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Do Economic Integration and Fiscal Competition Help to Explain Local Patterns?

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Do Economic Integration and Fiscal Competition Help to Explain Location Patterns?*

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Abstract

Do trade integration and fiscal competition contribute to shape the economic landscape? The answer is *yes*. This paper uses a theoretical model and an econometric analysis of Brazilian regional manufacturing employment data over the period 1990-1998 to address this question. Brazil is a natural case study because this country liberalized trade during the 1990s and their sub-national governments engaged in a fiscal dispute. Econometric results show that trade liberalization has had an impact on spatial developments and this effect is increasing over time. Moreover, subsidies also exert an influence, but their relative importance is falling.

Keywords: Economic Integration, Fiscal Competition, Location Patterns, Manufacturing Industries, Brazil

JEL Classification: F12, F15, H32, H71, R12, R30, R58

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1 Introduction

Many developing countries have implemented important trade liberalization programs since the mid-1980s. In addition, regional trade agreements have proliferated in recent years. 42 trade agreements were notified to the WTO between 1991 and 1995 and 58 between 1996 and 2000. Moreover, trade within these blocs accounts for a substantial fraction of world trade and virtually all WTO-countries are members of an agreement in the form of a free trade zone or a customs union. According to Fernández-Arias *et al.* (2001), the world has also witnessed increased competition between governments for attracting economic activities. The scope of this competition is global but at the same time largely intra-regional. More fundamentally, Oman (2000) states that sub-national governments seem to play an important role as competitors for activities in federal countries.

Trade integration and fiscal competition are important factors shaping a country's internal economic geography because they induce changes in the relative profitability of alternative locations. However, existing evidence of this phenomenon is rather limited.[1]

Brazil provides an interesting natural case study for several reasons. First, the country opened its economy on both a unilateral basis and a preferential basis in the framework of MERCOSUR, a regional trade bloc formed by Argentina, Brazil, Paraguay and Uruguay in 1991. Second, as reported in Goncalves Cavalcanti and Prado (2000), Brazilian states engaged increasingly in fiscal competition to attract manufacturing activities, which relates to the federal dimension of the country. Furthermore, the location implications of trade liberalization and fiscal disputes are relevant matters of concern for economic policy especially when pre-existing regional disparities are large. Indeed, these large disparities are a distinctive feature of the Brazilian economy.

This paper analyzes the influence of economic integration and fiscal competition on manufacturing location patterns. I use a *New Economic Geography* model and then test the resulting hypotheses on

[1] For example, Hanson (1998) examines the spatial implications of Mexican trade liberalization in the mid-1980s. In addition, although there are many studies on the influence of taxes on the geographical distribution of firms in the United States, e.g., Papke (1991), Hines (1996); and some recent contributions on Switzerland, e.g., Feld and Kirchgässner (2003); evidence for other (especially developing) federal countries is scarce.

Brazilian data over the period 1990-1998 following an econometric approach similar to that of Midelfart-Knarvik *et al.* (2000) and Overman *et al.* (2000). One main question is addressed in this paper: Do economic integration and fiscal competition help to explain manufacturing location patterns?

The rest of the paper is organized as follows. Section 2 sets out the theoretical framework based on an extended version of the "Footloose Capital Model" presented in Martin and Rogers (1995) and Baldwin *et al.* (2003). Section 3 describes the dataset. Section 4 presents a descriptive examination of manufacturing location patterns in Brazil. Section 5 reports and discusses the results of the econometric analysis. The results show that industries with highly tradable products tend to locate in states which are nearer to Argentina. This effect seems to be increasing over the decade studied, as economic integration proceeds. Moreover, trade liberalization has strengthened the tendency of industries to locate in states with better infrastructure and has weakened demand linkages. The evidence also suggests that subsidy policies have an influence on location patterns. This influence is, however, declining over time. Section 6 concludes.

2 Theoretical Framework

New Economic Geography models show that, in the presence of trade costs and increasing returns, initially similar regions may endogenously differentiate through a circular causation mechanism.[2] These models are, however, difficult to solve algebraically and hence generally require the use of simulation methods to obtain results. One simpler variant is the so-called "Footloose Capital Model" (FC), which has been developed in Martin and Rogers (1995) and Baldwin *et al.* (2003). This model and several of its extensions are aimed at examining the influence of specific factors on location decisions (e.g., infrastructure quality, subsidies, vertical linkages, and relative factor endowments) rely usually on a two-region setting. Since this paper focuses on the impact of trade liberalization on the internal economic geography of a country, a three-region framework is more appropriate and will be used to derive testable hypotheses. This section therefore introduces an extended FC model and highlights the role of economic integration and fiscal competition in shaping manufacturing location patterns.

[2] See, e.g., Krugman (1991); Venables (1996); and Fujita *et al.* (1999)

2.1 The Basic Model

Assumptions

The model assumes an economy with three regions: *1* and *2*, which are regions within the home country, and *3*, a foreign country. There are two sectors: *agriculture*, which produces a homogenous good under constant returns to scale in a perfectly competitive environment and whose output is costlessly traded, and *industry*, which produces differentiated goods under increasing returns to scale in a monopolistically competitive environment à la Dixit and Stiglitz (1977). Industry output faces iceberg interregional (international) trade costs (Samuelson, 1954) $\tau > 1$ ($\delta > \tau \geq 1$) so that firms must ship $\tau > 1$ units of the industrial good in order to sell one unit in the other region of the same country and $\delta > 1$ units in the other country. There are two production factors: *capital, K*, which is mobile across regions and *labor*, *L*, which is immobile across regions.[3] Total supplies of both factors are fixed, K^T and L^T, respectively.

The presented analysis concentrates on the location of industry. The agricultural sector is thus kept as simple as possible. In particular, it uses only a_A units of labor to produce one unit of output. As a consequence, the other sector, industry, intensively uses the mobile factor, *K*.

Three particular aspects related to capital are worth mentioning. First, capital owners are assumed to be completely immobile across regions so that even when physical capital moves, rewards are repatriated to the region of origin. Second, the spatial separation between physical capital and its owner requires to distinguish between the share of total capital owned by residents in region *1*, $s_K^1 \equiv K^1/K^T$ from the share of total capital employed in the region which is assumed to be equal to the region's share of total industry, $s_n^1 \equiv n^1/n^T$. Third, the cost function of industrial firms displays different factor intensities for fixed and variable costs. The fixed cost only involves capital whereas variable cost only involves labor. Formally, each industrial firm requires one unit of *K* and a_M units of labor per unit of output. Thus, the cost function has the following form:

[3] Incorporating labor mobility into the present framework would generate a model allowing for the analysis of phenomena such as "catastrophic agglomeration". Nevertheless, no additional insights would be produced for this paper because this model yields essentially similar qualitative results and comes at the expense of a lower analytical tractability. A similar assumption is made by Monfort and van Ypersele (2003).

$$C^1(x) = \pi^1 + w^1 a_M x^1 \quad (1)$$

where π^1 and w^1 are the rewards to capital and labor, respectively; a_M is the variable unit input requirement; and *x* is the firm-level output.

The typical consumer has a two-tier utility function with a Cobb-Douglas function determining a (constant) division of expenditure between the homogeneous good and the differentiated goods and a CES function defining tastes over industrial varieties. Formally:

$$U^1 = \left(C_M^1\right)^{\mu}\left(C_A^1\right)^{1-\mu} = \left(\int_0^{n^T} (c_j^1)^{1-1/\sigma} dj\right)^{\mu/(1-1/\sigma)} \left(C_A^1\right)^{1-\mu} \quad (2)$$

where C_M^1 and C_A^1 are consumption of the composite of manufacturing sector varieties and consumption of the agricultural sector good, respectively; n^T is the mass of total available industrial varieties, μ is the expenditure share on industrial varieties, and σ is the constant elasticity of substitution between any two varieties with $0 \langle \mu \langle 1 \langle \sigma$. The corresponding indirect utility function V^1 is given by:

$$V^1 = \frac{E^1}{P^1} = \frac{E^1}{\left(p_A^1\right)^{1-\mu}\left(\Delta n^T\right)^{\mu/(1-\sigma)}} \quad (3)$$

where E^1 denotes expenditure in region *1*, *P* is the “perfect” price index, p_A^1 is the price of the agricultural good; $\Delta \equiv \int_0^{n^w} \left(p_j^1\right)^{1-\sigma} dj \Big/ n^T$ where p_j^1 is the consumer price of industrial variety *j* in region *1*.[4] Notice that expenditure is equal to income since the model does not consider savings.

Physical capital looks for the highest nominal reward rather than the highest real reward because its income is spent in the region where the owners reside.[5] Therefore, interregional flows of capital take place according to:

$$\hat{s}_n^1 = \left(\pi^1 - \overline{\pi}\right)\left(1 - s_n^1\right)s_n^1 \quad (4)$$

where $\overline{\pi}$ is the average return to capital and s_n^1 is the share of industry located in region *1*. Definitions for regions *2* and 3 are analogous and denoted by superscripts *2* and *3,* respectively.

As shown in Appendix A1.A using the demand functions and the price policy of firms, the following equilibrium expressions for π^1, π^2 *and* π^3 can be derived:

[4] *P* is the perfect price index in the sense that real income defined with *P* measures utility.

