) market-clearing conditions for commodities and primary factors and; j) indirect taxes; k) regional and national macroeconomic variables and price indices.

On the other hand, the transport model measures the change in the interregional distance and the accessibility when improvements had been implemented in the highways. Considering that one region is attractive due to facilities of spatial linking with other regions, the transport model not only becomes an important instrument in order to supply of physical distances between the concern regions, but also of the economic distance between them. When it has a matrix of origin-destination with routes of minimum distance (physical distance) and, moreover, the time necessary to cover this distance, can be transformed this physical distance into economic distance, therefore it becomes possible to quantify in the distance in terms of monetary cost between two regions. The freight for road loads is a good indicator of economic distance between pairs of origin-destination (ISARD; BRAMAHALL, 1960). Beyond the physical and economic distance, one given region can be considered more or less distant when is introduced in the transport model others variable capable to influence, of some way, the demanders of goods and services. Of this way, it becomes possible to construct a transport model using the accessibility concept.

In the transport model developed by Kim et al. (2002) and by Kim and Hewings (2003), the accessibility concept is understood as easiness in the spatial interaction or in the potential contact among the regions activities. The authors, based in studies that had considered evaluating the economic benefits of transportation infrastructure projects to Europe, had used the accessibility index according potential economic approach. In the model developed for these authors, the accessibility index is a spatial transport module that is modeled exogenamente, being added to AGE model through the production module. There are others accessibility indicators defined in the literature and, according to Gutiérrez and Urbano (1996), the most part of these indicators attempt to express the greater or lesser ease of accesses to the activities or activity centers. When the interest falls on the regional development, the authors emphasize to the importance to measure the accessibility for the main connections of economic flows. In study lead by these authors to measure the accessibility in the European Union, with the goal to evaluate the impact of the "Trans-European" network, the accessibility indicator used consisted of calculating a weighed average of impedances separating each node with regard to the chief economic activities centers through the road network, using a matrix of minimum route. The accessibility index constructed in this work is based on the work of Gutiérrez and Urbano (1996), for believing that the use of impedances' average weighed by the GDP is a good indicator of the economic distance between Brazilian regions, beyond the biggest operational ease of this index. The accessibility index is defined by eq. 1.

$$IA_i = \frac{\sum_{j=1}^{n}\left(I_{ij}\, GDP_j\right)}{\sum_{j=1}^{n} GDP_j} \qquad (1)$$

where,

$IA_i =$ accessibility of node i - origin;

$I_{ij} =$ the impedance through the network between nodes i and j

$GDP_j =$ gross domestic product of the destination economic activity center.

Index i corresponds to six regions of study North, Northeast, Center-West, São Paulo, Southeast and South. Thus, it will be defined a matrix of accessibility index between the regions, forming pairs of origin-destiny. The centers of economic activities considered here, are the capitals of the Brazilian States. The GDP is used to weigh the importance of minimal route in accordance with the destination activity center. The impedance for highway between the node of origin and the destination center is the sum of the impedance of the arcs (I_a) and the node (I_n) that cross the minimal route, as established by eq. 2.

$$I = \sum I_a + \sum I_n \tag{2}$$

These impedances had been accepted in accordance with the following criterion. A) A) Arc Impedance. The time expended in the trip is taken account in the calculation of this impedance. Initially was set up a matrix of minimal distance between all Brazilian capitals (dimension 26x26). To construct this matrix a road roteirizador was used (Maplink). With this roteirizador was possible to establish a matrix of minimal distance between the capitals with all the highways used in each route, as well as the conditions of use these roads. To transform the distance physical into time was used an estimate of speed by type of highway (traffic condition). Then, the impedance in the arc was calculated by eq. 3.

$$I_a = \frac{dis\tan ce(km)}{speed\,(km/h)} \tag{3}$$

B) Node Impedance. The impedance in the node is a penalty introduced in the matrix of distance to simulate the effect of delay to cross through in great centers. This penalty is proportional to the population of the economic center of destination and is defined in agreement eq. 4. In other words, the impedance in the node is the main diagonal line of the distance matrix, therefore in the node in the distance between the same capitals is null. The use of a logarithmic function is because of the delay associated with the crossing through great agglomerations does not increase linearly with the size of them.

$$I_n = 15 * \log(P * 10) \tag{4}$$

Where,

$I_n =$ impedance associated with crossing through node n, and

$P =$ population living within this node.

