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Transportation Costs and Regional Development: An Interregional CGE Analysis

Eduardo A. Haddad¹ and Geoffrey J. D. Hewings²

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DRAFT

1. Introduction

As the process of global integration has reached the boundaries of developing countries, there has been concern about the role to be played by these nations in the new world economic order. In many parts of the developing world, efforts are being made to intensify economic activities so as to increase international competitiveness. Market-oriented policies have been generally adopted based on the World Bank and IMF recommendations, supported by the recognition of the distortionary effects of government intervention.

Distributional effects of such policies have been neglected on the grounds that greater efficiency would lead to rapid growth which would ultimately benefit the population in the lower income groups (Baer and Maloney, 1997). At the regional level, the desire to maximize economic growth, implied by the aim of increasing international competitiveness, is very likely to deteriorate the distribution of income among regions in developing countries (Baer *et al.*, 1998). As these countries present strong evidence of regional dualism, the more developed regions are those that concentrate the resources which can foster export-led national growth.

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Brazil was late in its efforts towards the integration of the country in the global network, as was the case of most Latin American countries until the 1990's.³ In this paper, the open policies of the 1990's and the national strategies for increasing international competitiveness are examined. An interregional computable general equilibrium model is used to analyze the long-run regional effects of structural policies, represented by the simulation of the effects of an increase in the total factor productivity in the transportation sector. The choice of this policy was made based on the relevance for the Brazilian case. It is part of a broader economic reform that is being carried out in the country and whose effects on the regions have not yet been considered in an integrated formal framework. The general equilibrium nature of economic interdependence and the fact that the policy impacts in various regional markets differ are considered in the results of the model presented below.

The remainder of the paper is organized as follows: in section 2, the assumptions underlying the interregional CGE model are exposed; section 3 discusses the role of the transportation infrastructure in improving regional competitiveness; section 4 presents the simulation of the effects of productivity gains in the transport sector; final remarks follow in section 5.

2. The Brazilian Multisectoral and Regional/Interregional Analysis Model (B-MARIA)

Many modeling approaches designed to address economic impact analysis in a regional system have been developed, initially, from international trade models. They evolved from the simple economic-base framework, through input-output and the general social accounting framework, to the more sophisticated econometric input-output and computable general equilibrium (CGE) models. In a sense, these models are all related to each other in that they might either form a chain of theoretical links

³ Sachs and Warner (1995) provide a categorization of developing countries according to the timing of trade liberalization – defined by the absence of certain characteristic impediments to open trade – in which most Latin American countries present relative late opening.

established in a consistent way, or they might simply play a role as a module of larger, integrated set of models (Hewings, 1985).

The CGE approach treats the economy as a system of many interrelated markets in which the equilibrium of all variables must be determined simultaneously. Any perturbation of the economic environment can be evaluated by recomputing the new set of endogenous variables in the economy. Optimizing behavior of consumers and producers is explicitly specified, as well as the institutional environment. Thus, demand and supply functions are derived consistently with prevalent consumer and production theories. Both production and consumption decisions respond to changes in prices. Regional interactions can be introduced through the interregional framework, allowing for regional imbalances and feedback effects from the other regions to be captured.

The **Brazilian Multisectoral And Regional/Interregional Analysis Model (B-MARIA)** is the first fully operational interregional CGE model for Brazil.⁴ The model is based on the MONASH-MRF Model, which is the latest development in the ORANI suite of CGE models of the Australian economy. B-MARIA contains over 200,000 equations, and it is designed for forecasting and policy analysis. Agents' behavior is modeled at the regional level, accommodating variations in the structure of regional economies. The model recognizes the economies of three Brazilian regions: North, Northeast, and Center-South (Rest of Brazil). Results are based on a bottom-up approach – national results are obtained from the aggregation of regional results. The model identifies 40 sectors in each region producing 40 commodities, a single household in each region, regional governments and one federal government, and a single foreign consumer who trades with each region. Special groups of equations define government finances, accumulation relations, and regional labor markets. In the Brazilian tradition of modeling, it benefits from the work by Guilhoto (1986, 1995), which provides a computable national model of the Johansen type with the solutions given in growth rates. Besides the Moreira and Urani (1994) model for the Northeast Brazil, which is rooted in the requirement analysis framework, and,

therefore, does not provide any supply-side constraint, B-MARIA is the first attempt to model the Brazilian economy in an interregional general equilibrium framework, taking into account both demand and supply constraints. [For a survey of CGE models applied for the Brazilian economy, see Guilhoto and Fonseca (1990), Moreira and Urani (1994), and Guilhoto (1995).]

2.1. Theoretical Structure

B-MARIA is based on the multiregional version of the MONASH Model, the MONASH Multiregional Forecasting Model – MONASH-MRF (Naqvi and Peter, 1995, 1996; Peter, 1996; Peter *et al.*, 1996a; Peter *et al.* 1996b). The equations of the CGE core module of the model are defined following the same structure of the ORANI Model (Dixon *et al.*, 1982), with a regional subscript added, when appropriate. It may be considered a Johansen-type model, in that the solutions are obtained by solving the *linearized* equations of the model. A typical result shows the percentage change in the set of endogenous variables, after a policy is carried out, compared to their values in the absence of such policy, in a given environment.

The schematic presentation of Johansen solutions for such models is standard in the literature. What follows is a summary of its contents in order to see how these models work. More details can be found in Dixon *et al.* (1982, 1992), Harrison and Pearson (1994, 1996), and Dixon and Parmenter (1994).

