THE TRANSPORT-REGIONAL EQUITY ISSUE REVISTED

by

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ABSTRACT

The objective of this paper is to analyze the relationship between transport and regional equity in Minas Gerais (Brazil). Furthermore, the existence of a trade-off between economic performance and regional equity is investigated as well. To do so, we develop a spatial computable general equilibrium model based on Bröcker's approach to implement comparative static analysis, explicitly incorporating iceberg transportation costs. Four activities are modeled, namely, production, final demand, transportation and exports. Two production factors are assumed: labor and other factors. In the model, there are twelve domestic regions and three external regions. We develop four counterfactual experiments based on decreases in transportation costs due to a "distance shortening." The main findings indicate that if the transport infrastructure improvement is focused only among poor regions, the promotion of the regional equity is insignificant. If the transport infrastructure improvement links are concentrated among rich regions, there is an increase in regional income inequalities. However, if the improvements are targeted to the roads linking poor regions and rich ones, there is promotion of regional equity. The same result will occur when improvements are made to all road links of the state.

KEY WORDS: spatial computable general equilibrium model; regional equity; economic performance; transportation costs.

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1. INTRODUCTION

Over the years, there has been an intense debate in the literature about the relationship between the role of the transport infrastructure provision and regional equity. With respect to the nature of this relationship, the research community has generated empirical evidence, suggesting either a positive or negative relationship (Kim *et al*. 2002; Dall'erba and Hewings, 2003; Haddad and Hewings, 1999; Vickermann *et al*., 1996; Buckley, 1992; Wigle, 1992). These inconsistent results are partially due to methodological differences. Hence, it is absolutely reasonable to admit that two different theories/models could generate potentially conflicting results about the nature of the relationship between transport and regional equity. For instance, it is understandable that a model based on the new economic geography may yield evidence that contests those arising from a neoclassical model, adopted to examine this research issue.

Similarly, distinct methods of investigation of this relationship have been used, such as multi-regional input-output and econometric models, transportation network models or spatial CGE models.[1] Once again, based upon strictly methodological grounds, it is understandable that, even adopting the same theoretical model, the evidence extracted from an econometric model may be quite different from those generated from a spatial CGE model. Even keeping the same theoretical model and method of investigation, it is also possible that different specifications of the method adopted are able to produce different outcomes.[2] Then, a spatial CGE model that includes the transport in its specification only as a sector may generate conclusions on the nature of the relationship that are different from a spatial CGE model that incorporates, in turn, the transport as an iceberg cost. Hence, interpretation of the relationship between transport and regional equity is unlikely to be independent of the model adopted. Further, there are likely to be differences in outcomes for models in which commodities move between regions in a topological sense rather than mapped onto a specific network. In the latter case, considerations of capacity limitations, route and modal choice can enrich the way in which commodity movements are modeled between regions. In the present paper, the flows between regions are not mapped onto a network and thus infrastructure improvements are viewed in a subtract sense and realized in the model through a reduction in transportation costs. Therefore, it is not surprising that there have been controversial results about the nature of the relationship.

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[1] See van den Bergh *et al*. (1995) on several methods available for dealing with some specific aspects of the issue of effects of transportation on the economic system.

[2] See also Harrigan and McGregor (1989) on the effect of different closures rules in CGE modeling.

Indeed, most of controversial evidences stem from this kind of methodological discrepancy. We can consider that these discrepancies have a spurious source, inasmuch as they do not allow us to focus on essentials of the issue.

Our objective in this paper is to reveal that, methodological differences aside, the evidence about the nature of the relationship between transport infrastructure provision and regional equity are controversial due to a fundamental characteristic associated with this issue. In other words, even with the same theory/model, method and its specification, we may continue to obtain different results about this relationship. This outcome arises because this relationship crucially depends upon *where* the transport infrastructure is located.[3] In addition to methodological considerations, there seems to exist authentic spatial reasons to yield controversial results. Indeed, transport infrastructure is strongly region-dependent. The *spatial structure* of the transport infrastructure provision matters in this question, playing a fundamental role in determining its effects on the economic system.

There is a further problem that derives from the nature of the spatial analysis being conducted. Recent evidence on income convergence has revealed that it is possible for convergence to take place at one level in a spatial hierarchy and divergence at another level. Transportation investment may be considered to have, potentially, similar outcomes. Investment in infrastructure improvements might enhance a state's overall competitive position vis a vis other states yet in the process it may generate an increase in welfare disparities between regions within the state. Policy-makers are thus faced with the difficult choice of managing competitive and welfare issues at different spatial levels. One contribution of this paper is to not only examine the relationship between transport and the regional equity, but to shed some light on another trade-off between economic performance (growth and efficiency) and regional equity, which is directly linked to transport infrastructure provision.

Transportation determines the general conditions of systemic efficiency of a region or a country, conditioning its economic development. Since transportation has the economic function of transferring final goods and intermediate inputs across regions, its performance affects the degree of competitiveness of the other sectors in the economy. However, improvements in economic performance do not manifest themselves randomly across space. The effects of

[3] This outcome has a parallel in the identification of analytically important elements in an input-output model. Location, as well as the size of the elements together with the overall complexity of the structure, determines importance.

transport infrastructure contribute to economic performance that induces, in turn, development impacts such that there will probably be winning regions as well as losing ones, and certainly regions that benefit more than others from any given investment.

In order to explore these issues in this paper, and given the complexity and the amount of feedbacks involved in this kind of investigation, we felt it important to consider the need for more explicit modeling of the behavior functions (production and demand functions) as well as the spatial structure of the phenomenon under study. Accordingly, we developed a spatial computable general equilibrium model, based on the parsimonious approach proposed by Bröcker (1998), Bröcker and Schneider (2002) and Schneider (1998). The main advantages of this approach rely on its analytical power and its capacity for examining policy shocks across regions in the midst of all complexity and feedback effects involved. Adopting this perspective, the model, the method of investigation and its specification are chosen and will be kept constant.

The paper is divided into four sections, aside from this introduction. A brief introduction to the region of analysis is provided in section two. The third section presents the basic ideas of the theoretical structure of the spatial CGE adopted. The fourth section is reserved for describing the experiments and exhibiting the simulation results, as well as interpreting them. The last section recovers the main conclusions drawn from the investigation.

2. REGION OF ANALYSIS

Minas Gerais is an interesting case to be examined from the 27 Brazilian states with respect to regional disparities and economic performance among its twelve domestic regions (see table 1). This is because Minas Gerais state is Brazil's third richest state and the country's second most populous state but also because there is strong regional inequality within its territory. It is noteworthy that the regions Triângulo Mineiro/Alto Paranaíba, RMBH and Sul/Sudoeste possess just 31 percent of Minas Gerais' territory, but they host 53 percent of Minas Gerais' population and 67 percent of the state's production. The regions Noroeste, Norte, Vale do Jequitinhonha and Vale do Mucuri possess almost half of the state's territory, but they contain just 17 percent of Minas Gerais' population and about 18 percent of the state's production. It is possible to propose that Minas Gerais can be split into two relatively homogeneous parts. The rich part, named henceforth "South", is composed of Triângulo Mineiro/Alto Paranaíba, Central, RMBH, Vale do Rio Doce, Oeste, Sul/Sudoeste, Campo das

Vertentes and Zona da Mata. The other part, named hereafter “North”, is composed of the following regions: Noroeste, Norte, Vale do Jequitinhonha and Vale do Mucuri.