[5] Nominal reward is the reward in terms of the *numeraire*, the agricultural good, and real reward is reward in terms of the composite industrial good.

$$\pi^1 = b\left(\frac{s_E^1}{s_n^1 + \phi_R s_n^2 + \phi_N s_n^3} + \frac{\phi_R s_E^2}{\phi_R s_n^1 + s_n^2 + \phi_N s_n^3} + \frac{\phi_N s_E^3}{\phi_N s_n^1 + \phi_N s_n^2 + s_n^3}\right)\frac{E^T}{K^T} \tag{5.1.}$$

$$\pi^2 = b\left(\frac{\phi_R s_E^1}{s_n^1 + \phi_R s_n^2 + \phi_N s_n^3} + \frac{s_E^2}{\phi_R s_n^1 + s_n^2 + \phi_N s_n^3} + \frac{\phi_N s_E^3}{\phi_N s_n^1 + \phi_N s_n^2 + s_n^3}\right)\frac{E^T}{K^T} \tag{5.2.}$$

$$\pi^3 = b\left(\frac{\phi_N s_E^1}{s_n^1 + \phi_R s_n^2 + \phi_N s_n^3} + \frac{\phi_N s_E^2}{\phi_R s_n^1 + s_n^2 + \phi_N s_n^3} + \frac{s_E^3}{\phi_N s_n^1 + \phi_N s_n^2 + s_n^3}\right)\frac{E^T}{K^T} \tag{5.3.}$$

where $b \equiv \mu/\sigma$, E^T is total expenditure and s_E^i is the share of expenditure in region *i*, and s_n^i is the share of region *i* in industry and, given the fact that each variety requires one unit of capital, the share of total capital employed in this region *(* $n^T = K^T$ *).* $\phi_R = \tau^{1-\sigma}$ is a measure of trade openness between regions within the same country and $\phi_N = \delta^{1-\sigma} \langle \phi_R$ is a measure of international trade openness, i.e., trade between each region in the home country and the foreign country. Thus, ϕ=0 if trade costs are infinite and $\phi = 1$ if there are no trade costs.

Equilibrium

In the long-run, capital is mobile between regions. Therefore, this long-run equilibrium requires that no capital flows take place. From Equation *(4)*, the following "locational condition" can be derived:

$$\pi^1 = \pi^2 = \pi^3 \tag{6}$$

The solution to this condition can take the following forms: $0 \langle s_n^i \langle 1$, i.e., interior outcomes where capital earns the same reward in all regions (as defined in Equation *(5)*) or $s_n^i = \{0,1\}$, i.e., core-periphery outcomes where manufacturing is concentrated in one of the regions.

In general, the share of manufacturing located in a given region is increasing in the share of expenditure accounted for by this region (*home market effect*). Clearly, industries with economies of scale prefer to settle in locations with larger markets since they can then avoid trade costs on a larger fraction of their sales. This gives rise to the following proposition:

Proposition 1: Manufacturing industries with increasing returns to scale locate in regions with larger market potentials.

The proof is provided in Appendix A1.B.

Some Extensions

What are the conditions under which the above model can generate a similar result to the standard Heckscher-Ohlin model? Assume, as in this last model, that both factors are immobile over space. In this case, even though labor rewards are equalized across regions by free trade in agricultural goods, rewards on capital may differ due to the presence of trade costs. In particular, assuming three regions with identical sizes in terms of their shares in total expenditure, from Equation *(5)*, it can be then shown that *capital-intensive manufacturing activities tend to locate in the capital-abundant region*. Thus:

Proposition 2: Industries locate in those regions that are relatively abundant in the factors that are used intensively in their production processes.[6]

Economic geography also hinges upon physical geography. In particular, regions within a country may differ in the access provided to third markets. The influence of these asymmetric locational advantages can be highlighted using the extended FC model assuming that the proximity to the foreign country differs across regions in the home country. The location of firms is then driven by two main factors: a *home market effect,* as before, *and* a *geographical effect*. The net result depends on the particular size-locational advantage distribution. If the region is relatively large and occupies a "central" position, i.e., it provides a good access to other regions' markets, both effects reinforce each other. However, if the region is relatively small, then the effects move in opposite directions. This can be translated into the following proposition:

Proposition 3: Industries locate in regions with better relative access to relevant foreign markets, provided that their local markets are large enough.

The proof is provided in Appendix A1.C.

As shown in Martin and Rogers (1995) and Baldwin *et al.* (2003), the *quality of infrastructure* is also an important factor for attracting firms as it directly affects the magnitude of transport costs. This can be easily incorporated into the analysis by assuming that firms face costs in both the local sales and external sales. Now reducing intra-regional transaction costs increases the effective size of the local market for local producers and, as previously seen a larger market attracts more firms. Thus, the following proposition can be derived:

Proposition 4: Industries locate in regions with better domestic infrastructure.

The proof is provided in Appendix A1.D.

[6] The proof is available from the author upon request.

Venables (1996) highlights the role of *vertical linkages* between activities subject to increasing returns to scale as an additional relevant location factor under the presence of trade costs. If imperfectly competitive industries are linked through an input-output structure and trade costs are positive, cost and demand linkages induce the agglomeration of downstream and upstream firms, i.e., firms in different stages of the production chain.

Appendix A1.E shows that vertical linkages can be introduced assuming that the production of a typical variety entails a fixed cost of one unit of capital and a variable cost that involves labor *and* intermediate inputs: In this case, regional market sizes, s_E^i, are endogenous, since expenditure now includes expenditure on intermediate goods by other mobile firms. These market sizes are increasing in the share of population and firms located in the region. Under positive trade costs and economies of scale, profits increase in output and output is proportional to the composite input including intermediates. Although it is not possible to get a closed form solution for the location variables s_n^i, the main forces at work can be identified.

There is one force favoring dispersion: the market crowding effect. An increase in the number of firms in a region will induce a decrease in the market share of existing firms. On the other hand, there are two forces pushing for spatial concentration. The first agglomeration force is the *cost linkage*. An increase in s_n^1 implies that more varieties are produced in region *1,* which reduces the production cost in this region and increases it in the other regions. Hence, firms prefer to be located in regions with a large industrial sector because required inputs are available at a lower price due to savings on trade costs. The second agglomeration force is the *demand linkage*. Under positive transport costs, firms buy a disproportionately large amount of intermediate goods on the domestic market. Thus, production shifting to region *1* in the form of an increase in s_n^1 is associated with expenditures shifting towards this region, raising profits there, and reducing them in the other regions. Firms selling to a large extent to industrial firms prefer to locate in regions with many industrial firms since these locations ensure a good market access. Agglomeration forces tend to prevail as relative internal trade becomes freer. In summary:

Proposition 5: Industries using intensively manufactured intermediate goods in the production process locate in regions with broad industrial bases (cost linkages).

Proposition 6: Industries whose demand comes to a large extent from the manufacturing sector locate in regions with broad industrial bases (demand linkages).

2.2 Economic Integration and Fiscal Competition

Economic Integration

Economic integration affects the spread of manufacturing industries in different ways. One important factor for these location effects is the physical geography.[7] Reduced trade costs have different impacts across regions depending on how close they are to the new market opened up by trade liberalization. Thus, Brazil's South Region, which is closest to Argentina, is likely to benefit more than other Brazilian regions from a trade agreement between both countries. In general, declining international trade costs tend to be associated with an inward flow of firms to the region providing an easier access to the foreign market as long as the region is not too small, i.e., if its locational advantage outweighs any eventual size disadvantage. This can be translated into the following proposition:

Proposition 7: A reduction in external trade costs will favor those regions with better relative access to relevant foreign markets, provided that their local markets are large enough.

The proof is provided in Appendix A1.F.

Further, as established in Proposition 4, a better infrastructure fosters industry location because it implies lower internal trade costs and thus a larger domestic market. It can be shown that this effect of infrastructure on location increases with trade liberalization. Effective prices in different markets depend on external and internal trade costs. Reduced international trade costs imply that the relative price of goods produced in the region with better infrastructure falls and thus induces a higher demand for the goods produced there.

Proposition 8: A reduction in external trade costs intensifies the tendency of industries to locate in regions with better domestic infrastructure.

The proof is provided in Appendix A1.G.

Venables (2001) argues that vertical linkages depend on the structure of the input-output matrix as well as on the tradability of the involved products. Krugman and Livas Elizondo (1996) state that economic integration, by increasing the share of inputs and outputs that may be exported and imported, on average tends to weaken cost and demand linkages within a country. The net result hinges upon the strength of inter-industry production relationships. Thus, industries with a high share of intermediate

[7] Hanson (1998) shows that the locational shift of Mexican manufacturing sector towards regions bordering with the United States that took place after the opening of the economy can be explained by the better access they provide to this relevant foreign market.

manufactured inputs in their production will show less pronounced changes as trade is liberalized than those using a relatively small amount of industrial inputs. This leads to the following proposition:

Proposition 9: A reduction in external trade costs will weaken cost and demand linkages within a country.

Fiscal Competition

Under certain circumstances regional subsidy policies will influence location decisions by firms. Martin and Dupont (2003) highlight that subsidies have two kinds of effect on the spatial patterns of economic activities: a direct impact relating to the increased profitability of the firms located in the region granting the subsidy and an indirect effect through the associated changes in the spatial distribution of expenditures, which in turn depends on the spread of capital ownership over space and that of the taxes financing the subsidy. This sub-section focuses on the first-order effects of subsidies on location using a partial equilibrium approach.

As expected, the first-order effect is positive, i.e., subsidies induce a re-location towards the conceding region because they increase the relative profitability of being settled in that region. Given the presence of trade costs, this relocation effect is generally increasing in the region's market size. The following proposition is thus derived:

Proposition 10: Industries with increasing returns to scale locate in regions ensuring more favorable fiscal conditions. This effect is more pronounced if these regions also have large home markets.

The proof is provided in Appendix A1.H.

The traditional tax competition literature shows that other regions may react to this policy by also offering subsidies. A so-called *race to the bottom* thus develops. Wilson (1999) contends that regions symmetric in size will end up conceding a tax break of the same size and the spatial equilibrium will be unaffected. Similarly, one could think that smaller regions provide larger subsidies to compensate for their size disadvantage or that larger regions concede tax breaks that, given their dimensional advantage, just compensate the fiscal actions by smaller regions. This is stated in the following proposition:

Proposition 11: Interregional tax competition will result in regions providing inversely proportional subsidies with no impact on location patterns of economic activities.

The proof is provided in Appendix A1.I.