In the Johansen approach, the system of linearized equations of the model can be written as

$$F(V) = 0 \tag{1}$$

where V is an equilibrium vector of length n , and F is a vector function of length m , which is assumed to be differentiable. Regarding the dimensions, n and m , it is assumed that the total number of variables is greater than the total number of

⁴ The complete specification of the model is available in Haddad and Hewings (1997), and Haddad

equations in the system, i.e., $(n > m)$. Thus, $(n - m)$ variables must be set exogenously. Examples of economic variables contained in the vector V include quantities, prices, taxes, and technological coefficients. The economic relations depicted in the system (1) are comprised of equations representing household and other final demand for commodities, equations for intermediate and primary-factor inputs, pricing equations relating commodity prices to cost, and market clearing equations for primary factors and commodities, among others.

For the purpose of calibration of the system, it is fundamental to assume that an initial solution, V^* , is known. In other words, $\exists V = V^* \text{ s.t. } F(V^*) = 0$.

For B-MARIA, the vector V^* is read from the interregional input-output data base especially designed from the regional input-output tables for the North (SUDAM, 1994) and Northeast (BNB, 1992) regions, and from the national input-output tables for Brazil (FIBGE, 1995), for the year of 1985.⁵ Given the initial solution, V^* , the basic approach used to compute a new set of solutions to the model starts with assigning the variables to the exogenous and endogenous categories.⁶ Let V_1 be the vector of m endogenous variables, and V_2 be the vector of $(n - m)$ exogenous variables. Equation (1) can be rewritten as

$$F(V_1, V_2) = 0 \quad (2)$$

By totally differentiating (2), we get

$$F_1(V^*)dV_1 + F_2(V^*)dV_2 = 0 \quad (3)$$

where F_1 and F_2 are matrices of partial derivatives of F evaluated at V^* . Solving (3) for dV_1 ,

(1997).

⁵ See Haddad (1997).

⁶ The following describes the one-step Euler or Johansen solution.

$$dV_1 = \underbrace{\left[-F_1^{-1}(V^*)F_2(V^*) \right]}_{B(V^*)} dV_2 \quad (4)$$

or

$$dV_1 = B(V^*)dV_2 \quad (5)$$

It is assumed that the relevant inverse, $F_1^{-1}(V^*)$, exists.

In the B-MARIA Model, the specification of F , i.e., the specification of the equations of the model, is presented in five different integrated blocks of equations: the CGE core module, the government finance module, the capital accumulation and investment module, the foreign debt accumulation module, and the labor market and regional migration module.

2.1.1. CGE Core Module

The basic structure of the CGE core module comprises three main blocks of equations determining demand and supply relations, and market clearing conditions. In addition, various regional and national aggregates, such as aggregate employment, aggregate price level, and balance of trade, are defined here.

Figure 1 illustrates the basic production technology encountered in B-MARIA. Dotted-line boxes represent functional forms used at each stage. Two broad categories of inputs are recognized: intermediate inputs and primary factors. Producers in each regional industry choose input requirements per unit of output through optimizing behavior (cost minimization). Constraints are given by the nested production technology. Fixed proportion combinations of intermediate inputs and primary factors are assumed in the first level. The second level involves substitution between domestically produced and imported intermediate inputs, on one side, and substitution between capital, labor and land, on the other side. At the third level, bundles of domestically produced inputs are formed as combinations of inputs from different regional sources. The modeling procedure adopted in B-MARIA uses a constant

elasticity of substitution (CES) specification in the lower levels to combine goods from different sources.

The treatment of the household demand structure, depicted in Figure 2, is based on a nested CES/linear expenditure system (LES) preference function. Demand equations are derived from a utility maximization problem, whose solution follows hierarchical steps. The structure of household demand follows a nesting pattern that enables different elasticities of substitution to be used. At the bottom level, substitution occurs across different domestic sources of supply. Utility derived from the consumption of domestic composite goods is maximized. In the subsequent upper-level, substitution occurs between domestic composite and imported goods.