<< insert table 1 here >>

Let us try to shed some further light on this issue through consideration of the Human Development Index at the municipal level (HDI-M).[4] We can observe that the overall HDI-M of Minas Gerais is 0.719, positioning it as Top 12 within Brazil (see table 2). Notwithstanding this good economic performance, there are strong regional inequalities inside its territory. Taking into account the dispersion of the HDI-M within the State, measured by the standard deviation across the municipalities, Minas Gerais is Brazil’s second most disperse state, denoting clearly the degree of inequalities among its regions. Furthermore, among the top 15 most disperse states, Minas Gerais exhibits the highest HDI level.

The variability in the level of development among municipalities of Minas Gerais can be verified by means of the spatial distribution of the HDI-M within the State, as presented in figure 1. It is possible to discern two distinct parts in Minas Gerais. First, there is the southern part of the State, the location of the more developed municipalities that exhibit high HDI-M levels, symbolized in figure 1 with darker shading. Secondly, there exists a northern part of the State, featuring less developed municipalities, showing low HDI-M levels, represented with lighter colors in figure 1. Hence, for Minas Gerais, levels of welfare are not distributed equally across its territory. Consequently, state economic development policy has to address the tension between efficiency and spatial equity.

As for the transportation system, the modal distribution of the freight transportation exhibits a heavy dependence on the highway mode in Minas Gerais state: in 1992, with 52.8 percent of the total volume are transported by trucks within the state. By the way of comparison, the average participation of this mode in developed countries amounts to about 30 percent. In Minas Gerais, the railroad freight transportation was responsible by 42.4 percent of all volume of

[4] This index was constructed by UNDP (United Nations Development Program), IPEA (Research Institute of Applied Economics), Fundação João Pinheiro and IBGE (Brazilian Institute of Geography and Statistics).

commodities transported, whereas about 4.8 percent were transferred by pipelines (BDMG, 2002).[5] Consequently, the modal composition of Minas Gerais reflects a non-multimodal environment. In Minas Gerais, there is a road network of approximately 265,000 kilometers, although the majority of it consists of non-paved roads (92.3 percent of the total network). In view of this, in this paper our focus is on the road infrastructure improvement in Minas Gerais.

<< insert table 2 here >>

<< insert map 1 here >>

3. THE THEORETICAL MODEL

Most spatial CGE models present a sophisticated theoretical structure that requires a great deal of interregional data and other information for empirical implementation. For example, it is often necessary to obtain a full social accounting matrix (SAM), with interregional trade flows, regional prices of all production factors, as well as their quantities. The problem is that few countries have statistical agencies that generate these types of data. Consequently, it is necessary to construct such a demanding database by means of regionalization techniques and gravity or other spatial interaction methods.

An alternative for elaborating spatial CGE models was proposed by Bröcker (1998), Schneider (1998) and Bröcker and Schneider (2002). Recognizing that we live in a "poor data world," it would be useful to simplify the theoretical structure to match the actual data generated by the statistical agencies. According to Bröcker and Schneider (2002), the set of information that is normally available consists of an input-output table, employment data by sector and region, information on regional wages and interregional transportation freight costs. Therefore, this strategy for elaborating spatial CGE models is based on a parsimonious mathematical specification of the theoretical model that is achieved through the adoption of simplifying assumptions.

[5] In Minas Gerais, the air and inland waterways freight transportation modes are insignificant.

We begin by exposing the basic ideas of the specification of the spatial CGE model for Minas Gerais (MINAS-SPACE).[6] There are three assumptions that reduce data requirements to apply this type of model, namely: a) the pooling concept (Nijkamp, 1986); b) the iceberg transportation cost assumption (Samuelson, 1952); and c) the Armington specification (Armington, 1969).

According to the pooling concept, all commodities produced by sector *i* in various regions are aggregated in a pool of the commodity *i* in region *s*; from this pool, deliveries are made to intermediate and final consumers. Hence, the pool goods, as well as the output of the sectors, are discriminated by region. Furthermore, there is no direct link between the production side and the consumption side; in other words, firms and consumers do not meet directly in the market. With the help of this concept, it is not obligatory to have the data about the trade flows among regions anymore.

The iceberg transportation cost assumption considers that a portion of the commodity transported dissipates itself during the transportation process. Hence, at the destination of the route there would be a smaller amount of commodity transported than at its origin because part of the commodity would have been "used" in the form of transportation costs. It is noteworthy that the iceberg assumption avoids the need for constructing a sector offering transportation services.

The Armington specification is adopted to differentiate the commodities according to origin regions. This specification rejects the assumption that the goods are perfect substitutes. The Armington specification recognizes that there is an imperfect degree of substitutability among the commodities; in this manner, it is possible to admit that the price system exerts a role in the determination of the trade flows. Further, the Armington specification allows a better matching of the interregional trade data, because it admits the presence of "cross-hauling".

We assume an open economy with *I* sectors, *R* domestic regions and *L* external regions.[7] There are four activities in this economy: production, transportation, final demand and export. Each region hosts *I* representative firms, a representative household and *I* transportation agents. From the production side, a firm *i* in region *r* produces the output *I* by means of a nested CES

[6] The complete list of equations and variables of the model is available in appendix A. For a detailed explanation of the equations and functioning of the model, see Bröcker (1998), Schneider (1998) or Almeida (2003).
[7] For the sake of clarity, the index *r* hereafter refers to origin regions, while the index *s* refers to destination regions.

(NCES) linear-homogeneous production technology, using intermediate inputs taken from the pool in region *s*, and using primary inputs *k=1,…, K*.

From the transportation side, a transport agent *i* in region *s* is responsible for transforming outputs of sector *i* in all regions, including its own region *s*, and the imported goods from all external regions into a pool good of type *i* available in region *s* by means of NCES linear-homogeneous production technology. This functional form allows for commodity diversity, because commodities from different regions are not considered as identical. Accordingly, the final demanders do not purchase just from the region with the lowest *cif* price (Bröcker, 1998, p. 371). Hence, we adopt the Armington specification to deal with the possibility of interregional substitution, treating commodities from different origins as imperfect substitutes. According to Bröcker (1998, p. 372), the transportation activity can be separated into two parts: "*One is transporting the outputs from all regions of origin to the region of destination; the other is merging the amounts left, after all commodities arrived in the region of destination, into the pool*".

Regarding the final demand activity, the regional representative household earns its income by selling its production factors to firms. Afterwards, it completely spends this income on pool goods of the region where the household is resident. Regional households enjoy welfare from the consumption of pool goods; such a behavior is described according to a linear-homogeneous utility function. Representative households do not save, spending their entire income on the consumption of pool goods. Following the duality theory, their preferences are specified by an NCES expenditure function. Note that the quantity of production factors owned by the representative household in each region is exogenously given.

Concerning the foreign sector, the MINAS-SPACE model is developed for an open economy where just the economic agents' behavior in Minas Gerais is optimized in microeconomic terms. It is not our intention to model the economic agents' behavior in external regions. Following this approach, trade is explained by means of a system of export demand and import supply functions. Due to the spatial nature of the model, it is necessary to have a regional distribution of the export and import flows according to the heterogeneity of commodity across distinct external regions by the Armington specification. The export activity is carried out by means of a NCES linear-homogeneous technology. Every external region *l* consists of *I* export agents, whose behavior is similar to the domestic transport agents. The activities in the model are depicted in figure 1.

<< insert figure 1 here >>

For the sake of simplicity, final demand is not subdivided into components such as public spending, investments or inventories. By the same token, value-added is not disaggregated into components such as indirect taxes, subsidies, contributions to social insurance, etc. A perfect competition environment is assumed where firms, transport agents and export agents minimize costs. In view of the linear-homogeneous technology, this assumption implies that, in equilibrium, prices equal unit costs. Hence, there is no possibility to accrue pure profits in the economy.

Minas Gerais is subdivided into the twelve regions shown in table 1. The model implemented here is an open system since there are three external regions, São Paulo State (SP), Rio de Janeiro State (RJ) and the Rest of Brazil (RB). The model is divided into five sectors: agriculture and livestock (AGR), mining (MIN), manufacturing industry (IND), construction (CON) and services (SER).