While the general equilibrium model specifies the behavior of supply and demand of producers, family, and government in a real economy, determining prices and quantities simultaneously, the transport model gives the interaction between the regions. In this sense, in the MIBRA model the equations that specify prices of sale have as premise zero pure profits. In other words, the price that the different users pay by good i produced in region s and consumed in region q is equal to sum of its basic value plus taxes and the margin services. Thus, using the language TABLO code, the value of purchase for the current production of good i, produced in origin s by sector j and consumed in the destination q ($PVAL1A_{i,s,j,q}$) can be defined by eq. 5.

$$PVAL1A_{i,s,j,q} = BAS1_{i,s,j,q} + TAX1_{i,s,j,q} + \sum_{1}^{6} MAR1_{i,s,j,q,r} \tag{5}$$

Where,

BAS1 = intermediate consumption;

TAX1 = taxes on the intermediate consumption;

MAR1 = margins used in the distribution of the goods;

i = represents commodity;

s = domestic regions plus exterior;

j = industries;

q = domestic regions;

r = commodities used as margins.

It is emphasized that eq. 5 is representative only of one of the users defined in the absorption matrix. Thus, the model specifies an equation of price for each different user.

The services of transport margins in the general equilibrium model can be translated as the acquisition of good named “margin” by firms, necessary to flow of goods and services between the pairs of origin-destination. Thus, a reduction of the necessity of acquisition of the good called "transport margin" can be translated as a reduction of transport cost to the demanders of services margins. As seen in Figure 3 (Absorption Matrix), the demanders of inputs, industrial goods, families and exportation, demand the margins services on flows consumed. In MIBRA model is considered that the margins are produced in the destination region the producers (user 1), investors (user 2) and family (user 3). For the exporters (user 4) the margin is produced in the origin region. By definition, a lesser necessity of use of the "margin" can be translated as a cost reduction to reducing the price paid by users. In MIBRA model is specified a set of equations, which represent the demand to good "margin". Thus, in the margins equations demand is put the technique change component, what in the specific case of the margins, can be used to simulate alterations in the transport cost. Generically, MIBRA model uses eq. 6, to define the percentage change in the margin demands.

$$x1m\arg_{i,s,j,q,r} = x1a_{i,s,j,q} + a1m\arg_{q,r} \qquad (6)$$

For a convention question, the TABLO code uses capital letters to assign variable with value in level and lower-case letters to percentage change. Thus, $x1m\arg_{i,s,j,q,r}$ represents a percentage change in the demand by margin of type r, of input i produced in region s and, used for industry j in the region of destination q. In turn, $x1a_{i,s,j,q}$ is the percentage change in the demand by inputs for the current production (user 1) and $a1m\arg_{q,r}$ is the technical change in the use of the margins in the current production (user 1). In accordance with Horridge (2001), the terms of technical change, in the use of the margins, for example, must be included either in the equations of demand for margin or in the price equations.

Thus, to simulate the effect of the road infrastructure improvements on the national economy and in the different regions, the transport model, defined here as the accessibility index, will be integrated to MIBRA model through the equations of demands for margin and purchaser's prices. Considering that the analysis will only be made on the road modal, alterations in the TABLO code had been made to introduce the accessibility index into desired equations. Of generic form, eq. 6, became the eq. 7.

$$x1m\arg_{i,s,j,q,r} = x1a_{i,s,j,q} + a1m\arg_{q,r} + indacess_{s,q} \qquad (7)$$

Where, the $indacess_{s,q}$ measures a percentage change in the accessibility index. For being necessarily an exogenous variable, who is it will suffer the shock, affecting the use of the transport margin, as eq. 8.