Figure 1. Nesting Structure of Regional Production Technology

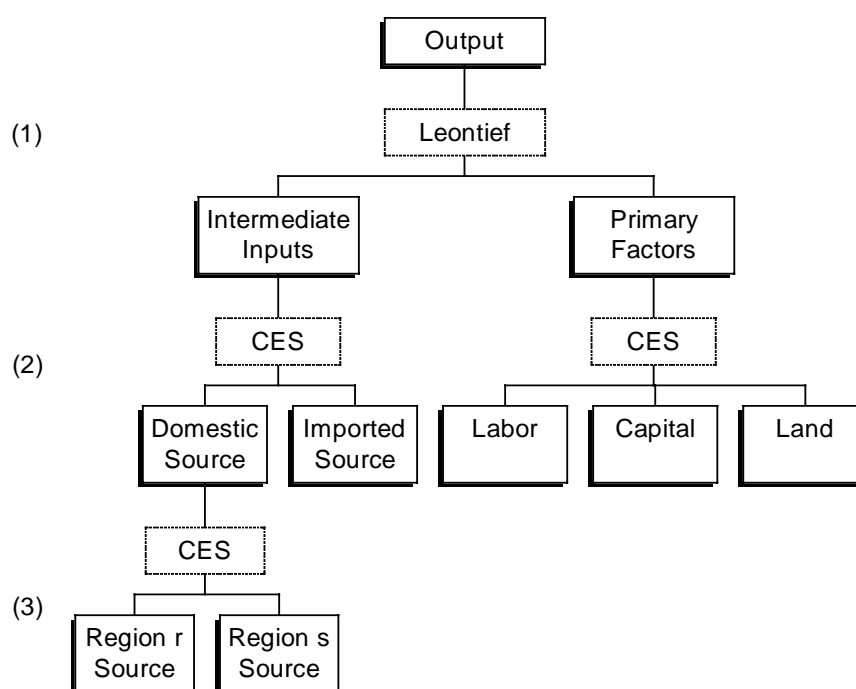
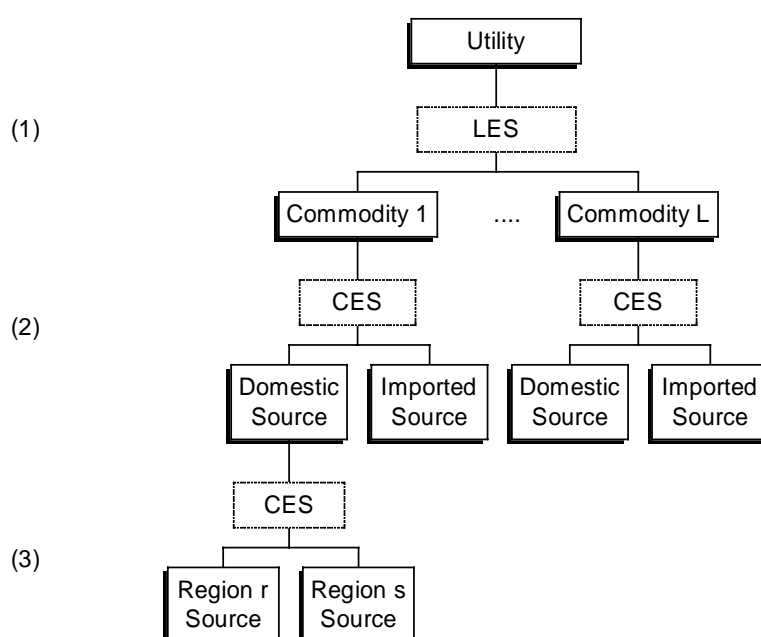


Figure 2. Nesting Structure of Regional Household Demand



Equations for other final demand for commodities include the specification of export demand and government demand. Exports are divided into two groups: traditional exports (agriculture, mining, coffee, and sugar), and non-traditional exports. The former faces downward sloping demand curves, indicating that traditional exports are a negative function of their prices in the world market. Non-traditional exports form a composite tradable bundle, in which commodity shares are fixed. Demand is related to the average price of this bundle.

One new feature presented in B-MARIA refers to the government demand for public goods. The nature of the input-output data enables the isolation of the consumption of *public goods* by both the federal and regional governments. However, productive activities carried out by the public sector cannot be isolated from those by the private sector. Thus, government entrepreneurial behavior is dictated by the same cost minimization assumptions adopted by the private sector. This may be a very strong assumption for the Brazilian case. It gains greater credibility, though, when the liberalization process of the 1990's is considered, in which the role of government is

being constantly reevaluated, and the privatization of previous government-owned activities is proceeding rapidly. Public good consumption is set to maintain a (constant) proportion with regional private consumption, in the case of regional governments, and with national private consumption, in the case of the federal government.

A unique feature of B-MARIA is the explicit modeling of the transportation services and the costs of moving products based on origin-destination pairs. The model is calibrated taking into account the specific transportation structure cost of *each* commodity flow, providing spatial price differentiation, which indirectly addresses the issue related to regional transportation infrastructure efficiency.

Other definitions in the CGE core module include: tax rates, basic and purchase prices of commodities, tax revenues, margins, components of real and nominal GRP/GDP, regional and national price indices, money wage settings, factor prices, and employment aggregates.

2.1.2. Government Finance Module

The government finance module incorporates equations determining the gross regional product (GRP), for each region, through the decomposition and modeling of its components. A similar approach is adopted for the value added components. GRP is defined from both the expenditure and the income side.

The budget deficits of regional governments and the federal government are also determined here. Regional governments are comprised of the state and municipal levels of direct administration within each region. At both levels of government, productive activities are not considered; they are included in the production sectors. The structure of the government accounts used in the model is heavily based on the State Fiscal Data Base developed by Dinsmoor and Haddad (1996). Some changes were carried out to accommodate the federal and the municipal administrations. Definitions of the main revenue and expenditure components of the government accounts are also available in this module of equations.

Another important definition in this block of equations refers to the specification of the regional aggregate household consumption functions. They are defined as a function of household disposable income, which is disaggregated into its main sources of income, and the respective tax duties.

2.1.3. Capital Accumulation and Investment Module

Capital stock and investment relationships are defined in this module. Comparative-static and forecasting versions of the model contain different equations. The forecasting equations were derived in B-MARIA for purposes of its future developments. As explained below, at this stage, only the comparative-static version of the model produces reliable results, restricting the use of the model to short-run and long-run policy analysis. When running the model in the comparative-static mode, there is no fixed relationship between capital and investment. The user decides the required relationship on the basis of the requirements of the specific simulation.⁷

2.1.4. Foreign Debt Accumulation Module

This module is based on the specification proposed in ORANI-F (Horridge *et al.*, 1993), in which the nation's foreign debt is linearly related to accumulated balance-of-trade deficits. In summary, trade deficits are financed by increases in the external debt.