To implement effectively the MINAS-SPACE model, seven types of information are needed to prepare the database: a) an input-output table for Minas Gerais State; b) regional employment data by sector; c) regional wages; d) substitution structure for the NCES functions; e) transport freights; f) domestic interregional distances; g) distances among the domestic regions of Minas Gerais and the external regions.[8]

The input-output data for Minas Gerais are derived from a non-survey study elaborated by FIPE (Economic Research Institute) and BDMG (Development Bank of Minas Gerais). This input-output table is available for the year 1996, the year chosen as the reference year for the entire benchmark dataset. The model is calibrated for two primary factors, labor (L) and other factors (N). The regional wages and the employment data are extracted from IBGE Census, National Survey of Sample of Households (PNAD) and Administrative List of Social Information (RAIS). The elasticities used in the model come from several sources in the literature (Guilhoto, 1995; Zini Jr., 1988; Bröcker and Schneider, 2002). The transport rates are

[8] For complete information about the dataset, see Almeida (2003).

estimated econometrically, adopting the procedure described in Castro *et al*. (1999). The idea of this procedure is to construct an econometric model where freight by sector is a function of the distance of routes. The distances are the shortest routes between the coordinates of two regions, which are computed as the latitude and longitude of the main city of these regions. The two distances matrices (one of them for interregional distances and the other one for distances between external regional and domestic one) are drawn from Cesar (1999).

The main advantage of the MINAS-SPACE model rests on the parsimony principle, avoiding extensive calibration of parameters. As a result, the model is tractable in terms of data requirements, computational burden and implementation costs. The disadvantages of the model stem from the absence of dynamics. There are no equations describing the capital utilization or the investment pattern. Consequently, the model is not able to take into account transportation project financing. Since there is no public sector, the transportation investments are modeled like final demand shocks. In addition, the welfare measure adopted in the model, as further defined, is imperfect, since it does not capture some relevant effects, such as environment costs, the macroeconomic impact of transportation financing and so forth. Furthermore, interregional migration is not modeled.

4. SIMULATIONS

4.1. Counterfactual Experiments

The MINAS-SPACE model is designed to implement comparative static analysis through a series of simulations. These simulations are based on counterfactual experiments that seek to grasp the fundamental aspects of the phenomenon under investigation. This section describes the counterfactual experiments to be carried out further. The reduction in the transportation cost stems from improvements in the road network that shorten the travel time between regions, increasing network connectivity. In the model, travel times can be regarded as similar to interregional distances within the Minas Gerais State. Thus, a road improvement that yields a reduction in the travel time between two regions within the State can be regarded as producing the same effect as a reduction in the interregional distances. By so doing, the interregional distance parameter in the model needs to be reduced. In line with this idea, four experiments are performed. The design of these counterfactual experiments is presented below.

The first experiment, named “All”, consists of shortening of all domestic interregional distances by 10 percent (the value was chosen arbitrarily) that leads to a further reduction in the transportation costs. In this experiment, all domestic[9] origin region-destination region pairs have their “distances” reduced by 10 percent, irrespective of whether the origin region or the destination one is considered as rich or poor.

The second simulation refers to a “shortening of the distances” by 10 percent just among the four poor regions in the North, to wit, Noroeste, Norte, Vale do Jequitinhonha and Vale do Mucuri. That is, such an experiment simulates an improvement of the road network just in the poor part of the Minas Gerais. This experiment is named “North.”

A third experiment refers to a “shortening of the distances” by 10 percent just among the eight rich regions of Minas Gerais, namely, Triângulo Mineiro/Alto Paranaíba, Central, RMBH, Vale do Rio Doce, Oeste, Sul, Campo das Vertentes e Zona da Mata. In other words, this auxiliary experiment simulates the improvement of road network in the South of Minas Gerais and is referred to as “South.”

The last experiment simulates the “shortening of the distances” by 10 percent just among rich region-poor region pairs (for instance, Central-Noroeste, Sul-Norte, etc), excluding completely rich region-rich region pairs or poor region-poor region pairs and will be termed “North-South.”

After simulation, it is very important to interpret properly the results obtained. In this sense, a spatial CGE model generates a myriad of results in terms of quantities and relative prices both at the aggregate and the regional level. Hence, it is important to consider a welfare measure in order to determine whether society as a whole or a particular region is gaining or losing with the implementation of any policy. Thus, the welfare effects represent a summary measure. The welfare gains (or losses) are defined according to an equivalent variation concept, that is, the amount of additional income, measured at benchmark prices, which is necessary to reach the level of utility of the counterfactual equilibrium (Bröcker and Schneider, 2002). Further, since one of our objectives is to investigate the regional equity, it is also relevant to adopt an indicator to measure income disparities among regions. To achieve this, the Gini index for regional real income per employee is computed.

[9] Domestic regions mean regions within the Minas Gerais State.

4.2. Issues in Interpretation

Before turning to the results of the simulations, we should deal with the driving forces that work inside the model, explaining their functioning. At the aggregate level, a transportation cost reduction generates a decrease of pool prices, which leads to an augmentation in household real income, creating welfare gains. The augmentation in real incomes is manifested by means of an increase in final demand, leading to an increase in the output level of firms. As a result, firms have to purchase more primary factors, and thus, the prices of these factors are increased, augmenting, at the end, household real income once again. All these aggregate results are reflected in welfare gains (see figure 2 below).

With better accessibility, there is an income effect, representing a more intense demand from other regions for goods produced in region *r*, which have their prices curbed because of the reduction of transportation costs. It is worth pointing out that the final demand increase is derived from two causes. The first cause is a *substitution effect* due to the decrease in pool prices. This effect means that, in region *s*, it is less expensive to purchase goods from region *r* and, therefore, the later region will export more goods to region *s*. The second one is an *income effect* due to an augmentation of real incomes.

<< insert figure 2 >>

As to the spatial impact on welfare and output levels, the causal mechanism works in the following way. Road network improvements may generate welfare losses for a particular region due to the reorientations of trade flows toward regions that enjoy a better market access after these improvements. In this case, we have interregional trade diversions that cause economic damages in certain regions. For instance, a region that makes little use of a new road may trade with other regions that, in turn, may use this new road more intensely. In this case, the former region could find that the demand for its goods will shift to the later regions, because now these regions become more accessible as purchasing regions. The lesson is that the benefits from a reduction in transportation costs do not accrue everywhere; and some regions may lose with this process.

Transportation costs are regarded as interregional trade barriers. In a sense, the reduction in transportation costs among regions has a similar effect of a diminution in tariffs among countries. Trade diversions aside, it is possible to have trade creation as well. Trade creation occurs when a region replaces its domestic production with imported goods from other regions due to transportation improvements among these regions. If there are winning or losing regions, the definition of a region's status depends on the possibility of a region having better access to the markets of other regions. In the presence of a reduction of transportation costs, a winning region enjoys more trade creations than trade diversions, obtaining a positive net impact on its welfare.

4.3. Results

Let us start presenting the most important results of the model at the aggregate level (table 3). For the first experiment ("All"), the road network improvement generates an increase in the welfare gains by 0.10% of the gross production (or R$ 71.7 millions). This welfare gain is due to two effects. From the production side, the better access to intermediate inputs and product markets allow firms to raise their output, augmenting the wages and other factor prices by 0.10% and, consequently, increasing household income. From the consumption side, the road network improvement reduces the pool prices, increasing real income. These two effects are responsible for an increase in the final demand by 0.09 percent and an increase in the output of pool goods by 0.06 percent.