$$MAR1_{i,s,j,q,r} = p0a_{r,q} * x1m\arg_{i,s,j,q,r} \qquad (8)$$

Where, $p0a_{r,q}$ is the basic price of the economy for type of margin (r) and for region (q). For definition, as eq. 9, changes in the margins modify of direct way the paid price by users. Thus, into price equations, which defining purchaser's prices, is included the technical change component. Generically the MIBRA model uses eq. 9, to define equations able to dislocate the purchaser's prices.

$$pa_{i,s,j,q} = \frac{\left[BAS_{i,s,j,q} + TAX_{i,s,j,q}\right] * p0a_{i,s} + BAS_{i,s,j,q} * deltax_{i,s,j,q} + \sum_{r=1}^{n} MAR_{i,s,j,q,r} * \left(p0a_{i,s} + am\arg_{q,r}\right)}{PVAL_{i,s,j,q}} \quad (9)$$

Where, pa represents a percentage change in the purchaser's prices, $p0a$ is a percentage change in the basic price, $deltax$ is a percentage change point in the taxes and $am\arg$ is a technical change in the use of the margins related to specific flow of origin-destination. The level variables had been defined previously. Of generic form, eq. 10, became eq. 11.

$$pa_{i,s,j,q} = \frac{\left(BAS_{i,s,j,q} + TAX_{i,s,j,q}\right) * p0a_{i,s} + BAS_{i,s,j,q} * deltax_{i,s,j,q} + \sum MARNR_{i,s,j,q,r} * \left(p0a_{i,s} + am\arg_{q,r}\right) + \sum MARRO_{i,s,j,q,r} * \left(p0a_{i,s} + am\arg_{q,r} + indacess_{s,q}\right)}{PVAL_{i,s,j,q}} \quad (11)$$

Where $MARNR$ is the not road margin and $MARRO$ is only road margin. The $indacess$ is null in base year. In other words, percentage change in the accessibility index does not exist and the transport margins reflect the highways use condition in the referential period.

Considering that the road condition linking is an important factor in the determination of trade flow between the regions, the evaluation of this flow in the base year can contribute with the results analysis after the simulations that implement improvements in the highways had been made. The trade flow relation between regions in that it says respect to region behavior in the year base, either exporting or import, it can lead the re-orientation of the trade flow in benefit of the exporting regions; or even of the regions more depressed. The Table 1 shows intra-regional and interregional trade flow as percentage of total. In the superior part of the table has the origin of the goods and in the inferior part the destination.

Table 1 - Origin-destination of In-flows and Out-flows as a percentage of total -1999

	North	Northeast	Center-West	São Paulo	Southeast	South	
North	70.77	1.04	1.20	2.14	0.86	0.73	
Northeast	3.06	77.34	1.46	2.84	1.73	1.36	
Center-West	3.45	0.87	67.29	1.96	1.69	2.04	
São Paulo	13.97	11.64	17.90	78.92	16.77	15.11	
Southeast	4.24	5.23	6.09	8.24	74.19	4.44	
South	4.51	3.88	6.06	5.89	4.76	76.32	
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	
	North	Northeast	Center-West	São Paulo	Southeast	South	TOTAL
North	69.83	3.74	2.16	16.76	4.34	3.17	100.00
Northeast	0.94	86.77	0.81	6.93	2.72	1.83	100.00
Center -West	2.12	1.97	75.45	9.61	5.33	5.51	100.00
São Paulo	1.61	4.91	3.75	72.19	9.90	7.64	100.00
Southeast	0.85	3.83	2.22	13.10	76.10	3.90	100.00
Sul	1.03	3.26	2.53	10.74	5.59	76.85	100.00

Source: data base of MIBRA model

The entries on the diagonal of both parts of the table reveal the degree to which the sales and purchases among sectors occurs within the region. It is clear the importance of the State of São Paulo not only as supplying as also demanders of the goods produced for all the other regions, being the biggest source for trade outside each region. In average, the portions southeast and south of the Country (SP, SE and S) had been responsible for 83% of the total sold by regions and for 78% of the total bought for them. These data show the strong concentration of the trade flow into regions Southeast and South of the country. Considering the origin of the goods, the region Center-West is more dependent on trade with the rest of the economy (especially São Paulo). In relation to intra-regional destination, the region North is the one that presents the lesser ratio and the Northeast region the greater. The data show the great dependence of the Northeast region as destination of its self-production.