3 Data

The basic unit of analysis in the empirical examination is the activity level of an industry as measured by employment at the state level. Employment data come from *RAIS* (Annual Social Information Report) and is for the period from 1990 to 1998. This database is prepared by the Brazilian Ministry of Works and reports employment in the 21 manufacturing industries identified in the *IBGE* (Brazilian Statistical Bureau) classification for each of the 27 states in the Brazilian Federation.[8] One important aspect of that data set is that *RAIS* is an administrative report filed by all tax registered Brazilian establishments. The information contained in this database is used to control labor legislation compliance so that firms who do not observe the law do not therefore appear in *RAIS*. Hence, *RAIS* may be seen as a census of *formal* Brazilian employment.[9] Because of this, the use of these employment data to study location issues is essentially correct if the informality ratio is similar across geographical units and across industries. In the case of Brazil Andrade and Serra (1998) have shown that the differences in the degree of informality among the most important metropolises is not high.[10]

The dataset *RAIS* is then combined with production statistics from the System of National Accounts published by *IBGE*, which provide a proper characterization of industries in terms of factor intensities, cost structures, and sales orientation; and with regional data from the *IBGE,* the *IPEA* (Institute of Applied Economic Research), the *GEIPOT* (Brazilian Firm of Transport Planning), the *DNER* (National Department of Routes), and the *CNI* (National Confederation of Industries), which provide a suitable characterization of states in terms of their factor endowments, market sizes, and fiscal policies. Table A2.A in Appendix A2 provides a detailed description of the variables, their definitions, the time period for which information is available, and the sources.

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[8] Brazil has no disaggregate data on manufacturing production at state level since the industrial census of 1985. There are only some estimates of these values for some regions and some specific states.

[9] FIPE-USP (2001) compares *RAIS* with the broader household survey *PNADS* carried out by the *IBGE.* Both are very close.

[10] The informality rate in Brazilian main metropolitan regions ranged from 20.15% in Porto Alegre to 26.74% in Recife in 1995.

4 Descriptive Evidence

The theoretical results obtained in Subsection 2.2 suggest that economic integration and fiscal policies have a significant impact on location patterns of industrial activities. This section characterizes these location patterns in Brazil, reports information on key explanatory variables, i.e., external trade costs, distance to Argentina, and regional subsidy policies, and finally presents descriptive evidence of the influence of these factors on the spread of manufacturing activities across Brazilian states and thus a preliminary empirical assessment of the theoretical propositions derived in Subsection 2.2.

4.1 Location Patterns

Table 1 reports the share of each Brazilian state in total national manufacturing employment.[11] The data suggest there have been noticeable changes in the spatial pattern of employment. First, the employment share of Brazil's traditional industrial region, the Southeast Region, has declined significantly. This region has lost more than 5 percentage points between 1990-1992 and 1996-1998. In contrast, the Southern Region's employment share has increased. This rise represents almost 60% of the fall in the share of the former region. The Mid-West Region accounts for another 30% of the drop in the Southeast Region's share. With respect to the initial share, this last region registered an impressive expansion (75%).

Second, employment changes have not been uniform across states within the same region. Thus, the decline in the share of the Southeast Region has mainly reflected developments in two states, Rio de Janeiro and Sao Paulo. Minas Gerais, in turn, has increased its share and has displaced Rio de Janeiro as the third industrial state by overall manufacturing employment. On the other hand, the increase in the South Region's employment share is concentrated in Paraná and Santa Catarina.

Finally, the performance of Rondonia stands out in the Northern Region. This state has doubled its employment share and has accounted for almost half of the slight increase in the regional share over the period. Ceará and Pernambuco in the Northeast Region show opposite trends in their employment shares increasing in the first case and decreasing in the second case.

[11] Figure A3.A in Appendix A3 presents a political map of Brazil.

4.2 Economic Integration and State Locational Advantages

Brazil has actively engaged in unilateral and regional trade liberalization over the 1990s. Non-tariff barriers were relaxed in 1990. In particular, the list of forbidden imports was abolished and quantitative restrictions covering 39% of tariff lines were virtually removed.[12] At the beginning of 1991, the country also launched a program of tariff reduction. As a result, the range of tariff rates went from 0%-105% to 0%-40% by July 1993. The simple average tariff fell from 50.6% in 1988 to 14.2% in 1993, and the dispersion of tariff levels reduced from 26.2 to 9.5 over the same period. Brazil also established MERCOSUR together with Argentina, Paraguay, and Uruguay in 1991. Trade was gradually liberalized among member countries of this regional trade agreement over the period 1991 to 1995 for most products. In fact, Olarreaga and Soloaga (1998) show that intra-MERCOSUR trade was almost free by 1996. In addition, a Common External Tariff averaging 11% was applied in 1995.

As a result of the traditional gravitational forces and the tariff preferential margins, trade liberalization has increased the relative importance of neighboring markets, especially that of Argentina, the second largest country in the Southern Cone. Thus Argentina's share of Brazilian exports increased from 2.1% in 1990 to 13.2% in 1998. Similarly, Argentina's share of Brazilian imports rose from 6.7% to 13.8% over the same period.[13] However, these developments are not uniform over space. As suggested by trade data, there are significant differences across states. Traditional industrial states in the South and the Southeast Region, which are closer to Argentina, have accounted for more than 90% of total exports to Argentina over the period 1990-1998.[14]

Distance is, according to gravity models, a relevant explanatory factor of trade flows between regions. In particular, the intensity of trade linkages declines with the distance between trading regions. Indeed, as shown in Figure 1, the distance to relevant Argentine markets, mainly Buenos Aires and its surrounding region differs substantially across Brazilian states.

As stated in Propositions 3 and 7 derived from the theoretical model presented above, these locational advantages in terms of market access provided by the different regions have an impact on the spatial distribution of production activities.

[12] See Estevadeordal, Goto, and Saez, (2000) for details.

[13] The data come from the United Nation's Commission for Latin America and the Caribbean.

[14] The data has been provided by the *FUNCEX* (Brazil's Foundation for International Trade).

4.3 State Subsidies

Brazil is a federal country with three levels of government: the federal government, 26 states and one Federal District, and more than 5,500 municipalities. The most important tax assigned to the states is the tax on the flows of goods and services (ICMS). According to Varsano (1999), this value-added tax (VAT) accounts roughly for about 25% of the total tax burden and represents 7% of Brazil's GDP. The ICMS is regulated according to a restricted origin principle. The magnitude of state revenues is thus an increasing function of the production taking place in its territory. Furthermore, each state can negotiate with firms the tax conditions. The absence of an effective institutional enforcement mechanism of horizontal tax coordination resulted in intense fiscal competition by Brazilian states to attract economic activities. This is reflected by the fact that all states implemented subsidy policies during the 1990s. This makes Brazil a particularly interesting case to assess theoretical Propositions 10 and 11 as discussed in Section 2.

The states in the Northeast Region such as Ceará, Piauí, Pernambuco, and Alagoas have in fact benefited firms through large reductions in the ICMS to be collected over relatively long periods. The state which has provided the most favorable financial conditions also belongs to this region (Bahia in 1995 and Alagoas in 1998). From 1995 to 1998, the number of states who conceded incentives relating to ICMS grew from 18 to 22. Furthermore, the average reduction in the amount of this tax to be collected rose from 68.08% to 71.85% and the coefficient of variation of the tax breaks declined from 0.25 to 0.23. Moreover, the average number of years over which fiscal benefits were extended increased from 7.91 to 10.00. In summary, there is clear evidence of an intensified fiscal competition.

Tax breaks have not been the only competitive instrument used. Brazilian states have resorted to diverse mechanisms, including direct financial support and donation of properties. Additionally, the conditions under which specific incentives have been conceded have differed across states. These conditions can be defined in terms of the credit limits, the time period, the interest rate charged, and the rate of monetary correction.

Therefore, information on the diversity of the instruments used and on the conditions on granted subsidies are combined into an index of "state aggressiveness" in stimulating the location of economic activities. Figure *2* reports this index for 1995 and 1998.

States pursuing more active subsidy policies mainly concentrate in Brazil's Northeast Region and include Paraíba, Pernambuco, Alagoas, and Bahía. Goiás, which belongs to the Mid-West Region, has also used a broad range of instruments and granted generous subsidies.

In general, the average fiscal aggressiveness indicator has increased from 1995 to 1998. This can be mainly explained by the reaction of states in other Brazilian regions. States such as Pará, Amapá, and Tocantins in the less developed Northern Region as well as states such as Minas Gerais, Espirito Santo, and Rio de Janeiro in the traditionally industrial Southeast Region, have followed more aggressive policies to attract firms.

4.4 State Characteristic Bias of Industries

Do industries facing lower barriers to foreign trade tend to locate in states which are nearer to Argentina and/or in states with better infrastructure as suggested by Propositions 7 and 8? Do industries with increasing returns or higher total tax burdens tend to settle in states proving more favorable fiscal conditions as stated in Proposition 10? One way to provide a preliminary answer to these questions consists of using an index of *State Characteristic Bias of Industries (SCB)* developed by Midelfart-Knarvik *et al.* (2000). This index results from averaging the characteristics of the states in which an industry is located and weighting each state characteristic by the share of the state in Brazil's manufacturing employment in this sector. Formally:

$$SCB_{jt} \equiv \sum_i s_{ijt} \varpi_{it_0} \qquad (7)$$

where

$$s_{ijt} \equiv \frac{x_{ijt}}{\sum_i x_{ijt}} \qquad (8)$$

is the employment level of industry *j* in state *i* at time *t* expressed as a share of Brazil's total employment in this industry. ϖ_i denotes a characteristic of state *i*: distance to Buenos Aires, infrastructure, or "aggressiveness" in fiscal policy for attracting activities; and t_0 refers to the initial year and, of course, applies only to the latter two state characteristics. The sample contains 21 manufacturing industries. To simplify the presentation, for each state characteristic, industries are classified according to the respective average score over the period 1990-1998 in a relevant characteristic into three categories: *H* (high), *M* (medium), and *L* (low). The industry characteristics considered are: tradability, tax intensity, and economies of scale. Specifically, the resulting pairings are: distance to Buenos Aires-tradability, infrastructure-tradability, fiscal aggressiveness-tax intensity, and fiscal aggressiveness-economies of scale.

Figure 3 shows the bias indicators. This figure has been constructed such that the vertical axis reports the state characteristic bias of industries and the horizontal axis shows time. In all cases, I use a simple two-year moving average.