<< insert table 3 here >>

As for the regional results, table 4 reveals the quantitative details of the simulations for the experiment "All". Indeed, all regions obtain welfare gains,[10] as well as reductions in the price level, provoked by the decline of the transportation costs. For this experiment, the average welfare increase is 0.20 percent, although there is dispersion around it. In this sense, note that the standard deviation is 0.11; hence the coefficient of variation is a little higher than 50 percent, since the maximum gain is 0.37 percent (Noroeste) while the smallest gain is 0.04 percent (RMBH).

Notwithstanding, the most striking outcome is in the spatial distribution of the welfare effects (see figure 3). Although all welfare effects are positive, it is worth pointing out that the

[10] The welfare gains are represented by the utility (real income) of households (per employee).

poorer regions benefit more than the richer ones in relative terms. As for regional income disparities, there is a decrease in the Gini index by 0.18 percent, signaling that the regional income disparities among the regions decline. This result occurs because these regions are farther from the richer regions, that are situated in the Center-South of Minas Gerais, and whose market size is greater. The rationale of the experiment is to "bring nearer" these farther regions to the richer regions. In this sense, such a phenomenon has a similar effect to a program to enhance economic integration.

To identify more clearly what is going on with this promotion of the regional equity, let us take a closer look at the other simulations. The experiment "South," at the aggregate level, provides similar results to the experiment "All." As to the regional results, the welfare gains for the richer regions remain almost the same, but for the poorer regions, they face welfare losses now (see figure 4). The average welfare gain is 0.06 percent, although there is considerable variation around it, as can be observed by the high standard deviation (0.13); thus, the coefficient of variation is more than 200 percent. The maximal gain is 0.25 percent (Triângulo/Alto Paranaíba), whereas the minimal gain (or maximal loss) is –0.10 percent (Vale do Mucuri). Consequently, the Gini index increases by 0.16 percent, increasing the regional income disparities when the road infrastructure improvements are focused on the richer regions.

The experiment "North," in turn, provokes minimal effect on most variables in terms of both the aggregate level and the regional level (see tables 3 and 4). In spite of this, the Gini index drops slightly by 0.01 percent.

The most important results come from the experiment "North-South." It seems the poorer regions capture all benefits at the expense of the richer regions (see figure 5), but the aggregate impacts on quantities (domestic production, pool goods production, final demand, export and imports) and relative prices are very small. This experiment reveals the largest decline in the Gini index by 0.33 percent, suggesting that the poorer regions catch-up in this simulated environment.

The trade-off between economic performance and regional equity strongly accrues from these findings. On one hand, the experiment "North-South" substantially improves the regional equity, but its economic performance is disappointing (see tables 3 and 4). On the other hand, the experiment "South" stimulates the regional income disparities, as indicated by the Gini index, but it has a good economic performance at the aggregate level.

<< insert table 4 here >>

The challenge for policy-makers, as noted in the introduction, consists of finding a strategy that is capable of mixing the performance and equity proprieties in relative harmony. This is the case of the experiment "All," which reaches a high level of economic performance, as can be shown by means of aggregate welfare gains (0.20 percent), with a considerable reduction in the regional income inequalities, as measured by the Gini index.

As can be appreciated, these different types of experiments generate different results regarding the regional equity issue. Two of them (experiments "All" and "North-South") generate promotion of the regional income equality, whereas one of them ("South") yields an increase in the regional income disparities, while the experiment "North" yields almost negligible benefits in terms of aggregate impact on the economic system.

The explanation of these results follows the argumentation lines carried out so far: poor regions benefit from the closer economic integration with regions with high market size when the trade barriers fall as a result of the reduction in transportation costs. The trade argument also allows us to shed some lights on this issue, connecting welfare gains to trade flow reorientations. The experiment "South" yields more trade diversions than trade creations for the northern regions. The experiment "North-South", in turn, generates more trade creations than trade diversions for the northern regions, benefiting them in detriment of the southern regions. The experiment "All" seems to exhibit intense trade flow reorientations in which trade creations dominate trade diversions, generating benefits for all regions, although the welfare gains for the poor ones prevail. Even hosting the road infrastructure improvement, the experiment "North" is not capable of creating significant trade flow reorientations in order to increase welfare gains for the northern regions.

It is well known that inter-regional transport improvements may reduce inter-regional inequalities at the expense of increasing intra-regional inequalities.[11] With this in mind, we considered the impact of transport costs within a region in three auxiliary simulations. One simulation consisted of shortening all the domestic intra-regional distances by 10 percent, that is, the transport costs were decreased just for own regions not for other regions; hence, the principal

[11] This point was suggested us by an anonymous referee. We would like to express gratitude for his suggestion.

diagonal elements, representing the intra-regional distances, were decreased in the inter-regional distances matrix. Another experiment shortened the intra-regional distances by 10 percent for the eight rich regions only. Finally, the last experiment reduced the intra-regional distances by 10 percent for the four poor regions. These three experiments generate null results (zero percent variation) at both the aggregate and regional levels. Our conclusion is that high-level inter-regional transport improvements reduce inter-regional inequalities, but not at the expense of increasing intra-regional inequalities. This is an interesting finding because it differs from the findings for European transport improvements (see Puga 2002). However, it should be noted that were these experiments conducted on an actual network, different results might be obtained since the spatial distribution of the intra-regional network is unlikely to be uniform.

In this sense, there would appear to be an opportunity to craft transportation policies that can promote regional equity, since these policies focusing on investments that link poor regions to rich ones so that the former can enjoy the integration benefits.

<< insert figure 3 here >>

<< insert figure 4 here >>

<< insert figure 5 here >>

5. CONCLUSIONS

Demonstrating empirically the relationship between transport and regional equity is very difficult. In the literature, the evidence about this relationship is often contradictory, although it would appear to be the case that most of the problems stem from methodological discrepancies. In this paper, an alternative approach was followed by adopting a parsimonious model strategy. We kept constant the theoretical model, the method of investigation, as well as its specification; only the spatial structure of the provision of transport infrastructure (captured through reductions in transportation costs) was changed. The results obtained can be summarized as follows.

In the case of Minas Gerais, if the transport infrastructure improvement is just among poor regions, the promotion of the regional equity is insignificant. This might be the preferred strategy for policy-maker intent on enhancing welfare levels in the least prosperous regions. If the transport infrastructure improvement links only rich regions, there is an increase of regional income inequalities. If the improvement happens to the roads linking poor regions and rich ones, there is a promotion of regional equity with a similar result when improvements are made to all road links of the state.

The explanation of this outcome derives from the fact that the poorer regions in Minas Gerais benefit more from enhanced economic integration with the richer regions that have a larger market size. In this context, the transportation cost reduction is able to diminish interregional trade barriers. The advantages from this integration are represented in a situation in which there are more opportunities of trade creations than trade diversions. With road infrastructure improvements, it seems that poor regions are capable of replacing domestic production for goods from the other regions with a cost advantage. This cost advantage is due to two different sources. Firstly, the production conditions are better in the importing regions. With a new road or a road improvement, these more inexpensive goods are available in the poor regions. The second source comes from the intrinsic reduction of transportation costs by means of "distance shortening". Of course, in a more complete model, some consideration would have to be given to the possibility of scale effects manifesting themselves with the more prosperous regions accumulating production (the core) at the expense of the less prosperous regions (the periphery). In this case, the spatial welfare outcomes may be more complicated to trace, especially if further distinctions are made to both the composition of final demand and value added.