In general way, the causal relationship generated by integration of the accessibility index into AGE model can be summarized as follows. The partial duplication of a highway to improving the accessibility between the regions, in accordance with the model structure can be translated in the AGE model as a reduction in the demand by good named "road transport margin".

The lesser use of the services of transport for unit of product makes to reduce directly the level of activity of this sector, what in turn, liberates primary factors of production (capital and labor), increasing their availability in the economy. The direct effect in the economy is the decrease of the pool goods price with a positive effect on the regional income. However, the effects are different between the regions. Regions not affected directly by duplication of the highway can suffer negative or positive effects, which go to depend on the effect on the trade flow between them. With the decrease of goods composites prices, the firms become more competitive with consequent rise of the real income. The income highest stimulates the domestic demand, as also the external demand due to the increase of the competitiveness of the national firms. Second, the biggest level of production of the firms increases the demand for primary factors, what cause a pressure on the price of the factors, what can result in a rise in the output level price.

The force of each region in picking up the benefits of the road infrastructure improvement, translated here in an accessibility index improvement, will depend on effect direct and indirect price substitution, as well as of the income-effect. It considers two regions qm and qx that commercialize between itself, being the first importer and the second exporter. If the transport costs between them fall, the region qx will produce more for the region qm, therefore it will become more advantageous to import from qx; this is the direct substitution-effect. There is an indirect effect due to the reason that to produce more for qm, qx will have to demand more inputs. Considering the accessibility improvement, the export regions of these inputs will become more competitive. However, the import regions can become competitive and also begin to export. The analysis of this trade flow also contributes for understanding of a contrary force to substitution effect, which is the income-effect. The accessibility improvement, as seen previously, provides a positive effect in the demand for goods produced in the exporting region qx, due to direct and indirect substitution-effect, because the goods produced in this region are cheaper. The demand the goods of this region also is raised due to the income-effect, because the real income increases. As consequence of a warm demand is rise of the prices.

The balance on the regional economy will depend on the total effect that is the sum of the substitution-effect (that benefits qx) and the income-effect (that harms qx). These alterations it can occur either the simulation of short run or the long run. But, in the long run, the economy can also adjust due to the movement of the production factors. Better accessibility among the regions it can not only conduce a spatial redistribution of the supply of capital as also of the population. With lower transport costs, it can have stimulation to the demand for goods produced in other regions. In this in case, it can have benefits for the import regions of these goods, as for the exporters, who will have incentives to raise the production. Regions with highest remunerations will become more attractive.

RESULTS OF THE SIMULATION

Initially is presented the percentage change in the accessibility index after the partial duplication of BR-116 highway. As it can be observed in the Table 2, nor all the pairs of origin-destination had been affected directly by the duplication. Despite BR-116 being an important route among the States of the Southeast region, mainly Rio de Janeiro and São Paulo, the justification for the variation in the accessibility index to be null in this linking is that the stretch of BR-116 highway that cuts this portion of the country already was duplicate in the year of 2000.

Table 2 - Percentage change in the accessibility index/ BR-116 highway

	North	Northeast	Center-West	São Paulo	Southeast	South
North	0	-0.17	0	0	0	-0.01
Northeast	-0.15	-0.67	-1.05	-5.97	-10.4	-5.08
Center-West	0	-1.01	0	0	0	-0.04
São Paulo	0	-7.73	0	0	0	-0.68
Southeast	-0.02	-8.99	0	0	0	-0.54
South	0	-6.40	-0.03	-0.89	-0.69	0

Source: results of the research.

It can be observed that the partial duplication of 116-BR cause relatively bigger impact when the origin and the destination is the Northeast region, with expressive values for the linking with the Center-South of the Country. In a lesser ratio, the South region also is benefited in almost all the pairs of origin-destination. This occurs because the changes in the accessibility depend on not only the location but also the connectivity of highway with others through the relocation of economics activities. The impacts of accessibility improvement on the national economy are summarized in Table 3.