Industries with highly tradable products exhibit a bias towards locations which are nearer to Buenos Aires. It is noteworthy that while industries whose products score highest in tradability remain roughly constant with respect to the distance to Buenos Aires, industries with intermediate tradability have been drawn closer to Argentine markets. Furthermore, industries that are tax intensive and present increasing returns to scale locate in states with aggressive fiscal policies, as measured by the indicator of generosity in granted subsidies. However, both correspondences show a declining trend. Finally, there is no clear pattern for infrastructure.

5 Econometric Analysis

The previous section has presented some preliminary evidence on possible explanations of observed geographical patterns of manufacturing activity. In particular, I have associated the spatial distribution of sectors with selected industry and state characteristics, but in such a way I have considered only one pair at a time. However, actual location is the result of multiple interactions between industry and state characteristics. Industries and states do not differ in only one feature; their differences are multi-dimensional. Industries have distinct intermediate input structures, different biases in the main destination of their sales, are subject to increasing returns to scale of varying degree, and face different external trade costs. Similarly, states differ in their industrial base, the access they provide to important markets, their abundance of agricultural products and the skill level of their population, and the fiscal policies they implement. The spatial distribution of industries cannot thus be attributed to only one of those characteristics, but to a set of them and their interactions. The relevant question is: do economic integration and fiscal competition among states help us understand the geographical configuration of Brazilian manufacturing sector? This section presents an econometric analysis addressing this question. First, the central hypotheses are described. Second, the specification is defined. Third, the main results are reported and their robustness is discussed.

5.1 Hypotheses

Location patterns in Brazil are described by the distribution of state shares in the national employment level for each industry, s_{ij} as defined in Equation *(8)*. The approach followed in this paper to explain these location patterns has been used by Ellison and Glaeser (1999), Midelfart-Knarvik *et al.* (2000), and Overman *et al.* (2000). The main idea is that industries that use intensively a given "factor" tend to locate in states that are relatively abundant in this "factor".[15] Hence, if states differ in their endowments of educated population, industries which use intensively well educated workers will be drawn to states with relatively high shares of these workers. Operatively, this suggests explaining the location patterns through a set of interactions resulting from a specific pairing of industry characteristics and state characteristics. The particular correspondence of these characteristics is defined according to Propositions 1 to 11 derived from the theoretical model presented in Section 2. The resulting hypotheses will be considered next in detail.

Table 2 presents the state characteristics, the industry characteristics, and the interactions used in the econometric exercises. Key interactions for the time pooling regressions are marked as bold. This table also specifies the dimensions on which variables change.

The first seven interaction variables aim at controlling for the contribution of *comparative advantage* considerations and the interplay between trade costs, scale economies, and input-output linkages, as highlighted in the theoretical model.

Hypothesis 1: Industries using agriculture inputs intensively locate in states in which agriculture accounts for an important share of total production.

Hypothesis 2: Industries with relatively high use of labor in the production process locate in states with relatively low average manufacturing wage.[16]

Hypothesis 3: Industries using a skilled workforce intensively are drawn to states which are relatively well endowed with skilled labor.

Hypothesis 4: Industries with increasing returns to scale locate in states with large market potentials.

Hypothesis 5: Industries which devote a relatively high share of their total sales to final consumption by households locate in states providing a better access to high shares of population.

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[15] Brülhart and Trionfetti (2004) also use similar interactions to explain location patterns in Europe.

[16] In this case, the expected sign of the estimated coefficient is negative. Ellison and Glaeser (1999) include this interaction among the explanatory factors of location patterns in the United States.

Hypothesis 6: Industries which heavily rely on manufactured intermediate inputs locate in states ensuring a better access to a large industrial base and thus to their relevant providers.[17]

Hypothesis 7: Industries in which the manufacturing sector itself is an important user find it advantageous to locate in states providing better access to a large industrial base and hence to a significant demand source.

Hypotheses 8-12 aim to assess the role of economic integration and fiscal competition in shaping manufacturing location patterns. As shown in the theoretical model above, reduced trade costs (i.e., increased tradability) induce firms to locate in regions with a better infrastructure, since this implies a lower effective price for the purchaser and therefore a higher relative demand for goods produced in such territories.[18] This translates into the following hypothesis:

Hypothesis 8: Industries facing lower trade barriers to foreign trade (and who therefore trade more) locate in states with a better infrastructure.

Diminutions in international trade costs imply a change in the conditions of access to other markets and their greater influence subsequently alters the balance of forces determining the predominant location pattern. Trade liberalization and the establishment of MERCOSUR thus actually expanded the set of markets that Brazilian firms could serve. This can then promote a spatial shifting of Brazil's manufacturing sector aimed at improving access to the new customers. In other words, as stated in Proposition 7, industries will be drawn into states with increasing locational advantages. There is therefore an incentive for Brazilian firms to relocate their activities southwards, even more when Brazil's Southern Region has an important own market and offers a good access to other large markets because it occupies a "central position". The Southern Region lies between the traditional industrial region in Brazil, the Southeast Region, and the most important Argentine economic centers at the Pampeana Region. The interaction term between tradability (as an inverse measure of trade impediments to foreign

[17] Black and Henderson (1999) find that in United States capital goods plants agglomerate in locations with high manufacturing employment, which is considered by the authors as a supporting evidence for the role of inter-industry linkages.

[18] Infrastructure, which is measured as the density of *total* paved roads in each state, cannot be viewed as an indicator of fiscal policies by Brazilian states, due to the significant differences across them with respect to the share of *total roads* that effectively are *state roads*. On the other hand, external trade costs are essentially determined by tariffs so that there is *a priori* no concern in disentangling cause and effect implied by this interaction.

trade) and the distance to Buenos Aires tries to capture this relocation effect[19]. This leads to the following hypothesis:

Hypothesis 9: Industries facing lower external trade costs (and who therefore trade more) locate in states situated nearer to Buenos Aires.

The remaining variables are included in order to evaluate the influence of fiscal policies on the actual location patterns of industries. The indicator of generosity in granted subsidies, which reflects the fiscal conditions in each state, is interacted alternatively with different variables. The logic of comparative advantage leads to the following proposition:

Hypothesis 10: Industries subject to relatively high taxes prefer to locate in states providing more favorable (and compensating) fiscal conditions.

According to the theoretical model presented in Section 2, the impact of subsidy policies on location depends on the size of the market in the region implementing these policies. In particular, the attraction of economic activities induced by the subsidies will increase, the larger the market potential of the granting state. This is stated in the following hypothesis:

Hypothesis 11: Industries subject to relatively high taxes prefer to locate in states providing more favorable (and compensating) fiscal conditions especially if they have large market potentials.

Moreover, as stated in Proposition 10, the influence of fiscal measures on the spatial distribution of industries is especially important for activities with increasing returns to scale for which indivisibilities are a major issue. Furthermore, subsidies are usually concentrated in large projects both because of their alleged higher multiplicative effects and their greater political impact. Scale economies are thus a natural candidate to capture this size effect. This argument is translated into the following hypothesis:

Hypothesis 12: Industries with increasing returns to scale locate in states which provide more favorable fiscal conditions.

Finally, recall that, as suggested by Proposition 11 derived in Section 2, regions can end up granting proportionally-sized subsidies so that *fiscal measures implemented by regions compensate and location is unaffected in equilibrium.*

[19] I have chosen Argentina as a relevant foreign market on the basis of the relative size distribution within MERCOSUR. According to data from the UN's Economic Commission for Latin America and the Caribbean, Paraguay and Uruguay jointly account for only 3% of aggregate GDP. In addition, economic activity is highly concentrated within Argentina. Data from the *CFI* (Argentina's Federal Investment Council) suggest that the province of Buenos Aires and their neighboring provinces account for almost 70% of national GDP over the 1990s. In this case a negative sign on the estimated coefficient should be expected.

5.2 Specification

The dependent variable is the share of a state in Brazil's manufacturing employment in each industry, s_{ij} as defined in Equation *(8)*. This ratio can only take values within [0,1] so that the dependent variable is truncated. As a consequence, OLS estimations will be biased. Therefore, I perform a logistic transformation. Formally, the basic specification is the following:

$$\ln\left(\frac{s_{ijt}}{1-s_{ijt}}\right) = \sum_z \beta(z)\left(\varpi_{it}(z) - \overline{\varpi}(z)\right)\left(\theta_{jt}(z) - \overline{\theta}(z)\right) + \varepsilon_{ijt}$$
$$\ln\left(\frac{s_{ijt}}{1-s_{ijt}}\right) = \alpha + \sum_z \left(\beta(z)\varpi_{it}(z)\theta_{jt}(z) - \beta(z)\overline{\theta}(z)\varpi_{it}(z) - \beta(z)\overline{\varpi}(z)\theta_{jt}(z)\right) + \varepsilon_{ijt} \quad (9)$$

where *z* indexes the interactions; $\varpi_i(z)$ is the level of the *zth* characteristic in state *i* and $\theta_j(z)$ is the industry *j* value of the industry characteristic paired with the state characteristic. The upper bar denotes a reference value.

The coefficients to be estimated are the $\beta(z)$, which measure the importance of the interaction; $-\beta(z)\overline{\theta}(z)$ and $-\beta(z)\overline{\varpi}(z)$, which amount to level effects in the interaction; and a constant α, which contains the sum (over *z*) of the products of all level effects.

The intuition behind the selected functional form is exhaustively explained in Midelfart-Knarvik *et al.* (2000). Consider, e.g., skill so that *z*=skill, $\varpi_i(skill)$ is the abundance of skilled workers in state *i* and $\theta_j(skill)$ is the skill intensity of industry *j*. In this case, Expression *(9)* means that if $\beta(skill) \rangle 0$, then industries with skill intensity greater than $\overline{\theta(skill)}$ locate in states with skill abundance greater than $\overline{\varpi(skill)}$ and out of states whose skill abundance is lower than this level.

Equation *(9)* is first estimated by OLS, pooling across industries, and across years, considering 20 industries, 27 states, and 9 years (1990 to 1998).[20] Therefore, the sample contains 4,860 observations. Furthermore, I condition the data on the standard deviation of the underlying variables in order to make comparison across variables more appropriate so that standardized coefficients will be presented. Finally, there are three main sources of heteroscedasticity, across states, across industries, and across time.[21] Hence, I report White's heteroscedastic consistent standard errors and use these standard errors for hypothesis testing.