This paper provides an opportunity to explore the sensitivity of the results to alternative spatial mixes of improvements in transport infrastructure provision. Even controlling for the methodological aspects and study site, the effects of transport infrastructure on regional equity in Minas Gerais are extremely sensitive to spatial structure. As noted earlier, the penchant for a policy maker to target these prosperous regions needs to be re-evaluated when the nature of the investment has the capacity to change the spatial structure of the economy. In this regard, an investment in a new firm in a poor region may not generate the same welfare gains as a similar investment in transportation improvements linking this region to more prosperous neighbors. Our findings indicate clear evidence that this issue depends substantially upon the spatial structure of the links. The nature of the relationship between road infrastructure improvement and regional equity depends strongly on "where the road comes from and where it goes to." A more sophisticated network-based model would be able to trace the impacts of improvements in a link in a network (i.e., increasing capacity or reducing travel times) as opposed to constructing a new link.

The model also enables investigation of the trade-off between economic performance and regional equity. Our findings reveal that this kind of trade-off exists in Minas Gerais. The experiment that is more capable of reducing the regional income inequalities yields the smallest aggregate impact on several variables, such as welfare gains, production, final demand, exports and imports. Accordingly, we return to the issue raised in the introduction that the policy maker faces of addressing the overall competitiveness of the state vis a vis regional equity issues. In the Minas Gerais case, there would be strong pressure to enhance connectivity from the more prosperous southern and central regions with the states of São Paulo and Rio de Janeiro,[12] but, as the analysis in this paper demonstrates, the "spillover" welfare gains on the less prosperous north are small or negative. Clearly, additional experimentation would be required in an attempt to uncover some possible strategy that would accomplish both objectives. However, in the case, it would be necessary to explore specific links rather than the stylized network employed in this paper.

While the results are interesting, these findings need to be regarded cautiously, inasmuch as the model presents clear drawbacks. First, the model assumes perfect competition, the same production technology in all regions and constant returns to scale. These assumptions provide neutrality in the impact of transport improvement linking richer and poorer regions. If these assumptions are not valid, then greater economic integration might give rise to important linkage effects, which may modify the nature of the impact among the regions. Besides, it is possible that increasing returns to scale will generate changes in prices, cost advantages and/or backward linkages differently across the regions, benefiting the richer ones, which could be able to capitalize on the transport improvements more effectively.[13]

Obviously, further work is needed to investigate whether the pattern of the sensitivity to the results of alternative spatial mixes of improvements in transport infrastructure provision remains the same with the incorporation of imperfect competition and increasing returns to scale.

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[12] São Paulo is Brazil's first richest state, while Rio de Janeiro is the country's second richest state.

[13] This point was suggested us by an anonymous referee. We would like to express gratitude for his suggestion.

In addition, the relationship between increasing returns to scale and agglomeration and location, as well as the labor mobility and migrations, as studied in the New Geography literature [Krugman (1991); Krugman and Venables (1995); Venables (1996); Fujita *et al*. (1999)], are absent in our discussion, because of the limitations of the model. However, these issues might also modify the results obtained.

From the spatial standpoint, the results were obtained using an iceberg model, adopting across the board transport cost reductions, which is more informative within a macro-regional context. Future research needs to analyze the trade-off between economic performance and regional equity in the presence of transport cost changes, using a CGE model containing an explicit network representation, which could pinpoint specific road links to host the transport improvement. Indeed, a model with a network representation can be more informative specially in the micro-regional context, since the spatial distribution of welfare gains due to transport cost to specific routes may be different from the across the board reductions, as implemented in this paper. Once again, it would be interesting to check if the findings from this paper are not sensible for other forms of incorporating transport costs into a CGE model.

The type of investigation proposed here is promising in terms of regional policy, but future research is needed to address the other relevant issues absent in our discussion before advancing the outcomes from the present paper as the foundations for policy initiatives.

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APPENDIX

LIST OF EQUATIONS AND VARIABLES OF THE MINAS-SPACE MODEL

A.1 Variables

Indices

j	J	Number of sectors (output goods)
i	I	Number of sectors (*pool goods*)
r	R	Number of regions (source regions)

s	S	Number of regions (destination regions)
k	K	Number of primary factors
l	L	Number of external regions

***Endogenous Variables*:**

Quantities:

x_s^j	JxS	Output of sector *j* in region s
x_r^i	IxR	Output of sector i in region r
d_s^i	IxS	Final demand for good *i* in region s
m_l^i	IxL	Imports of good *i* from external region *l*
e_l^i	IxL	Exports of good *i* to external region *l*
e_{rl}^i	IxRxL	Regional export of good *i* from domestic region *r* to external region *l*

Prices:

p_s^j	JxS	Price of one output unit of sector *j* in region *s*
p_r^i	IxR	Price of one output unit of sector i in region r
q_s^i	IxS	Price of one unit of *pool good* of sector *i* in region *s*
q_l^{Ei}	IxL	Price of one unit of export good *i* in external region *l*
p_l^{Mi}	IxL	Price of one unit of import good of sector *i* in external region *l*
w_s^k	KxS	Price of one unit of primary factor *k* in region *s*
r	1	Price index

IO Coefficients

a_s^{ij}	IxSxJ	Demand for *pool goods i* to produce one unit output in sector *j* in region *s*
c_s^{kj}	JxSxK	Demand for primary factor *k* to produce one unit output in sector *j* in region *s*
c_r^{kj}	JxRxK	Demand for primary factor *k* to produce one unit output in sector *j* in region *r*
c_r^{ki}	IxRxK	Demand for primary factor *k* to produce one unit output in sector *i* in region *r*
t_{rs}^i	IxSxR	Demand for output goods *i* in region *r* to produce one unit of *pool good i* in region *s*
t_{ls}^{Mi}	IxLxS	Demand for imports from external region *l* to produce one unit of pool goods *i*

		in region *s*
t_{rl}^{Ei}	IxRxL	Demand for output goods *i* in region *r* to produce one unit export goods *i* in external region *l*

Income and utility

y_s	Sx1	Real income of the representative household in region *s*
u_s	Sx1	Level of utility of the representative household in region *s*
ch_s	Sx1	Expenditure needed to reach one unit of utility in region *s*
eh_s	Sx1	Total expenditures of the representative household in region *s*

Position parameters

Parameters

α^{ij}	JxI	Position vector of CES function: production – intermediary inputs
γ^{kj}	KxJ	Position vector of CES function: production – primary inputs
δ^{i}	1xI	Position vector of CES function: households
ϑ_r^{i}	IxR	Position vector of CES function: transport
ϑ_l^{Mi}	IxL	Position vector of CES function: imports
π_l^{i}	IxL	Import supply parameter
τ_l^{i}	IxL	Export demand parameter

Quantities:

f_r^{k}	RxK	Primary inputs *k* in region *r*
f_s^{k}	SxK	Primary inputs *k* in region *s*

Elasticities

σ_P^{j}	I	Elasticity de substitution – production
σ_M^{i}	I	Elasticity de substitution – transport imports vs. domestic goods
σ_T^{i}	I	Elasticity de substitution – transport
σ_H	1	Elasticity de substitution – households
μ_l^{i}	IxL	Price elasticity of foreign import supply

ε_l^i	IxL	Price elasticity of foreign export demand

Parameters

λ_l^{Mi}	IxL	Import supply shift parameter
λ_l^{Ei}	IxL	Export demand shift parameter

Miscellaneous

η^i	I	Transport rate
z_{rs}	RxS	Interregional distances between domestic regions
z_{ls}	LxS	Distance from external region *l* to domestic region s
z_{rl}	RxL	Distance from domestic region *r* to external region *l*
er	1	Exchange rate