Table 3- Aggregated results in percentage change/ BR-116 highway

	Short run	Long run
Prices		
Consumer price index	-0.014	-0.007
Export price index	-0.008	-0.0052
Regional demand price index	-0.012	-0.0025
Federal demand price index	-0.012	-0.002
Investment price index	-0.016	-0.015
Aggregated Demand		
Real household consume	0.007	0.008
Aggregated real investment	-	0.0006
Aggregated real demand regional	0.006	0.007
Aggregated real demand federal	0.007	0.008
Export volume	0.04	0.027
Primary Factors		
Aggregated employment, wage bill weights	0.005	-0.00009
Aggregated capital stock, rental weights	-	0.004
Aggregated payments to labor	-0.005	0.0026
Aggregated capital nominal rents	-0.003	0.003
Aggregated Indicator		
Real GDP	0.018	0.017

Source: results of the research.

As waited, in short run, it has a fall in all the levels of prices as reflect of the decrease of the transport costs. The level of activity of the road transport sector falls either in the short run or in the long run, due to fall of the demand for road transport services for unit of product; the fall in the level of activity of this sector is more expressive in the regions Northeast and Southeastern than others. In the long run, however, the reduction in the activity level is lesser because of the indirect demand increase due to the heating of the economy. In spite of warm demand, the levels of prices continue to have negative change in the long run. The level of national employment has positive change in short run, but in the long run it suffers a small reduction.

In relation to the components of the final demand, with exception of the investments that are exogenous in short term, all the component have positive change, with prominence for the exportations, which are benefited with the increase of the competitiveness due to reduction of the production costs. In monetary terms and with the value of GDP to 2004, the partial duplication of BR-116 highway fields the GDP (short term) in the order of R$ 273 million. In the long run, it has a small reduction in the activity level, but the percentage change in the GDP continues positive.

The Table 4 sows the results for the percentage change of the interregional trade flow. In contrast (bold) it has the interregional linking not directed affected by accessibility improvement.

Table 4- percentage change in the interregional trade flow - improvement in BR-116 highway

Short Run	North	Northeast	Center-West	São Paulo	Southeast	South
North	**0.003**	-0.10	**0.005**	**-0.003**	**0.003**	0.01
Northeast	0.03	-0.008	0.050	0.14	0.21	0.08
Center-West	**0.002**	-0.07	**0.002**	**-0.008**	**-0.004**	0.009
São Paulo	**-0.001**	0.053	**-0.001**	**0.006**	**-0.0008**	0.014
Southeast	-0.005	0.09	**-0.005**	**-0.006**	**0.003**	0.007
South	**-0.008**	0.067	-0.006	0.013	0.008	**0.005**
Long Run						
North	**-0.00001**	-0.125	**0.0028**	**-0.002**	**0.0024**	0.011
Northeast	0.0063	-0.032	0.03	0.13	0.20	0.077
Center-West	**-0.0024**	-0.084	**0.0037**	**-0.0066**	**-0.004**	0.011
São Paulo	**-0.00064**	0.035	**0.0029**	**0.009**	**0.0044**	0.019
Southeast	-0.0046	0.076	**-0.0007**	**-0.00045**	**0.0076**	0.013
South	**-0.006**	0.054	-0.001	0.019	0.014	**0.011**

Source: results of the research.

In short run, with capital and labor fixed among industries and regions, it is possible to verify an expressive intensification in the trade flow between the Northeast region (origin) and the regions São Paulo and Southeast (destination). Considering that the Northeast region already had as bigger trade partners these regions, accessibility improvements intensified the trade flow between them, with prominence for the Southeast region. But, it is interesting to observe that there is a substitution effect acting in the alteration of trade flow. As seen previously, almost 90% of the total produced in the Northeast region in the year of 1999, had as destination itself. However, the partial duplication of BR-116, reduces the intra-regional trade flow of this region, expanding the interregional trade flow, either in the short run or in the long run.

Another interesting effect is on the South region. Despite the intra-regional accessibility not having suffered alteration, the intra-regional trade flow has a positive change, probably reflecting the increase of the production due to rise of the demand for products of this region. The South region starts to buy more from all regions (variation in the column) and, has a small negative change in the sale flows (variation in the row) with the regions North and Center-West.