[20] The industry "Other products", which is a residual component, has been dropped out.

[21] The White general test statistics suggests that indeed there is heteroscedasticity.

5.3 Results

Table 3 reports the estimated coefficients on the interaction terms with the respective heteroscedastic-consistent standard errors.[22] Industries that use labor and skilled workers intensively tend to locate in states with relatively low average manufacturing wages and with a well educated labor force, respectively. These results confirm Hypotheses 2 and 3. Moreover, industries with increasing returns to scale are mainly located in central places. Cost and demand linkages are also important in explaining location patterns. Industries with high final demand bias and high intermediate demand bias are located close to their customers while industries which depend heavily on industrial intermediate inputs are located close to their providers. Hypotheses 4 to 7 are therefore also confirmed.

The coefficient on the interaction between agriculture abundance and agriculture intensity is insignificant but shows a sign that does not coincide with what we would expect from the theory. A possible explanation relates to transport costs. The location of industries which use intensively agriculture inputs is determined by the availability of inputs and the closeness to customers. Indeed, most of these industries exhibit a medium/high bias to final demand. In addition, agriculture abundant states do not generally have large population potential. These industries may thus find it more profitable to let transport costs fall on input transfers than on reaching purchasers and thus settle closer to consumer markets than to their input sources.[23]

The interaction between infrastructure and tradability has the right sign, but seems to be insignificant. This might be due to the pooling of years with different average degrees of trade liberalness. This point will be addressed below. However, the remaining rows of Table 3 suggest accepting Hypotheses 9 to 12 and thus provide a clear positive answer to the original question motivating this research. Economic integration and fiscal competition do help to explain manufacturing location patterns.

As expected, the estimated coefficient on the interaction between distance and tradability is negative and significant. Therefore, industries with highly tradable products and thus facing lower barriers to foreign trade tend to locate in Brazilian states which are closer to Argentina because they provide a better

[22] Tables including estimated coefficients on state and industry characteristics are available from the author upon request.

[23] Amiti (2001) assumes vertically linked industries with different factor intensities and shows that firms may locate in regions where standard trade models would suggest they would not locate. Thus, labor-intensive downstream firms may locate in a capital abundant region in order to be close to the intermediate input suppliers. *Mutatis mutandis*, a similar argument applies here.

access to this market. More specifically, states in the South Region, Paraná, Santa Catarina, and Rio Grande do Sul, profit specially from liberalized trade.

In addition, the estimated coefficients on the interactions involving the subsidy policies are positive and significant. This suggests that industries facing higher tax burdens and exhibiting increasing returns to scale tend to locate in states that are more generous in the fiscal incentives they grant. As previously stated, the effectiveness of fiscal policies for inducing location of economic activities is not uniform across state sizes. More precisely, states with larger market potentials are in a better position to undertake a fiscal dispute. To take this possibility into account I have scaled the fiscal policy variable by multiplying this variable with the market potential index. Regression results using this interaction term confirm the theoretical priors. The influence of the subsidies on location patterns is higher the larger the market potential of the conceding state. Nevertheless, overall results indicate that subsidies are only one element in a broader set of factors determining location decisions in which regional *fundamentals* play a decisive role.

5.4 Robustness[24]

A certain industry or state might experience a shock to its share in national manufacturing employment. Overman *et al.* (2000) suggest using a double relative measure that ameliorates the incidence of shocks correlated across states and/or industries so that the state employment shares are normalized through state and industry sizes. The main message from the results using this re-formulated dependent variable remains the same.

Taking natural logarithms raises a problem for observations which are equal to zero, since the logarithm does not exist for them. In this case, zero observations do not seem to be quantitatively important (roughly 6% of the whole sample). Nevertheless, these observations might convey important information. For example, shares could be systematically zero for industries with high increasing returns to scale in states with very low market potentials. Therefore, before performing the previous estimations, following Wang and Winters (1991) and Kume and Piani (2000) I replaced zero employment shares by small values. More precisely, I substituted the half of the minimum value of the dependent variable for zero values. In order to check the robustness of these original results, I performed Tobit regressions and

[24] Most results from estimations aimed at checking for robustness are not reported to save space. They are available from the author upon request.

estimated sample selection models. I controlled also for influential observations using the estimator developed by Welsch (1980). Main estimation results are the same as before.

One non-minor point in this econometric analysis is the sample size. Large sample sizes the use of classical t-value for hypothesis testing purposes inappropriate. As indicated in Greene (1997), the use of consistent estimators causes the rejection of almost any hypothesis if the sample size is large enough. However, most coefficients remain significant under the stronger criterion defined by the sample size-adjusted t-value proposed by Leamer (1978).

Furthermore, state endowments and industry intensities might be systematically subject to measurement errors for one particular state or industry. These errors would then translate into fixed effects for the state or industry in question. Hsiao (1986) contends that, by using information on both the inter-temporal dynamics and the individuality of the entities being examined, panel data allows for a better control of the effects of missing, unobserved, or mismeasured variables. Therefore, I preformed Least Square Dummy Variables (LSDV) estimations. In this case, the error term varies across industries, states, and years so that I used a three-way-error component model. Again results are similar to those previously reported.

Another major concern is raised by the fact that state's endowments may be endogenous to location decisions by firms. Thus, firms belonging to an industry which intensively uses skilled workers may locate in a certain state due to the relative abundance of this factor. However, it is also possible that the setting of these firms generates an inflow of well educated workers to the state. In this case, endowments would be endogenous and resulting estimations would be inconsistent. Therefore, I carried out two verification exercises. First, I performed 2SLS regressions instrumenting explanatory variables by the respective 1-, 2-, and 3-lagged values and I calculated the Hausman test statistics. Second, I re-estimated the original regressions using only the initial values (i.e., the scores of 1990) of the variables for 1990-1998, 1991-1998, 1992-1998, and 1993-1998. The same result pattern emerges. The Hausman test statistics indicates that the null hypothesis of non contemporaneous correlation between the explanatory variables and the error term cannot be rejected. Specifically, according to the overall evidence, results obtained with contemporaneous values of right-hand-side variables do not significantly differ from those when lagged-values are used. In this sense, endogeneity seems to be a less severe problem.

Moreover, the previous estimations assume a relatively simple error term. Given the panel nature of the data, a specific pattern of disturbances associated with groups of observations may be presumed. Baltagi (1995) has shown that ignoring groupwise heteroscedasticity, cross sectional correlation, and/or serial correlation when present, result in consistent but inefficient estimates of the regression coefficients and biased standard errors. The modified Wald statistic for groupwise heteroscedasticity in the residuals suggests that the null hypothesis of homoscedasticity across panels should be rejected. In addition, the Breusch-Pagan LM test indicates that the null hypothesis of independence of errors across panels should be also rejected. Finally, the Baltagi-Li LM test for first order serial correlation in a fixed effects model suggest that the null hypothesis of no autocorrelation should be rejected, too.

I accordingly implemented an alternative econometric strategy. I removed autocorrelation from the data using the Prais-Winsten transformation as indicated in Greene (1997) and used panel-corrected-standard errors to account for groupwise heteroscedasticity and contemporaneous correlation across panels as suggested by Beck and Katz (1996).

Results obtained using this estimation method are reported in Table 4. The interactions between market potential and economies of scale, industrial base and industrial intermediate consumption, distance to Buenos Aires and tradability, and subsidies and economies of scale have the right sign and are significant at conventional levels.

A similar message comes out from *GMM* estimations based on the procedure developed by Arellano and Bond (1991). These results are presented in Table 5. Note that now the interaction between tax intensity and fiscal generosity becomes significant. After these multiple robustness checks, the main conclusion remains true: both economic integration and fiscal competition have had a significant impact on manufacturing location patterns.

5.5 Increased Economic Integration and Time Stability

The original estimations have pooled across the 9 years of the sample. This implies assuming that the parameters of Equation *(9)* are stable across time. Propositions 7 to 9 derived from the theoretical model developed in Section 2 suggest that the underlying system may have changed as a consequence of the broad unilateral trade liberalization program implemented by Brazil as well as the establishment of MERCOSUR. The sensitivity of location decisions to state and industry characteristics has likely varied over the period under examination. Indeed, the Wald test statistics shows that the parameters are not stable over the decade. In particular, estimated coefficients are significantly different across two MERCOSUR sub-periods: the so-called transition period (1990-1994) and the customs union period

(1995-1998). I thus performed separate regressions for each sub-period. Table 6 reports estimation results

The (absolute) increase observed in the estimated coefficient on the interaction between average manufacturing wage and labor intensity suggests a strengthening of the tendency of industries to look for places providing relatively better cost conditions. The firms may be thus in a better position to face the increased external competition induced by the opening of the economy as well as being better placed in their ability to export to third markets.

The estimated coefficient on the interaction between market potential and scale economies has decreased. This might be also related to deepened economic integration. The simultaneous opening of economies that has taken place in South America may have implied a redefinition of relevant market potentials by increasing the weight of foreign markets. In order to test for this hypothesis, I dropped the interaction between distance to Buenos Aires and tradability, which accounts for the location influence of Argentina's market, and I re-estimated the basic regression. The estimated coefficient on the interaction between market potential and economies of scale is larger than before. This precisely amounts to the plausibility of the explanation previously advanced.

The increase of the estimated coefficient on the interactions between infrastructure and tradability and the decline of the coefficients between final demand bias and domestic population market potential and intermediate demand and domestic industrial market potential also seem to confirm the growing importance of external markets in determining location patterns of firms. Reciprocal trade liberalization in South America has implied that a higher share of production is being exported. Thus, industries facing lower trade barriers tend to relocate to states offering an appropriate infrastructure since they can serve the enlarged market in more favorable conditions. As seen in Section 2, better infrastructure means lower effective prices and higher demand for the products. In addition, the increased weight of exports in total demand weakens the home demand linkages, i.e., the tendency of industries to settle in states with large population and industrial market potentials within the country with the purpose of reaching a large number of customers without incurring transports costs.