A.2 Equations

A.2.1 Firms

Unit-cost functions:

$$p_s^j = \left(\sum_{i=1}^{I} q_s^i \Phi_P^{ij} + p_{ws}^j \Phi_{PK}^{kj} \right) \cdot \left(\sum_{i=1}^{I} \alpha^{ij} + \sum_{k=1}^{K} \gamma^{kj} \right)$$

where

$$\Phi_P^{ij} = \frac{\alpha^{ij}}{\sum_{i=1}^{I} \alpha^{ij} + \sum_{k=1}^{K} \gamma^{kj}} \ , \ \Phi_{PK}^{kj} = \frac{\sum_{k=1}^{K} \gamma^{kj}}{\sum_{i=1}^{I} \alpha^{ij} + \sum_{k=1}^{K} \gamma^{kj}} \ , \text{ and } \ p_{ws}^j = \left[\sum_{k=1}^{K} \left(w_s^{k(1-\sigma_P^j)} \frac{\gamma^{kj}}{\sum_{k=1}^{K} \gamma^{kj}} \right) \right]^{\frac{1}{1-\sigma_P^j}}$$

IO coefficients intermediary inputs:

$$a_s^{ij} = \Phi_P^{ij} \left(\sum_{i=1}^{I} \alpha^{ij} + \sum_{k=1}^{K} \gamma^{kj} \right) = \alpha^{ij}$$

where

$$\Phi_P^{ij} = \frac{\alpha^{ij}}{\sum_{i=1}^{I}\alpha^{ij} + \sum_{k=1}^{K}\gamma^{kj}}$$

IO coefficients primary inputs:

$$c_s^{kj} = \left(\sum_{k=1}^{K}\left(w_s^{k(1-\sigma_P^j)}\frac{\gamma^{kj}}{\sum_{k=1}^{K}\gamma^{kj}}\right)\right)^{\frac{1}{1-\sigma_P^j}-1} w_s^{k-\sigma_P^j}\gamma^{kj}$$

A.2.2. Transport

Unit-cost functions:

$$q_s^i = \left[p^{i(1-\sigma_M^i)}\phi_T^{ir} + \sum_{l=1}^{L}\left(p_l^{Mi}e^{(\eta^i z_{ls})}\right)^{(1-\sigma_M^i)}\phi_M^{il}\right]^{\frac{1}{1-\sigma_M^i}}\left(\sum_{r=1}^{R}\vartheta_r^i + \sum_{l=1}^{L}\vartheta_l^{Mi}\right)$$

where

$$\phi_T^{ir} = \frac{\sum_{r=1}^{R}\vartheta_r^i}{\sum_{r=1}^{R}\vartheta_r^i + \sum_{l=1}^{L}\vartheta_l^{Mi}}, \quad \phi_M^{il} = \frac{\vartheta_l^{Mi}}{\sum_{r=1}^{R}\vartheta_r^i + \sum_{l=1}^{L}\vartheta_l^{Mi}} \text{ and } p^i = \left(\sum_{r=1}^{R}\left(p_r^i e^{(\eta^i z_{rs})}\right)^{(1-\sigma_T^i)}\frac{\vartheta_r^i}{\sum_{r=1}^{R}\vartheta_r^i}\right)^{\frac{1}{1-\sigma_T^i}}$$

IO coefficients transport:

$$t_{rs}^i = \left[p^{i(1-\sigma_M^i)}\phi_T^{ir} + \sum_{l=1}^{L}\left(p_l^{Mi}e^{(\eta^i z_{ls})}\right)^{(1-\sigma_M^i)}\phi_M^{il}\right]^{\frac{1}{1-\sigma_M^i}-1}\left(\sum_{r=1}^{R}\left(p_r^i e^{(\eta^i z_{rs})}\right)^{(1-\sigma_T^i)}\frac{\vartheta_r^i}{\sum_{r=1}^{R}\vartheta_r^i}\right)^{\frac{-\sigma_M^i+\sigma_T^i}{1-\sigma_T^i}} \vartheta_r^i\left(p_r^i e^{(\eta^i z_{rs})}\right)^{-\sigma_T^i} e^{(\eta^i z_{rs})}$$

IO coefficients imports:

$$t_{ls}^{Mi} = \left(p^{i(1-\sigma_M^i)} \phi_T^{ir} + \sum_{l=1}^{L} (p_l^{Mi} e^{(\eta^i z_{ls})})^{(1-\sigma_M^i)} \phi_M^{il} \right)^{\frac{1}{1-\sigma_M^i}-1} (p_l^{Mi} e^{(\eta^i z_{ls})})^{-\sigma_M^i} e^{(\eta^i z_{ls})} \vartheta_l^{Mi}$$

A.2.3. Households

Incomes:

$$y_s = \sum_{k=1}^{K} f_s^k w_s^k$$

Unit expenditure functions:

$$ch_s = ch_s(q_s^i, \delta^i) = \left(\sum_{i=1}^{I} q_s^{i\,(1-\sigma_H)} \frac{\delta^i}{\sum_{i=1}^{I} \delta^i} \right)^{\frac{1}{1-\sigma_H}} \sum_{i=1}^{I} \delta^i$$

Total expenditures:

$$eh_s = ch_s(q_s^i, \delta^i) u_s = \left(\sum_{i=1}^{I} q_s^{i\,(1-\sigma_H)} \frac{\delta^i}{\sum_{i=1}^{I} \delta^i} \right)^{\frac{1}{1-\sigma_H}} \sum_{i=1}^{I} \delta^i u_s$$

Budget restrictions:

$$y_s = eh_s(q_s^i, u_s) = ch_s(q_s^i, \delta^i) u_s$$

Final demands:

$$d_s^i = y_s \frac{\delta^i}{\left(\sum_{i=1}^{I} q_s^{i\,(1-\sigma_H)} \delta^i \right) q_s^{i\,\sigma_H}}$$

A.2.4. Foreign sector

Foreign export demand function:

$$e_l^i = \lambda_l^{Ei} \tau_l^i \left(\frac{q_l^{Ei}}{er} \right)^{-\varepsilon_l^i}$$

Foreign export prices:

$$q_l^{Ei} = \left(\sum_{r=1}^{R} \left(p_r^i e^{(\eta^i z_{rl})} \right)^{(1-\sigma_T^i)} \frac{\vartheta_r^i}{\sum_{r=1}^{R} \vartheta_r^i} \right)^{\frac{1}{1-\sigma_T^i}} \sum_{r=1}^{R} \vartheta_r^i$$

IO coefficients exports:

$$t_{rl}^{Ei} = \left(\sum_{r=1}^{R} \left(p_r^i e^{(\eta^i z_{rl})} \right)^{(1-\sigma_T^i)} \frac{\vartheta_r^i}{\sum_{r=1}^{R} \vartheta_r^i} \right)^{\frac{1}{1-\sigma_T^i}-1} \left(p_r^i e^{(\eta^i z_{rl})} \right)^{-\sigma_T^i} e^{(\eta^i z_{rl})} \vartheta_r^i$$

Regional export demand:

$$e_{rl}^i = t_{rl}^{Ei} e_l^i$$

Foreign import supply functions:

$$m_l^i = \lambda_l^{Mi} \pi_l^i \left(\frac{p_l^{Mi}}{er} \right)^{\mu_l^i}$$

A.2.5. Equilibrium condition

$$x_r^i = \sum_{s=1}^{S} t_{rs}^i (d_s^i + \sum_{j=1}^{J} a_s^{ij} x_s^j) + \sum_{l=1}^{L} t_{rl}^{Ei} e_l^i$$

A.2.6. Market clearing conditions:

Factor markets:

$$\sum_r f_r^k = \sum_i c_r^{ki} x_r^i$$

Import goods:

$$m_l^i = \sum_{s=1}^{S} t_{ls}^{Mi} \left(d_s^i + \sum_{j=1}^{J} a_s^{ij} x_s^j \right)$$

Table 1: Area, Population and Production in Minas Gerais,1996 (in %)

Region	*Area*	*Population*	*Production*
1. North			
Noroeste	10.7	1.9	1.6
Norte	21.7	8.7	4.4
Jequitinhonha	8.6	4.1	1.1
Vale do Mucuri	3.4	2.4	1.0
2. South			
Triângulo/Alto Paranaíba	15.5	10.2	11.7
Central	5.4	2.2	1.6
RMBH	6.7	29.9	44.6
Vale do Rio Doce	7.2	9.0	9.1
Oeste	4.1	4.6	3.8
Sul/Sudoeste	8.5	12.5	10.9
Campo das Vertentes	2.1	2.9	1.9
Zona da Mata	6.1	11.6	8.3

Source: IBGE.