In terms of the macroeconomic results in regional level, the main economic indicators are presented in Figure 4.

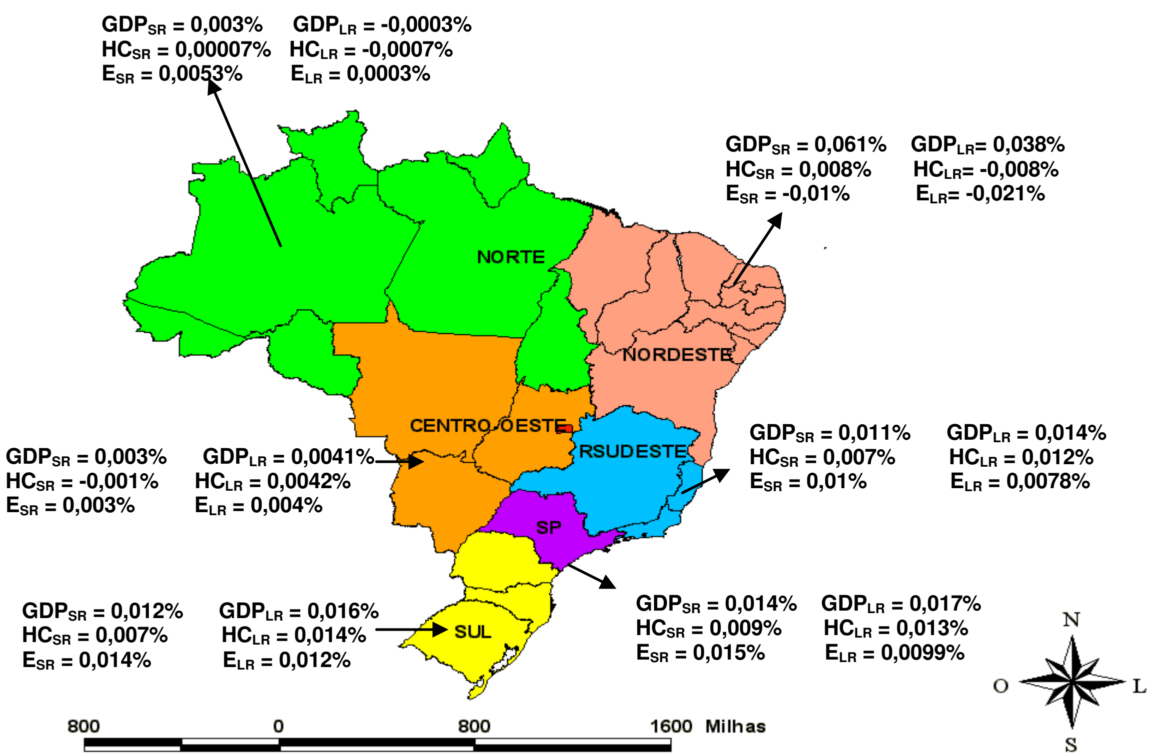

Figure 4- Regional results – partial duplication of BR-116 highway

Source: results of the research.

In the long stated period however, the improvement in the accessibility seems to less exert a perverse effect on the favored regions (mainly Northeast and North), comparatively to the regions Center-South of the country. With the possibility of mobility of the factors of capital production and work, the variation of the GIP of the Northeast region is positive, but it grows less of the one than in short term and, of the region the North it becomes negative. Contrary factor occurs in the regions Southeastern, São Paulo, South and in lesser intensity in the region Center-West. The variation in the flow of commerce between the e regions, the percentage change in the aggregate payments to the factors work and capital (Table 5), corroborate with this result.

Table 5 - Percentage change in the aggregate payments to the factors capital and labor - improvement in BR-116 highway

	Aggregate payments to labor		Aggregate payments to capital	
Regions	Short run	Long run	Short run	Long run
North	-0.009	-0.0015	-0.01	-0.006
Northeast	-0.023	-0.023	-0.04	-0.031
Center-West	-0.011	0.0021	-0.014	-0.0022
São Paulo	0.0013	0.008	0.005	0.0083
Southeast	-0.003	0.006	0.0009	0.0068
South	0.0009	0.011	0.005	0.011

Source: results of the research.