2.1.5. Labor Market and Regional Migration Module

In this module, regional population is defined through the interaction of demographic variables, including interregional migration. Links between regional population and regional labor supply are provided. Demographic variables are usually defined

⁷ For example, it is typical in long-run comparative-static simulations to assume that the growth in capital and investment are equal (see Peter *et al.*, 1996b).

exogenously, and together with the specification of some of the labor market settings, labor supply can be determined together with either interregional wage differentials or regional unemployment rates. In summary, either labor supply and wage differentials determine unemployment rates, or labor supply and unemployment rates determine wage differentials.

2.3. Closures

B-MARIA can be configured to reflect short-run and long-run comparative-static, as well as forecasting simulations. Although a forecasting closure might be theoretically delineated, availability of reliable, consistent time series at the regional level for Brazil precludes this option to be operationalized. At this stage, two basic closures for alternative time frames of analysis in single-period simulations are available. A distinction between the two closures relates to the treatment of capital stocks encountered in the standard microeconomic approach to policy adjustments. In the short-run closure, capital stocks are held fixed, while, in the long-run, policy changes are allowed to affect capital stocks. In the simulations presented below, the long-run closure was adopted. The main assumptions for both closures follow.

Short-run. In addition to the assumption of interindustry and interregional immobility of capital, the short-run closure would include fixed regional population and labor supply, fixed regional wage differentials, and fixed national real wage. Regional employment is driven by the assumptions on wage rates, which indirectly determine regional unemployment rates. These assumptions describe the functioning of the regional labor markets as close as possible to the Brazilian reality. First, changes in the demand for labor are met by changes in the unemployment rate, rather than by changes in the real wage. This seems to be the case in Brazil, given the high level of disguised unemployment in most of the areas of the country; excess supply of labor has been a distinct feature of the Brazilian economy. Secondly, labor interregional immobility in the short-run suggests that migration is not a short-term decision. Finally, nominal wage differentials in Brazil are persistent, reflecting the geographical

segmentation of the workforce (Savedoff, 1990). On the demand side, investment expenditures are fixed exogenously – firms cannot reevaluate their investment decisions in the short-run. Household consumption follows household disposable income, and government consumption, at both regional and federal levels, is fixed (alternatively, the government deficit can be set exogenously, allowing government expenditures to change). Finally, since the model does not present any endogenous-growth-theory-type specification, technology variables are exogenous (see Peter, 1997).

Long-run. A long-run (steady-state) equilibrium closure is also available in which capital is mobile across regions and industries. Capital and investment are generally assumed to grow at the same rate. The main differences from the short-run are encountered in the labor market and the capital formation settings. In the first case, aggregate employment is determined by population growth, labor force participation rates, and the natural rate of unemployment. The distribution of the labor force across regions and sectors is fully determined endogenously. Labor is attracted to more competitive industries in more favored geographical areas. While in the same way, capital is oriented towards more attractive industries. This movement keeps rates of return at their initial levels.

3. Transportation Infrastructure Policies and the *Custo Brasil*

One of the main obstacles to economic development in Brazil is the so called *Custo Brasil*, the costs of doing business in the country. Enterprises are faced with a heavy burden that competing firms in other countries do not confront, hampering competitiveness. It includes different components that represent distortions in the relation between the public and the private sectors, reflecting inadequate legislation and deficient provision of public goods. Ongoing debate centers on the contribution of different sectors to the *Custo Brasil*: labor costs; transportation infrastructure; the tax system; and the regulatory system.⁸

⁸ See, for instance, CNI (1995) and World Bank (1996).

A recent study by the World Bank (1996) provides a comprehensive examination of the diverse components of the *Custo Brasil* and an exploration of their implications for total firm costs. Regarding land transport costs, which are often viewed as a significant component of the *Custo Brasil*, the available evidence collected for the report suggests that the costs of providing rail and trucking services are high in Brazil. Nevertheless, because of overcapacity and significant competition in trucking, these costs are not passed on to shippers; transport rates per ton-kilometer are low by international standards. The principal problem with land transportation, from the point of view of shippers, is not the unit costs of different modes of transportation, but rather excessive reliance on trucking. Railroad and barge transport over long distances are far cheaper than trucking, particularly for bulk commodities. Inefficiencies and low productivity in the railroad sector have meant that the percentage of total cargo carried by trucks in Brazil is approximately twice as large as the share in Australia and the United States. Increased reliance on rail-based shipping could reduce freight costs along principal corridors by as much as 20 percent.

Brazilian transport infrastructure is deteriorating fast from lack of investment and maintenance. Decay in the transportation system curtails economic growth as well as international competitiveness. Deterioration of Brazil's transportation network in the last years contributed to high operational costs, obstructing the competitive integration of the country. A study developed by AERI/CNT (1996) shows that one of the main consequences of the impact of the MERCOSUR on the Brazilian highway network is the increase in the number of critical points, or bottlenecks, in most of the corridors, under the assumption that no investment in the expansion of the system takes place. The study analyzes the impact of MERCOSUR on the transportation systems from a regional perspective, where the trade characteristics of each area are investigated in connection with the available transportation infrastructure. The expansion of multimodal systems is advocated, by enhancing participation of the railroad and inland waterway systems in the Brazilian transportation matrix, in order to increase productivity in the sector. Other measures including regulatory reform, acceleration of the privatization process to highways and railroads, and capacity

expansion in some highway segments are also recommended in order to improve the Brazilian transportation system, and, hence, lead to gains in competitiveness both in the internal and external markets.