Table 2: HDI-M for the States of Brazil and its dispersion in 2000

State	*HDI-M*	*Rank*	*Dispersion*	*Rank*
Acre	0.625	21	0.071	1
Amazonas	0.618	23	0.066	2
Pernambuco	0.626	19	0.057	3
Roraima	0.679	14	0.057	4
Minas Gerais	0.719	11	0.056	5
Tocantins	0.661	16	0.049	6
Pará	0.671	15	0.047	7
Maranhão	0.581	27	0.047	8
Piauí	0.587	25	0.046	9
Alagoas	0.583	26	0.045	10
Paraíba	0.592	24	0.044	11
Sergipe	0.621	22	0.043	12
Amapá	0.698	13	0.043	13
Rio Grande do Norte	0.637	17	0.043	14
Bahia	0.626	20	0.043	15
Paraná	0.740	7	0.040	16
Mato Grosso	0.738	8	0.040	17
Goiás	0.735	9	0.038	18
Espírito Santo	0.730	10	0.038	19
Ceará	0.631	18	0.038	20
Rio Grande do Sul	0.783	2	0.036	21
São Paulo	0.779	3	0.034	22
Mato Grosso do Sul	0.740	6	0.034	23
Rio de Janeiro	0.760	4	0.033	24
Rondônia	0.706	12	0.029	25
Santa Catarina	0.791	5	0.021	26
Distrito Federal	0.845	1	0.000	27
Brazil	0.699	-	0.084	-

Source: IPEA/UNDP.