The strength of the cost linkages as measured by the interaction between industrial market potential and the intensity of the use of manufactured inputs is, contrary to Proposition 9 derived in Section 2, increasing over the decade. This suggests that Brazilian manufacturing sector still heavily relies on locally produced industrial inputs. The relative industrial size of Brazil within MERCOSUR together with the fact that intermediate industrial consumption seems to be more intense than demand linkages, and the tariff structure with varying degrees of protection may play a role in explaining this result.

More interestingly, the estimated coefficient on the interaction between distance to Argentine markets and tradability has increased over time (in absolute value). This is consistent with the theoretical results presented in Section 2. Locational advantages have become relatively more important as economic integration proceeds. As a consequence, Brazilian states which provide a better access to the new relevant markets, such as those of Argentina, have experienced increasing locational share gains over the decade.

The interactions between the fiscal policy indicator and tax intensity seem to be insignificant in both sub-periods. However, the interaction between the subsidy indicator and scale economies and this fiscal indicator scaled by state market potential and tax intensity clearly have a declining trend. This suggests that fiscal instruments are becoming increasingly ineffective due to their relative generalization, i.e., a *race to the bottom* has developed and consequently these instruments have lost their differentiating power across states attempting to influence the location decisions of firms, as would be the case in an equilibrium scenario of tax competition.

6 Concluding Remarks

Do economic integration and fiscal competition help to explain location patterns? This paper has attempted to answer this question, both theoretically and empirically. The theoretical model is a variant of the Footloose Capital Model developed by Martin and Rogers (1995) and Baldwin *et al.* (2003). The econometric analysis uses a methodological approach similar to that of Midelfart-Knarvik *et al.* (2000) and Overman *et al.* (2000). This empirical analysis is based on the Brazilian experience. The reason to choose this country is twofold. Brazil has liberalized trade over the 1990s on a unilateral basis and in the context of regional trade agreement, MERCOSUR. In addition, Brazil witnessed an intensification of the fiscal dispute among states seeking to attract manufacturing activities.

The answer to the above question is *yes*. The theoretical model shows that economic integration has a significant impact on economic geography and that, among other things, this impact is mediated by the physical geography, i.e., the distribution of locational advantages in terms of market access over space. Subsidy policies also contribute to shape the spread of manufacturing industry, but only before these policy instruments become generally used.

Econometric results suggest that industries with highly tradable products locate in those states closer to Argentina who offer a better access to this market and that this tendency has accentuated over time. The increased relative importance of foreign markets induced by trade liberalization has been also associated with a weakening of home demand linkages, i.e., both between domestic firms and between these firms and domestic consumers as well as with a strengthening of the propensity of firms to locate in those states with better infrastructure.

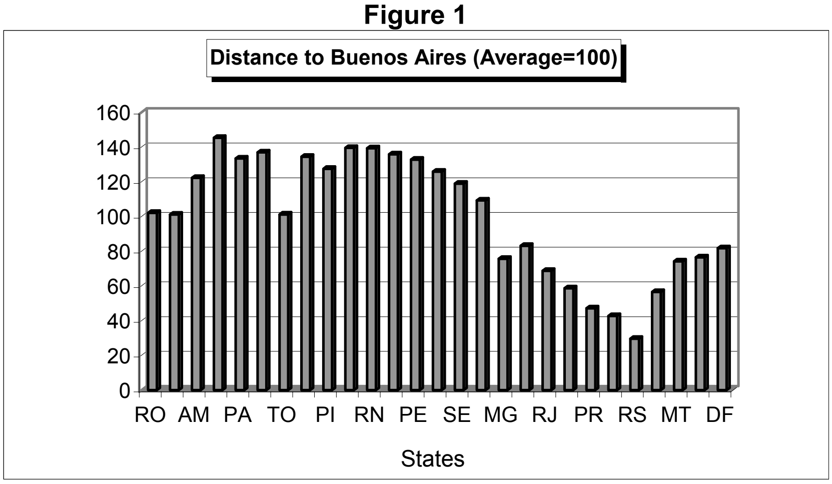
In addition, industries with increasing returns to scale have been shown to locate in those states that have more generous fiscal incentives. Moreover, industries facing relatively high tax burdens tend to be drawn into states providing more favorable fiscal treatment especially when these states have relatively large market potentials. Nevertheless, subsidies are only one element in a broader set of factors determining location decisions, in which regional *fundamentals* do play a decisive role. These fiscal instruments are becoming increasingly ineffective due to the relative generalization of their use, as is expected in a traditional *race to the bottom* scenario.

Table 1

Brazil - Spatial Distribution of Manufacturing Employment (1990-1998) Percentages						
Period		**1990-1992**	**1993-1995**	**1996-1998**	**Variation**	**Variation**
State/Region		**(I)**	**(II)**	**(III)**	**(II)/(I)**	**(III)/(I)**
AC	**Acre**	0.04	0.04	0.05	0.00	0.01
AM	**Amazonas**	1.08	0.99	1.15	-0.09	0.07
PA	**Pará**	0.97	1.03	1.07	0.06	0.10
RO	**Rondonia**	0.15	0.21	0.33	0.06	0.18
AP	**Amapá**	0.02	0.03	0.03	0.01	0.01
RR	**Roraima**	0.01	0.01	0.02	0.00	0.01
TO	**Tocantins**	0.05	0.05	0.08	0.00	0.04
North Region		**2.33**	**2.37**	**2.74**	**0.04**	**0.41**
MA	**Maranhao**	0.37	0.38	0.44	0.01	0.06
PI	**Piauí**	0.25	0.29	0.34	0.04	0.09
CE	**Ceará**	1.83	2.00	2.46	0.17	0.64
RN	**Rio Grande do Norte**	0.69	0.62	0.76	-0.07	0.07
PB	**Paraíba**	0.76	0.71	0.89	-0.06	0.13
PE	**Pernambuco**	3.77	2.94	2.91	-0.83	-0.86
AL	**Alagoas**	1.12	1.12	1.32	0.00	0.20
SE	**Sergipe**	0.46	0.39	0.40	-0.07	-0.06
BA	**Bahía**	1.85	1.79	1.83	-0.06	-0.02
Northeast Region		**11.10**	**10.23**	**11.36**	**-0.87**	**0.25**
MG	**Minas Gerais**	8.17	9.04	9.98	0.87	1.80
ES	**Espirito Santo**	1.13	1.19	1.34	0.06	0.21
RJ	**Rio de Janeiro**	9.12	8.14	7.26	-0.99	-1.86
SP	**Sao Paulo**	45.53	43.76	40.19	-1.78	-5.35
Southeast Region		**63.96**	**62.12**	**58.76**	**-1.84**	**-5.19**
PR	**Paraná**	5.16	5.89	6.75	0.72	1.59
SC	**Santa Catarina**	5.82	6.63	6.88	0.81	1.05
RS	**Rio Grande do Sul**	9.62	10.17	9.99	0.55	0.37
South Region		**20.60**	**22.69**	**23.62**	**2.09**	**3.02**
MT	**Mato Grosso**	0.45	0.64	0.94	0.19	0.48
MS	**Mato Grosso do Sul**	0.33	0.43	0.56	0.09	0.22
GO	**Goiás**	0.97	1.22	1.64	0.25	0.67
DF	**Distrito Federal**	0.25	0.31	0.39	0.06	0.14
Mid-West Region		**2.01**	**2.60**	**3.52**	**0.58**	**1.51**

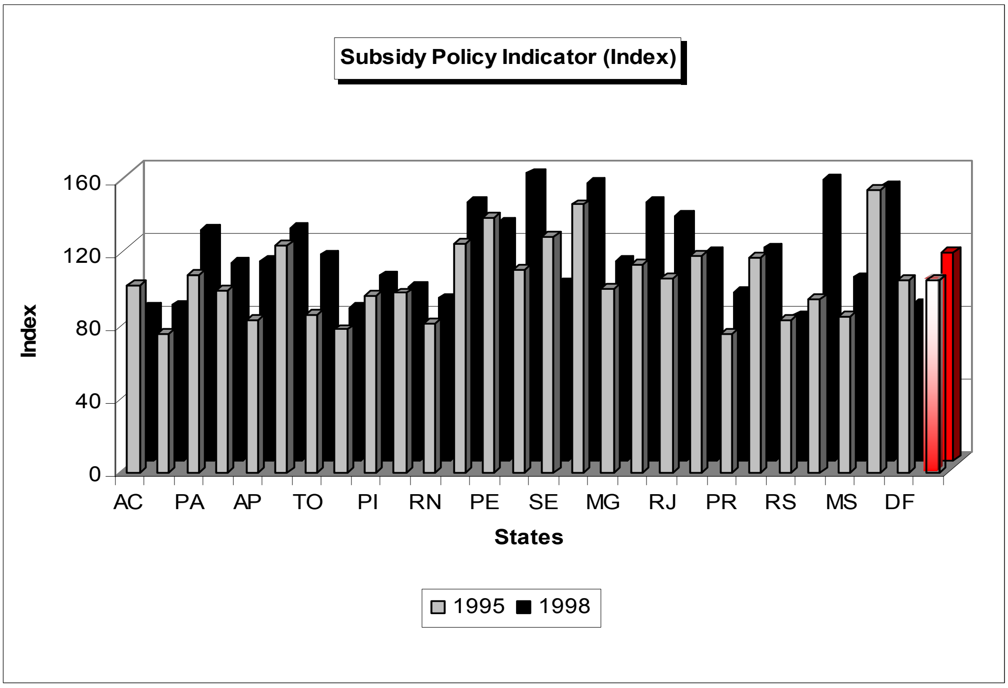
Source: Own calculations on RAIS-Brazilian Ministry of Works