In the next section, the issue related to the role of the transportation system in determining regional competitiveness is addressed. The CGE model is used to measure the regional and sectoral impacts of the improvement of the transportation infrastructure component of the *Custo Brasil*.

4. Simulation Results

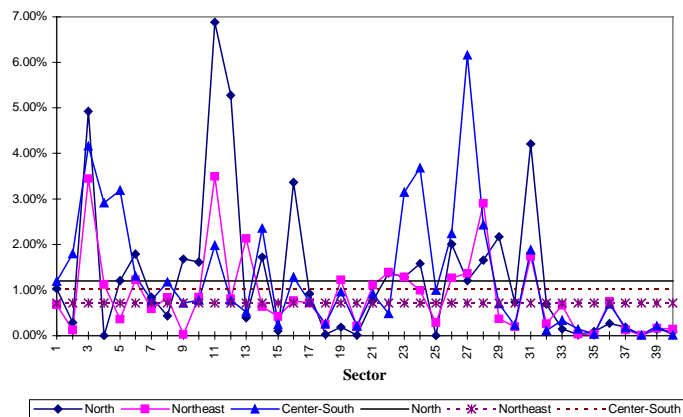
The modeling approach adopted here specifies the growth in total productivity of the transportation sector, in each region, which defines proportional direct effects on the respective regional output. The share in GRP of payments to factors of production of the transportation sector equals 3.50% (0.14% of GDP) in the North, 2.95% (0.45% of GDP) in the Northeast, and 3.81% (3.08% of GDP) in the Center-South. Thus, a 20.00% improvement in total factor productivity in the Center-South has a direct impact on GRP of approximately 0.76%; to get a similar direct effect in the other regions' output, a 21.77% increase is needed in the North, and 25.88% in the Northeast. Using these estimates, a simulation was carried out in which a regional-output-equivalent shock in total factor productivity was considered.

As already mentioned, B-MARIA models explicitly transportation services and the costs of moving products based on origin-destination pairs. Thus, the model is calibrated taking into account the specific transportation structure cost of each commodity flow, providing spatial price differentiation.⁹ The modeling specification is based on a mark-up structure which assumes that margins on goods used by industry, capital creators, regional households and governments are produced at the point of consumption, and margins on exports are produced at the point of production.

⁹ The lack of regional input-output tables for the Australian economy and the lack of regional margins data (Peter *et al.*, 1996a) make this feature unique in B-MARIA, as differential interregional costs are considered. Buckley (1992) provides an intermediary framework, in which the costs of regional-composed goods are based on origin-destination pairs.

As the price paid for commodity i from source s by each user in region q equals the sum of its basic value and the costs of the relevant taxes and margins (transportation and trade), the growth in total factor productivity in a margin industry will have a direct impact on every user. Figure 3 shows the extent to which transportation costs are relevant in the total costs of industrial production, in each region. On the average, transportation costs have a relative higher weight in the North (1.20%) and Center-South (1.03%); the average share in the Northeastern industries is only 0.72%. Service sectors have a low transportation content, while some sectors such as nonmetallic minerals, wood products and furniture, and construction are transportation-intensive sectors. Regional specific contents refer to the relative high weight of transportation costs in some sectors in the North (e.g. other chemicals), in the Northeast (e.g. rubber) and in the Center-South (e.g. mining).

Figure 3. Transportation Share in Total Costs, by Regional Industry



Higher efficiency in the transportation sector in the Center-South is reflected in the lower cost per unit flow, shown in Table 1; the North presents the less efficient transportation system. In the case of the relative low value of transportation costs from the North to the Northeast, it reflects the trade relations within the Carajás region, and the lower costs of waterways and railways available in the area, that account for a considerable part of interregional trade. As for the imported commodities, the Northeast presents much higher transportation costs in the benchmark data base.

Table 1. Average Transportation Cost per Interregional Dollar-Flow¹⁰

		<u>to</u>		
		<i>North</i>	<i>Northeast</i>	<i>Center-South</i>
<u>from</u>	<i>North</i>	0.035	0.022	0.042
	<i>Northeast</i>	0.000*	0.020	0.005
	<i>Center-South</i>	0.000*	0.011	0.017
	<i>foreign</i>	0.014	0.041	0.014

* Information disregarded in the published sources

The results of the simulation (Tables 2-4) using a long-run closure show a concentration of economic activities in the Center-South portion of the country. It should be clear that the figures presented in each of the following tables refer to the percentage changes in the variables from the levels they would have reached in the base case year in the absence of the exogenous shock. Thus, the Center-South benefits from the total factor productivity growth with an increase in GRP of 2.009% above the base case, while the North presents relatively small gains (0.367%), and the Northeast has a decrease in its GRP of -1.464%. The multiplier for the national economy is approximately $1.87 \{1.43 / [(0.14*0.2177) + (0.45*0.2588) + (3.08*0.2000)]\}$.