Map 1: HDI-M for Minas Gerais in 2000

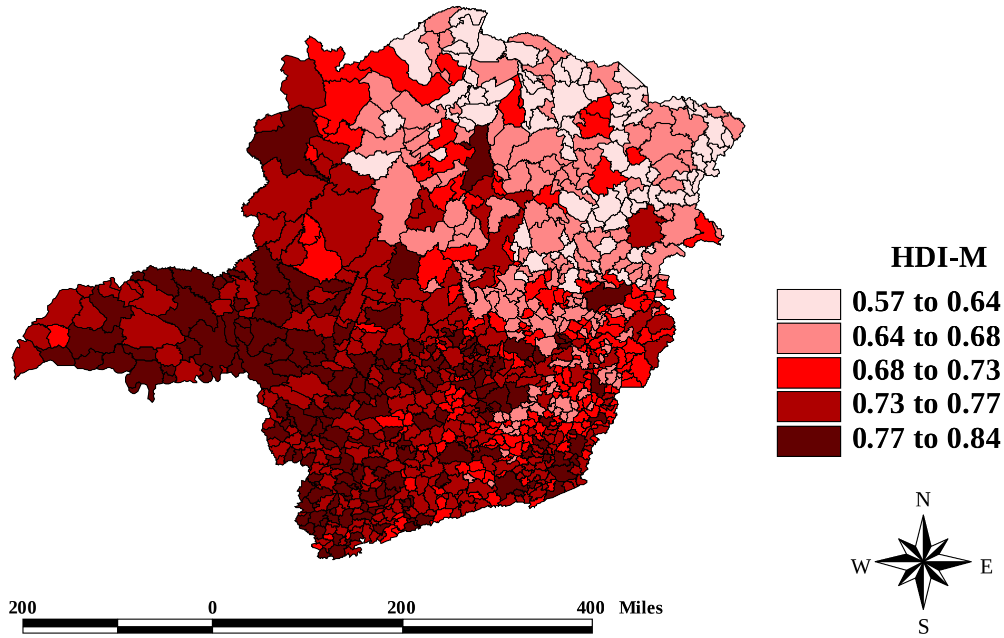

Figure 1: Economic Agents and Activities in the Model

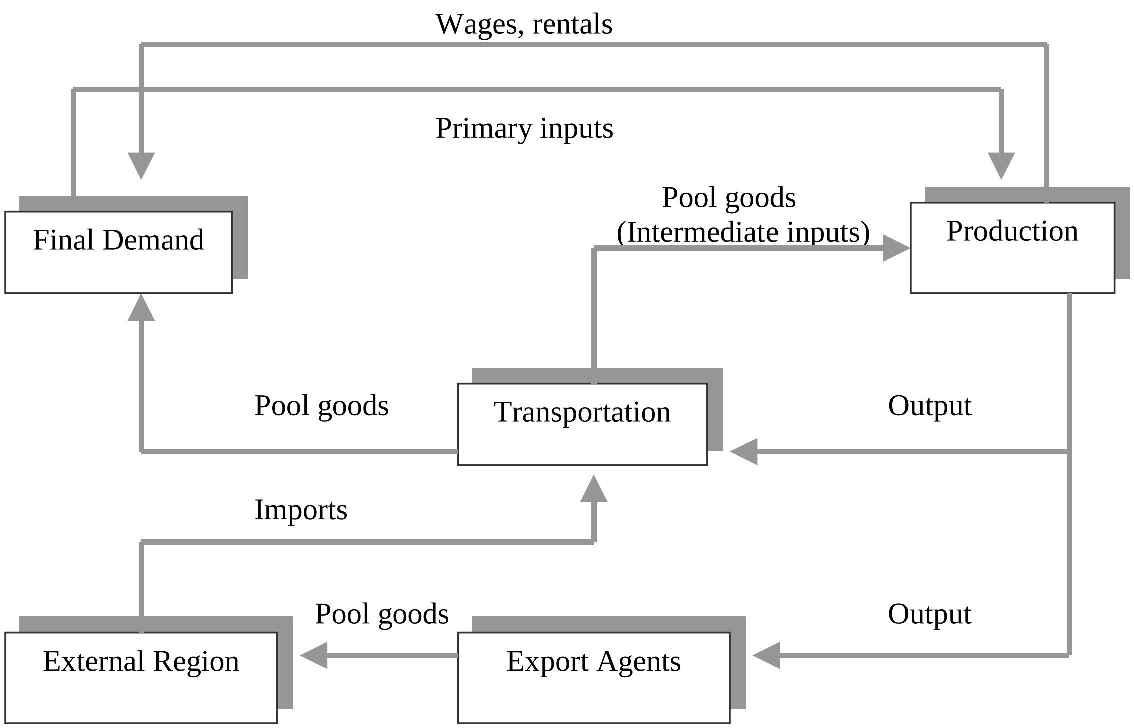

Figure 2: The Driving Forces of the MINAS-SPACE at the Aggregate Level

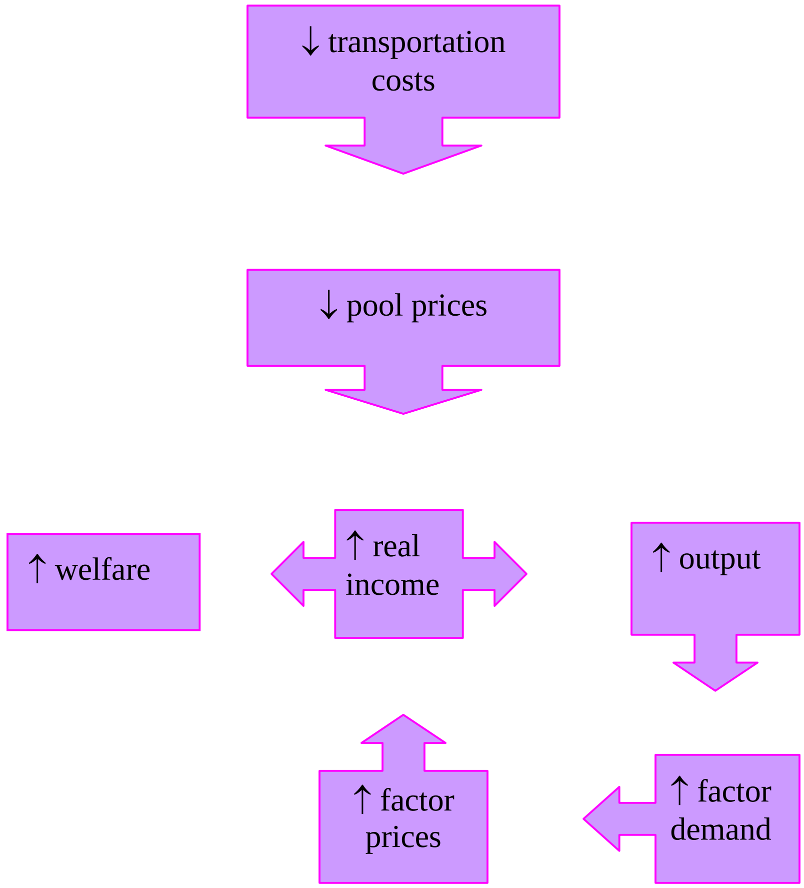

Table 3: Aggregate Results of the Model (in %)

	"All"	*"North"*	*"South"*	*"North-South"*
Quantities				
Total exports	0.00	0.00	0.00	0.00
Total imports	-0.01	0.00	-0.01	0.00
Domestic production	0.00	0.00	0.00	0.00
Pool goods production	0.06	0.00	0.05	0.01
Final demand	0.09	0.00	0.08	0.01
Relative Prices				
Prices of total exports	0.04	0.00	0.04	0.01
Prices of total imports	0.06	0.00	0.05	0.00
Production prices	0.05	0.00	0.04	0.01
Pool prices	-0.01	0.00	-0.01	0.00
Wage	0.10	0.00	0.09	0.01
Other factor price	0.10	0.00	0.09	0.01
Other Results				
Welfare gains	0.10	0.00	0.09	0.01
Gini index	-0.18	-0.01	0.16	-0.33
Price index	-0.06	0.00	-0.05	-0.01

Table 4: Regional Results of the Model

	Welfare			
	"All"	*"North"*	*"South"*	*"North-South"*
Noroeste	0.37	0.01	-0.09	0.45
Norte	0.29	0.01	-0.09	0.38
Jequitinhonha	0.31	0.01	-0.08	0.39
Vale do Mucuri	0.35	0.01	-0.10	0.43
Triângulo/Alto Paranaíba	0.25	0.00	0.25	0.00
Central	0.11	0.00	0.12	-0.01
RMBH	0.04	0.00	0.04	0.00
Vale do Rio Doce	0.22	0.00	0.22	0.00
Oeste	0.07	0.00	0.07	0.00
Sul/Sudoeste	0.15	0.00	0.15	0.00
Campo das Vertentes	0.11	0.00	0.10	0.00
Zona da Mata	0.15	0.00	0.15	0.00
Average	0.20	0.00	0.06	0.14
Standard Deviation	0.11	0.00	0.13	0.20
Maximum	0.37	0.01	0.25	0.45
Minimum	0.04	0.00	-0.10	-0.01

Figure 3: Welfare Gains of the Experiment "All"

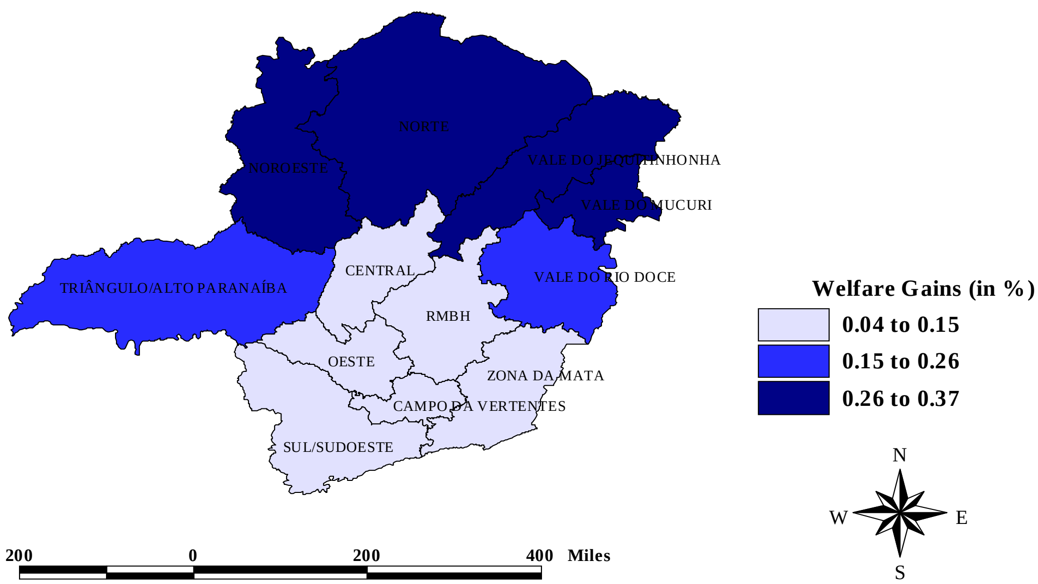

Figure 4: Welfare Gains of the Experiment "South"

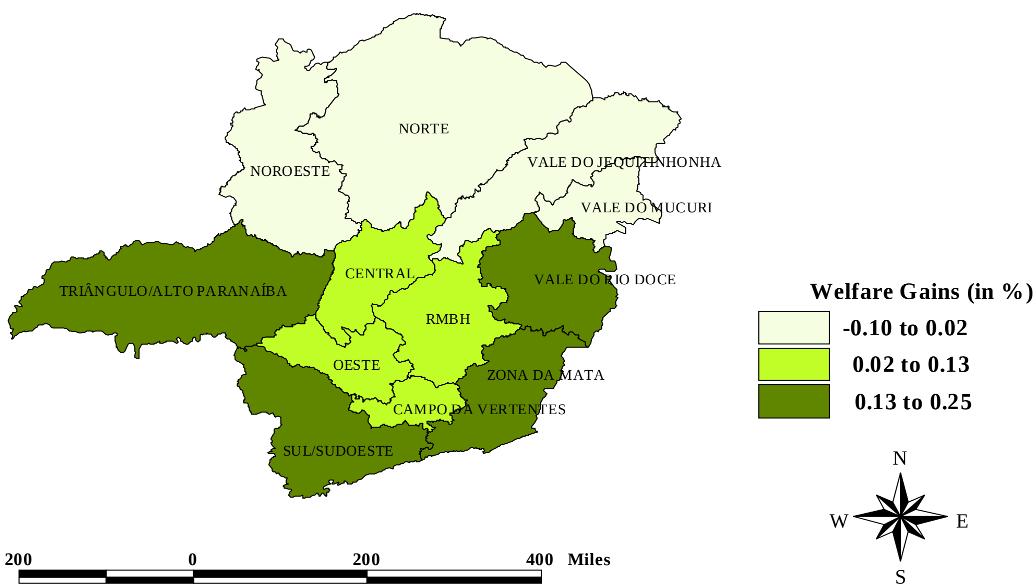

Figure 5: Welfare Gains of Experiment "North-South"