Figure 1



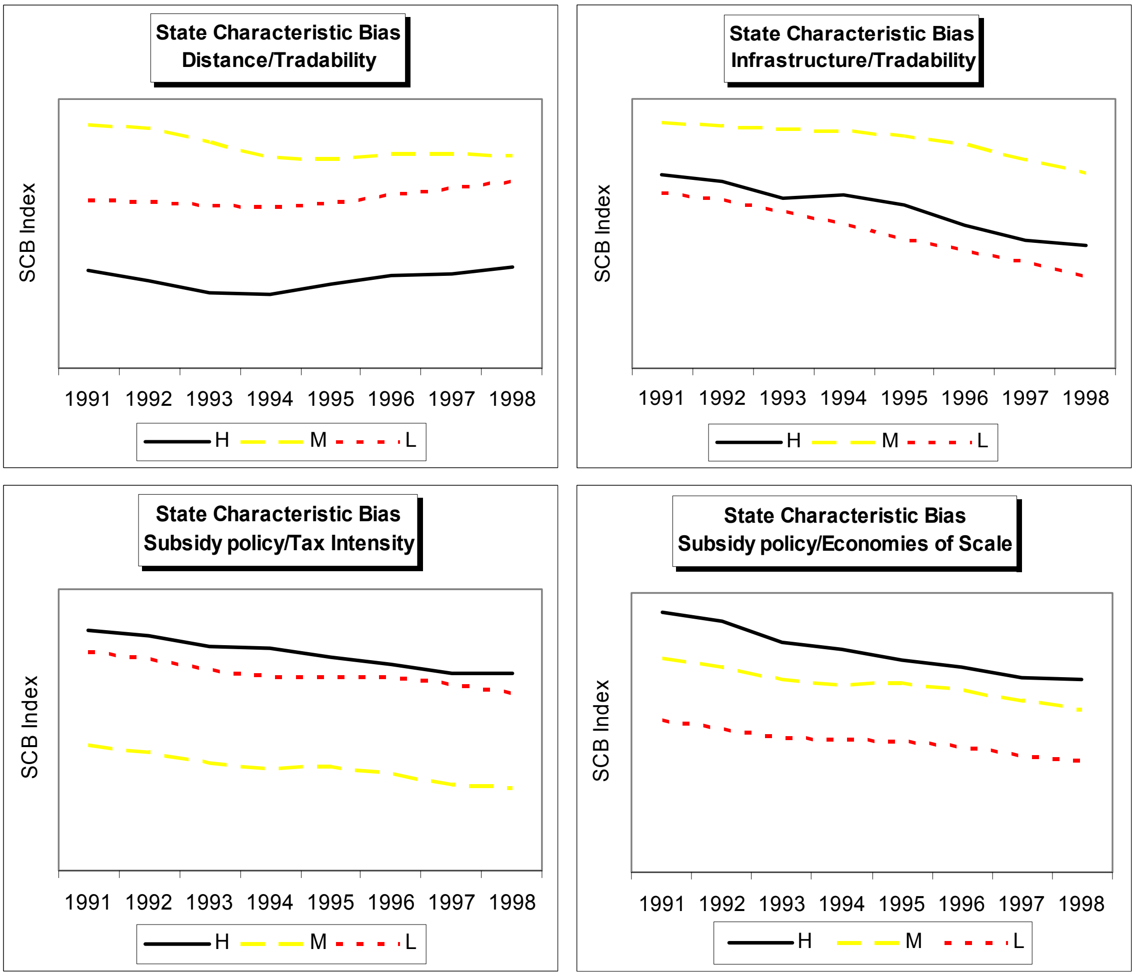
Source: Own calculations on IGM, IBGE, and CEPII

Figure 2



Source: Own calculations on Piancastelli and Perobelli (1996) and CNI (1998)

Figure 3



Source: Own calculations on RAIS, IBGE, PP (1996), CNI (1998), IGM, and CEPII

Table 2

Regressions			
Category	**Explanatory variables**		**Dimension**
State characteristics	Agriculture abundance		S.T
	Human capital abundance		S.T
	Average manufacturing wage		S.T
	Market potential		S.T
	Population		S.T
	Industrial GDP		S.T
	Infrastructure		S.T
	Distance to Buenos Aires		S..
	Subsidies		S.T
Industry characteristics		Agriculture intensity	.IT
		Human capital intensity	.IT
		Labor intensity	.IT
		Final demand bias	.IT
		Industrial intermediate consumption	.IT
		Sales to industry	.IT
		Economies of scale	.IT
		Trade intensity	.IT
		Tax intensity	.IT
Interaction terms	Agriculture abundance	* Agriculture intensity	SIT
	Average manufacturing wage	* Labor intensity	SIT
	Human capital abundance	* Human capital intensity	SIT
	Market potential	* Economies of scale	SIT
	Population	* Final demand bias	SIT
	Industrial GDP	* Industrial intermediate consumption	SIT
	Industrial GDP	* Sales to industry	SIT
	Infrastructure	*** Trade intensity**	**SIT**
	Distance to Buenos Aires	*** Trade intensity**	**SIT**
	Subsidies	*** Tax intensity**	**SIT**
	Subsidies*Market potential	*** Tax intensity**	**SIT**
	Subsidies	*** Economies of scale**	**SIT**

Note:
S.T: Variables that vary across states and years, but not across industries.
.IT: Variables that vary across industries and years, but not across states.
SIT: Variables that vary across states, industries, and years.
(*) Variables included one at a time.

Table 3

OLS Regressions				
Explanatory Variables - Interaction Terms		**(1) Ins**	**(2) Ins**	**(3) Ins**
Agriculture Abundance	**Agriculture intensity**	-0.117	-0.117	-0.114
		(0.079)	(0.080)	(0.079)
Average manufacturing wage	**Labor intensity**	-0.398***	-0.337***	-0.400***
		(0.120)	(0.122)	(0.120)
Human capital abundance	**Human capital intensity**	0.394***	0.402***	0.411***
		(0.098)	(0.098)	(0.098)
Market potential	**Economies of scale**	0.216***	0.185***	0.191***
		(0.058)	(0.060)	(0.057)
Population	**Final demand bias**	0.206**	0.229**	0.222**
		(0.092)	(0.092)	(0.092)
Industrial GDP	**Industrial inputs**	0.723***	0.661***	0.722***
		(0.113)	(0.116)	(0.114)
Industrial GDP	**Sales to industry**	0.135*	0.254***	0.136*
		(0.075)	(0.083)	(0.075)
Distance to Buenos Aires	**Trade intensity**	-0.514***	-0.536***	-0.528***
		(0.085)	(0.085)	(0.085)
Infrastructure	**Trade intensity**	0.054	0.071	0.046
		(0.071)	(0.072)	(0.071)
Subsidies	**Tax intensity**	0.453***		
		(0.134)		
Subsidies*Market potential	**Tax intensity**		0.304***	
			(0.099)	
Subsidies	**Economies of scale**			0.614***
				(0.133)
Number of Observations		4860	4860	4860
Adjusted R2		0.64	0.64	0.64

Dependent variable is the logistic transformation of the location shares as defined in Equation (8)
Explanatory variables are defined in Table A2.A in Appendix A2
Robust standard error in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4

Prais-Winsten Regressions with Panel-Corrected Standard Errors				
Explanatory Variables - Interaction Terms		**(1) lns**	**(2) lns**	**(3) lns**
Agriculture Abundance	**Agriculture intensity**	-0.048	-0.048	-0.044
		(0.064)	(0.065)	(0.069)
Average manufacturing wage	**Labor intensity**	-0.088	-0.088	-0.089
		(0.136)	(0.137)	(0.136)
Human capital abundance	**Human capital intensity**	0.179	0.182	0.187
		(0.138)	(0.139)	(0.141)
Market potential	**Economies of scale**	0.421***	0.419***	0.392***
		(0.073)	(0.074)	(0.070)
Population	**Final demand bias**	0.143	0.148	0.150
		(0.107)	(0.109)	(0.105)
Industrial GDP	**Industrial inputs**	0.598***	0.584***	0.594***
		(0.164)	(0.159)	(0.164)
Industrial GDP	**Sales to industry**	0.103	0.127	0.102
		(0.081)	(0.094)	(0.078)
Distance to Buenos Aires	**Trade intensity**	-0.320***	-0.322***	-0.329***
		(0.115)	(0.115)	(0.116)
Infrastructure	**Trade intensity**	-0.020	-0.020	-0.019
		(0.062)	(0.062)	(0.061)
Subsidies	**Tax intensity**	0.218		
		(0.161)		
Subsidies*Market potential	**Tax intensity**		0.075	
			(0.163)	
Subsidies	**Economies of scale**			0.571***
				(0.145)
Number of Observations		4860	4860	4860

Dependent variable is the logistic transformation of the location shares as defined in Equation (8)
Explanatory variables are defined in Table A2.A in Appendix A2
Panel corrected standard error in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5

Arellano-Bond Estimations (First Step)				
Explanatory Variables - Interaction Terms		**(1) Ins**	**(2) Ins**	**(3) Ins**
Agriculture Abundance	**Agriculture intensity**	0.526**	0.560**	0.594**
		(0.232)	(0.230)	(0.247)
Average manufacturing wage	**Labor intensity**	-0.088	-0.143	-0.169
		(0.118)	(0.125)	(0.129)
Human capital abundance	**Human capital intensity**	-0.135	-0.086	-0.145
		(0.123)	(0.125)	(0.109)
Market potential	**Economies of scale**	0.522***	0.492***	0.369***
		(0.127)	(0.117)	(0.097)
Population	**Final demand bias**	-0.317	-0.401	-0.170
		(0.251)	(0.269)	(0.243)
Industrial GDP	**Industrial inputs**	0.288	0.275	0.313
		(0.198)	(0.200)	(0.193)
Industrial GDP	**Sales to industry**	0.061	0.103	0.146
		(0.098)	(0.099)	(0.104)
Distance to Buenos Aires	**Trade intensity**	-0.250*	-0.261**	-0.244**
		(0.131)	(0.125)	(0.124)
Infrastructure	**Trade intensity**	0.002	-0.039	-0.007
		(0.079)	(0.080)	(0.080)
Subsidies	**Tax intensity**	0.390*		
		(0.209)		
Subsidies*Market potential	**Tax intensity**		0.095	
			(0.072)	
Subsidies	**Economies of scale**			0.562**
				(0.277)
Number of Observations		3780	3780	3780
Sargan Test		467.67	469.92	471.98
Test for second order autocorrelation		0.19	0.20	0.13