With the regional average rates of return and the aggregate level of employment exogenous, adjustments occur via industrial capital stocks, overall level of real wage, and interregional and intersectoral labor movements. The growth in total factor productivity reduces the cost of production of the transportation sector in each region and also, as a margin industry, reduces the unit cost of other industries through their transportation cost component, as the transportation sector becomes more efficient. This initial cost reduction increases the marginal productivity of primary factors, making it profitable to hire labor and capital at the initial levels of real wage and

¹⁰ One way to correct for the lack of information is to consider the transportation cost of the interregional purchases from the North to be symmetric to their respective sales flows, i.e., the average

capital rental prices. The increased demand for capital and labor increases the real prices of hiring primary factors. However, as the productivity gains in the industries in the Center-South are relatively higher, capital and labor tend to move towards that region.¹¹ The net regional effects of factor movements are shown in the estimates for increases in capital stocks and employment – persons weights – for each region. It is clear that the net supply effects benefit heavily the Center-South, with negative results in the Northeast; even though there is a net increase in the capital stock of the North, the net effect in labor movements is negative in the region. The Northeast, again, suffers from lower levels of labor productivity. Thus, the productivity of the domestic labor force increases, as shown by the result for national employment using wage-bill weights.

From the demand side, real household consumption in the North and Center-South grows faster than GRP as a result of the combined effects of higher real wages and increases in employment. In the Northeast, the wage effect is not strong enough to offset the fall in employment. Regional government expenditures follow the path of household consumption, showing a positive net effect in the country as a whole. Federal expenditures increase in the three regions at the same rate, suggesting the compensatory policies assumed in the model. The last component of domestic absorption reflects the differential attractiveness of investment opportunities in the regions, as explained above.

transportation cost per dollar would be \$0.022 for purchases from the Northeast, and \$0.042 from purchases from the Center-South.

¹¹ Wage differentials are set exogenously, and the capital-labor ratios in the transportation sector (North, 0.5321; Northeast, 0.4938; Center-South 0.7268) point to a higher increase in the capital productivity in the Center-South.

Table 2. Long-Run Effects on Selected Regional and Macro Variables

	<i>N</i>	<i>NE</i>	<i>C-S</i>	<i>Brazil</i>
<i>Real GDP/GRP</i>	0.367	-1.464	2.009	1.430
<i>Real Household Consumption</i>	0.498	-0.993	2.305	1.675
<i>Real Investment</i>	0.370	-2.664	1.035	0.409
<i>Capital Stock</i>	0.024	-1.584	1.309	0.842
<i>Regional Government Consumption</i>	0.498	-0.993	2.305	1.570
<i>Federal Government Consumption</i>	1.675	1.675	1.675	1.675
<i>Consumer Price Index</i>	0.973	0.736	0.793	0.793
<i>Regional/National Consumption Rate</i>	-1.157	-2.624	0.620	--
<i>Employment: Persons Weights</i>	-0.630	-2.182	1.012	--
<i>Employment: Wage-Bill Weights</i>	-0.630	-2.182	1.012	0.494
<i>Interregional Export Volume</i>	1.188	1.475	-1.244	--
<i>Interregional Import Volume</i>	0.396	-2.078	1.464	--
<i>Interregional BT (ordinary change)</i>	113.0	1443.8	-1556.8	--
<i>International Export Volume</i>	-4.413	-13.457	3.910	2.170
<i>International Import Volume</i>	0.997	-1.321	2.541	2.395
<i>Balance of Trade (ordinary change)</i>	-239.6	-1826.5	3253.7	1187.6
<i>Nominal Wage</i>	2.359	2.359	2.359	2.359
<i>GDP/GRP Deflator</i>	1.151	1.149	1.010	1.032
<i>Population</i>	-0.630	-2.182	1.012	--

The initial reduction in the cost of production of the transportation commodity stimulates regional exports. However, the growth in domestic absorption generated through the increase in the factor income imposes demand pressures on the economy and the domestic prices go up, pushed also by the increase in nominal wages, which is due to the competition for labor in an environment of fixed employment level. Thus, exporters face two countervailing forces that affect their position in international markets. The net effects in the regions are perceived differently: in the North and Northeast, the domestic-demand-driven price effect is strong enough to harm the

region's competitiveness, decreasing their international exports; in the Center-South, the cost reduction prevails, showing net increments in the regional exports to foreigners. Imports are benefited by both the lower transportation margins and the increase in the activity levels in the North and Center-South; in the Northeast, the intensity of changes in economic activity is sufficiently detrimental to completely offset the positive effects of cheaper imports. Nevertheless, the results for regional exports (-13.457%) and imports (-1.321%) suggest strong substitution effects towards imported commodities, in the Northeast. As an aggregate result for the balance of trade, the deficits observed in the North and Northeast are compensated by an international trade surplus in the Center-South, revealing a total national surplus.

The last component of GRP, from the expenditure side, reflects the interregional trade linkages in the Brazilian economy. Interregional backward linkages from the Center-South are important to attenuate the adverse effects in the Northeast, as suggested by the increased volume of purchases by the former region from the latter, and the positive effects of the interregional trade balance presented in the Northeast. Table 3 also reveals the spread effects of the more developed region on the North, which, given its relative dependency on interregional linkages, faces trade increases in both directions.