The variation in the aggregate payments to the factors capital and labor is more favorable to the regions of the Center-South of the Country, either in the short run or in the long run. The flexibility for the side of supply in the long run is leading to a movement not only of the population but also of the production in direction to more favored regions. In sectorial terms, it is observed a negative change in the level of labor of the sector of road transport in all the regions (except for the region North), but with bigger expression in the Northeast region. In the aggregate, the variation of the level of labor of the Northeast region reduces. This also occurs due to fall in the level of activity of the transport sectors and the civil construction, what it does not occur in the all regions. There is a fall in the demand for primary factors of the sector of transport due to fall in the level of activity of these sectors, which usually employ a bigger contingent of people.

In spite of the price index continuing having negative variation in the long run, in all regions, the nominal consumption of the families has negative variation in the regions North and Northeast, leading to a negative real consumption in the long term. Despite the improvement in BR-116 to favor in the long run the regions of the Center-South of the Country, in detriment of a reduction in the level of activity, mainly of the regions North and Northeast, is important to point out that this simulation is a indicator of the importance and necessity of improvement in the road infrastructure, considering that most part of the traffic of product and people is made by this modal.

SUMMARY EVALUTATION

The main objective of this paper was to evaluate the effect of the duplication partial of highways on the growth of the Brazilian economy having how methodological framework the integration of a transport model to general equilibrium model. With the construction of the accessibility index able to absorb the road transport improvement in the interregional level and, the integration this index to AGE, allowed to analyze the impacts to the GDP, labor, real consumption of the families, among others. This paper, it took as an illustrative case, the impact of the partial duplication of BR-116 highway, the one of the most important routes between the Northeast region and Center-South of the Country.

The spite of the partial duplication of BR-116 not to affect directly the accessibility of all Brazilian regions, the use of an interregional applied general equilibrium model, became possible to evaluate the impacts of accessibility improvements for beyond the regional borders where the duplication of the highway occurred. In other words, the integration of the index of accessibility to AGE model allowed evaluating the importance of the road infrastructure in the spatial allocation of the resources. The construction of an accessibility index that not only capture the physical distance between the regions, but also takes account furthermore the traffic highways conditions and the economic variable able to influence, of some way, the demanders of goods and services, become an important tool, that to the being integrated to AGE is able to help to hierarchical projects of infrastructure of transport when the interest lie in the evaluation of the regional development.

The simulations had been lead in two economic environments, short and the long run. In terms of macroeconomic results in national level, either in the short or in the long run, the variation of the GDP was positive, as also to components of the final demand and the primary factors of production. The consequence of this was a negative change in the price index.

The improvement of the accessibility provided differentiated results in regional terms, with bigger benefit for the Northeast region of the Country. However, it had an overflow positive effect in terms of variation of the GDP, for all the Brazilian regions. The effect of long run seem to show that the regions most dynamic are capable to attract more strongly the benefits of the transport infrastructure improvement; as it is the case of the Southeast region and São Paulo, for example. The results indicate that to improve the accessibility of depressed regions it can induce to one better distribution of the production, with consequent reduction of the regional inequalities.

The methodological framework used in this paper is similar to developed in the works and Almeida (2003) and Haddad (2004). The two authors had evaluated the impacts of improvements in the infrastructure of transport in the Brazilian economy. In general way, the results found for them, similarly to the found one here, point to the reduction of the regional inequalities when improvements in the conditions of traffic of the highways are implemented.

It is important highlight that the results found in this work present the limitations that are inherent to AGE models, not only in respect to the structural questions, as also in the difficulty faced in the construction of the data base mainly in that it says respect to the elasticities. Another important factor is that the model reflects the structure of the economy in one determined moment and, that the shock used in the simulation does not produce structural change in the economy and yes leads to a reallocation of the productive resources.

In spite of restrictions of this type of modeling, as of any another modeling used in the economic research, the results point with respect to the fertile field of the added modeling of general balance to the transport model when the interest rests in regional studies.

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