Table 3. Long-Run Effects on Interregional Trade Flows

		<u>to</u>		
		<i>North</i>	<i>Northeast</i>	<i>Center-South</i>
<u>from</u>	<i>North</i>	0.912	-1.713	1.270
	<i>Northeast</i>	-0.117	-1.449	1.602
	<i>Center-South</i>	0.449	-2.083	1.918

Sectoral results are presented in Table 4 and Figures 4-6. The only sectors in the Northeast that present a positive performance, besides the transportation sector, are transportation equipment and rubber, which have a large share of their sales to the

Table 4. B-MARIA Projected Percentage Long-Run Effects of an Increase in Total Factor Productivity in the Transportation Sector

	Employment by Industry				Activity by Industry				Capital Creation by Industry			
	North	Northeast	Center-South	Brazil	North	Northeast	Center-South	Brazil	North	Northeast	Center-South	
S1	Agriculture	0,788	-2,297	0,870	0,224	0,741	-2,064	1,055	0,407	0,680	-1,525	1,491
S2	Mining	-6,627	-1,765	8,634	5,455	-3,967	-1,590	6,973	4,110	-2,220	-1,352	4,272
S3	Nonmetallic Minerals	1,764	-2,239	0,854	0,624	1,526	-1,929	1,152	0,911	1,080	-1,522	1,486
S4	Steel	0,758	-5,636	1,858	1,609	0,741	-4,305	1,905	1,684	0,714	-3,106	1,953
S5	Nonferrous Metals	2,091	-3,443	1,875	1,483	1,766	-2,759	1,901	1,430	1,310	-2,075	1,963
S6	Other Metal Products	1,302	-0,380	1,688	1,652	1,247	-0,447	1,715	1,672	0,979	-0,650	1,884
S7	Machinery	0,373	-1,745	1,920	1,806	0,401	-1,671	1,920	1,802	0,509	-1,313	1,918
S8	Electrical Equipment	1,759	-0,613	1,646	1,575	1,669	-0,666	1,670	1,585	1,100	-0,846	1,818
S9	Electronic Equipment	2,310	-0,870	1,856	1,913	1,901	-0,895	1,862	1,847	1,324	-0,934	1,875
S10	Transportation Equipment	2,346	0,419	1,007	1,013	1,893	0,193	1,216	1,212	1,387	-0,369	1,533
S11	Wood Products and Furniture	2,011	-1,034	1,754	1,651	1,944	-1,017	1,784	1,661	1,353	-0,935	1,912
S12	Paper Products and Printing	2,648	-1,445	1,893	1,791	2,255	-1,318	1,871	1,737	1,341	-1,208	1,843
S13	Rubber	2,117	1,446	2,216	2,205	1,567	0,551	2,133	2,093	1,267	0,044	2,047
S14	Chemicals	1,855	-1,130	1,871	1,556	1,749	-1,120	1,869	1,518	1,076	-1,100	1,865
S15	Petroleum Refining	1,580	-3,169	2,416	1,640	1,338	-2,541	2,277	1,533	0,978	-1,905	2,093
S16	Other Chemicals	3,569	-3,419	1,193	1,082	3,189	-2,903	1,266	1,134	1,741	-2,005	1,615
S17	Pharmaceuticals and Veterinary	-0,330	-1,759	1,508	1,393	-0,250	-1,657	1,548	1,426	0,235	-1,302	1,785
S18	Plastics	1,406	-1,645	1,647	1,503	1,141	-1,398	1,716	1,502	0,864	-1,305	1,768
S19	Textiles	0,597	-1,213	1,527	1,218	0,593	-1,162	1,616	1,263	0,585	-1,106	1,750
S20	Clothing	-0,169	0,474	1,733	1,603	-0,052	0,182	1,771	1,618	0,276	-0,431	1,839
S21	Footwear	5,008	-0,834	2,024	1,926	4,138	-0,883	2,005	1,879	2,319	-0,953	1,955
S22	Coffee	-0,216	-1,207	-5,602	-5,094	0,096	-1,131	-2,820	-2,606	0,286	-1,088	-1,275
S23	Processed Vegetables	1,479	-4,991	1,320	0,377	1,299	-3,879	1,460	0,542	0,968	-2,683	1,673
S24	Meat Packing Plants	1,189	-0,863	1,838	1,710	1,048	-0,933	1,862	1,620	0,862	-0,954	1,886
S25	Dairy Products	5,526	-0,914	1,693	1,188	4,650	-0,936	1,764	1,292	2,570	-0,967	1,833
S26	Sugar	2,814	-8,841	1,176	-3,548	2,314	-7,466	1,402	-2,037	1,506	-4,376	1,617
S27	Vegetable Oil Mills	-1,418	-4,957	2,157	1,648	-1,255	-3,573	2,075	1,717	-0,238	-2,669	2,028
S28	Other Food Products	1,057	-0,670	0,788	0,642	0,994	-0,738	1,010	0,816	0,803	-0,873	1,460
S29	Other Manufacturing	1,919	-2,565	1,734	1,663	1,463	-1,897	1,743	1,580	0,994	-1,646	1,762
S30	Electric, Gas, and Sanitary Services	0,510	-1,584	1,988	1,465	0,536	-1,411	1,970	1,498	0,568	-1,242	1,954
S31	Construction	0,776	-2,490	1,449	-0,225	0,754	-2,430	1,493	-0,078	0,664	-1,624	1,716
S32	Trade	1,114	-1,068	1,837	1,352	1,080	-1,064	1,849	1,377	0,827	-1,034	1,920
S33	Transportation	-23,819	-29,525	-20,972	-22,186	2,402	0,666	4,537	4,015	-11,295	-15,356	-9,086
S34	Communication	0,920	-0,571	2,184	1,992	0,784	-0,741	2,077	1,845	0,661	-0,885	1,944
S35	Financial Institutions	0,921	-0,685	2,558	2,283	0,883	-0,734	2,492	2,198	0,747	-0,880	2,195
S36	Personal services	0,649	-0,160	2,708	1,722	0,648	-0,303	2,549	1,648	0,644	-0,662	2,269
S37	Business Services	1,349	-1,367	2,090	1,566	1,134	-1,304	2,020	1,548	0,814	-1,195	1,923
S38	Real Estate	0,569	-0,972	2,263	2,079	0,628	-0,996	2,094	1,362	0,629	-0,996	2,079
S39	Public Administration	0,881	-0,095	1,966	1,628	0,858	-0,174	1,962	1,617	0,713	-0,654	1,941
S40	Community Services	0,422	-0,994	2,280	1,204	0,435	-0,995	2,257	1,197	0,541	-1,001	2,078

Figure 6.16. B-MARIA Projected Long-Run Activity Effects of an Increase in Total Factor Productivity in the Transportation Sector: North

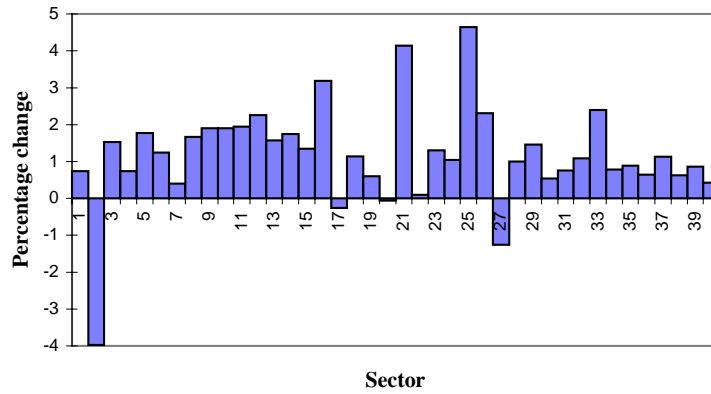


Figure 6.17. B-MARIA Projected Long-Run Activity Effects of an Increase in Total Factor Productivity in the Transportation Sector: Northeast

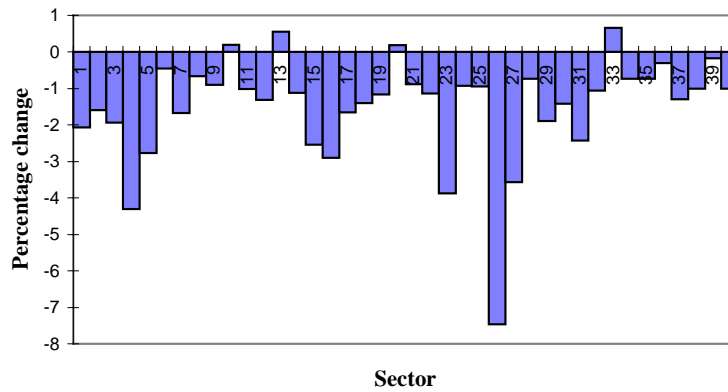
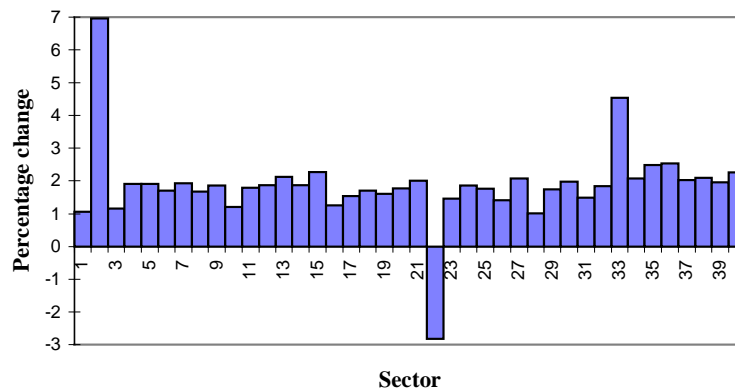


Figure 6.18. B-MARIA Projected Long-Run Activity Effects of an Increase in Total Factor Productivity in the Transportation Sector: Center-South



transportation sector (36.4% and 29.3%, respectively), and the clothing sector, which benefits from labor productivity increase and its interregional sales.

Traditional exports such as mining (North), sugar (Northeast), and coffee (Center-South) are harmed. As these sectors present relatively low transportation content, the benefits arising from the initial cost reduction due to productivity gains are not strong enough to offset the price hike due to domestic demand pressures. In addition, interregional substitution effects operate, resulting in declining shares in domestic markets for the regional commodities. In the mining sector of the Center-South, the detrimental effect of increasing production costs is not sufficient to offset the direct effects of technological change, and the industry increases its shares in international markets.

The productivity gains in the transportation sector free primary factors that are absorbed by other industries. Capital and labor movements benefit the sectors in the Center-South and North. Through multiplier effects driven by the increase in the investment and consumption components of domestic absorption in those regions, capital goods and consumer goods industries, in general, are positively affected; capital formation is an intensive user of local inputs in the Center-South, driving the overall positive results in the region. Internal multipliers generate increasing demand for capital goods, which also are favored by relatively low substitution effects. The few drawbacks in sectoral activity verified in the North are heavily influenced by substitution effects against the regional commodities.

5. Conclusion

As the AERI/CNT (1996) study shows, physical constraints in the transportation network play an important role in the facilitation of flows of goods and services. B-MARIA does not consider this issue explicitly, and the simulation results described above reflect productivity growth derived from the initial existing capacity. As a general result, the Center-South is the main beneficiary, suggesting that the interplay of the countervailing forces of backwash and spread effects, as implied by the

intraregional and interregional linkage structure, favors the more developed region due to different levels of agglomeration economies captured in the model.

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