Dependent variable is the logistic transformation of the location shares as defined in Equation (8)
Explanatory variables are defined in Table A2.A in Appendix A2
The Sargan tests are based on the two-step estimations
State characteristics and interactions are treated as endogenous
Robust standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6

Prais-Winsten Regressions with Panel-Corrected Standard Errors							
Explanatory Variables - Interaction Terms		1990-1994 lns	1995-1998 lns	1990-1994 lns	1995-1998 lns	1990-1994 lns	1995-1998 lns
Agriculture Abundance	**Agriculture intensity**	-0.028	-0.140**	-0.023	-0.140***	-0.002	-0.138**
		(0.066)	(0.055)	(0.067)	(0.054)	(0.076)	(0.058)
Average manufacturing wage	**Labor intensity**	-0.078	-0.464**	-0.063	-0.467**	-0.066	-0.478**
		(0.219)	(0.211)	(0.214)	(0.199)	(0.215)	(0.213)
Human capital abundance	**Human capital intensity**	0.337***	0.213	0.310**	0.212	0.342***	0.204
		(0.125)	(0.152)	(0.130)	(0.152)	(0.128)	(0.153)
Market potential	**Economies of scale**	0.454***	0.182*	0.432***	0.185*	0.423***	0.173*
		(0.083)	(0.099)	(0.092)	(0.107)	(0.075)	(0.100)
Population	**Final demand bias**	0.240**	0.072	0.242**	0.080	0.241**	0.077
		(0.103)	(0.128)	(0.116)	(0.130)	(0.100)	(0.131)
Industrial GDP	**Industrial inputs**	0.662***	0.850***	0.603***	0.864***	0.633***	0.847***
		(0.212)	(0.092)	(0.193)	(0.071)	(0.216)	(0.091)
Industrial GDP	**Sales to industry**	0.107	0.024	0.218*	0.011	0.102	0.026
		(0.107)	(0.033)	(0.128)	(0.089)	(0.100)	(0.032)
Distance to Buenos Aires	**Trade intensity**	-0.279	-0.397***	-0.298	-0.394***	-0.304*	-0.403***
		(0.184)	(0.139)	(0.187)	(0.137)	(0.180)	(0.142)
Infrastructure	**Trade intensity**	-0.128	0.095**	-0.111	0.092**	-0.132	0.097**
		(0.086)	(0.041)	(0.085)	(0.041)	(0.081)	(0.043)
Subsidies	**Tax intensity**	0.305	0.156				
		(0.277)	(0.149)				
Subsidies*Market potential	**Tax intensity**			0.310*	-0.045		
				(0.163)	(0.302)		
Subsidies	**Economies of scale**					0.959***	0.184
						(0.152)	(0.131)
Number of Observations		2700	2160	2700	2160	2700	2160

Dependent variable is the logistic transformation of the location shares as defined in Equation (8)
Explanatory variables are defined in Table A2.A in Appendix A2
Panel corrected standard error in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

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Appendix A1

Appendix A1.A

Perfect competition in the agricultural sector implies that prices are set equal to marginal cost: $p_A^i = a_A w^i$ *i=1,2,3*. Further, costless trade between regions leads to interregional price equalization, $p_A^1 = p_A^2 = p_A^3 = p_A$ and indirectly to interregional wage equalization, $w^1 = w^2 = w^3 = w$, as long as the agricultural good is produced in each region, which is assumed henceforth.[26] On the other hand, utility maximization yields the following demand function for that good: $C_A^1 = (1-\mu)E^1 / p_A$, where the numerator indicates the total spending of consumers in region *1* on the agricultural good. The demand of consumers in regions *2* and 3 is isomorphic. By Walras's law this sector's market clearing condition drops out.

In the manufacturing sector, due to Dixit-Stiglitz monopolistic competition, each firm is atomistic and does not therefore take into account the repercussions of its price decision. Furthermore, there is no strategic interaction among firms because varieties are differentiated. The individual firm acts thus as a monopolist facing a demand curve with constant elasticity of σ. The first-order conditions from the profit maximization of a typical firm in region *1* determine the following prices for sales to the local market (p^{11}) and the export markets (p^{12} *and* p^{13}), respectively:

$$p^{11} = \frac{wa_M}{1-1/\sigma} \qquad p^{12} = \frac{\tau w a_M}{1-1/\sigma} \qquad p^{13} = \frac{\delta w a_M}{1-1/\sigma} \tag{A1.1.}$$

The price is a constant mark-up of marginal cost. Moreover, it is optimal for firms to resort to mill-pricing. On the other hand, utility maximization implies that consumers spend μE^1 on industrial goods and that they have CES demand functions for each industrial variety:

$$c_m^1 = \frac{\left(p_m^1\right)^{-\sigma} \mu E^1}{\int_0^{n^T} \left(p_j^1\right)^{1-\sigma} dj} \tag{A1.2.}$$

where $E^1 = \pi^1 K^1 + wL^1$; L^1 symbolizes region *1*'s labor. In the Dixit-Stiglitz monopolistic competition setting, free and instantaneous entry drives pure profits to zero so that *E* only consists of factor income. Isomorphic expressions hold for regions *2* and 3.

Physical capital is used only in the fixed cost component of industrial production. Hence, the reward to capital is the operating profit of a typical variety, which, under the Dixit-Stiglitz assumptions, is the value of sales divided by σ. Formally: $\pi = px/\sigma$. Using the demand functions and the price policy of firms, the equilibrium expressions for π^1, π^2 *and* π^3 (*Equation (5)* in main text) are derived:

$$\pi^1 = b\left(\frac{s_E^1}{s_n^1 + \phi_R s_n^2 + \phi_N s_n^3} + \frac{\phi_R s_E^2}{\phi_R s_n^1 + s_n^2 + \phi_N s_n^3} + \frac{\phi_N s_E^3}{\phi_N s_n^1 + \phi_N s_n^2 + s_n^3}\right)\frac{E^T}{K^T} \tag{A1.3.}$$

$$\pi^2 = b\left(\frac{\phi_R s_E^1}{s_n^1 + \phi_R s_n^2 + \phi_N s_n^3} + \frac{s_E^2}{\phi_R s_n^1 + s_n^2 + \phi_N s_n^3} + \frac{\phi_N s_E^3}{\phi_N s_n^1 + \phi_N s_n^2 + s_n^3}\right)\frac{E^T}{K^T} \tag{A1.4.}$$

[26] This non-full-specialization condition requires that no region has enough labor to satisfy the total demand for the agricultural good, i.e., that the total expending on this good is larger than the maximum value of its production that is possible in one region.

$$\pi^3 = b\left(\frac{\phi_N s_E^1}{s_n^1 + \phi_R s_n^2 + \phi_N s_n^3} + \frac{\phi_N s_E^2}{\phi_R s_n^1 + s_n^2 + \phi_N s_n^3} + \frac{s_E^3}{\phi_N s_n^1 + \phi_N s_n^2 + s_n^3}\right)\frac{E^T}{K^T} \tag{A1.5.}$$

Equations *(A1.3.-A1.5.)* indicate that the reward of the mobile factor, physical capital, hinges upon the spatial distribution of industry s_n^i (which is taken as exogenous in the short run) and the spatial distribution of expenditure, s_E^i. The denominator of s_E^1 is equal to $E^T = wL^T + \pi K^T$. Given the preferences functional form and the mill pricing with a constant mark-up, total payment to capital is equal to bE^T. Hence, $E^T = wL^T + bE^T$. This leads to the following expression:

$$E^T = \frac{wL^T}{1-b} = \frac{\sigma w L^T}{1-\mu} \tag{A1.6.}$$

The numerator of s_E^1 is equal to $E^1 = wL^1 + \pi^1 K^1$. The first component can be expressed as $ws_L^1 L^w$, where s_L^1 is the share of region 1 in total labor. The second component is determined assuming that 1/3 of the capital in each region belongs to owners residing in region *1.* As a consequence, capital from this region earns the average reward. This reward is constant regardless the spatial distribution of industry and the degree of openness. As previously seen, total payment to capital is equal to bE^w so that the average operating profit per variety equals bE^T/K^T. Hence, $E^1 = ws_L^1 L^T + b\left(E^T/K^T\right)$. Dividing by E^w and using Equation *(A1.6)*:

$$s_E^1 = (1-b)s_L^1 + bs_K^1 = \left(\frac{\sigma-\mu}{\mu}\right)s_L^1 + \frac{\mu}{\sigma}s_K^1 \tag{A1.7.}$$

where $s_L^1 \equiv L^1/L^T$, $s_K^1 \equiv K^1/K^T$ with $s_L^1 = s_K^1 = s_E^1 = 1/3$ in the symmetric case. The expenditure share of region *1* is a weighted average of its endowment shares of total labor and total capital. The weighting factor *b* is increasing in the share of expending that manufacturing goods account for μ and in the degree of market power in industry (as measured by the operating profit margin $1/\sigma$).[27]

Some useful standard normalizations are introduced in order to make expressions easier. The agricultural good is selected as a *numeraire*. Furthermore:

$$a_A = 1 \Rightarrow p_A^1 = p_A^2 = p_A^3 = w^1 = w^2 = w^3 = 1 \quad ; \quad a_M = 1-(1/\sigma) \Rightarrow p^{11} = w^1 = 1 \Rightarrow p^{12} = \tau \ and \ p^{13} = \delta$$
$$K^T = 1 \Rightarrow n^T = 1 \Rightarrow n^1 + n^2 + n^3 = 1 \ and \ n^1 = s_n^1 \quad ; \quad E^T = 1 \Rightarrow L^T = 1-b = (\sigma-\mu)/\mu$$

Appendix A1.B

The solution to the model for the spatial distribution of firms associated with an equalization of rental rates across regions ($\pi^1 = \pi^2 \ and \ \pi^2 = \pi^3$) is given by:

$$s_n^1 = \frac{\left(1+\phi_R - 2\phi_N^2\right)\left[\frac{(1-\phi_N)}{(1-\phi_R)}s_E^1 - \frac{(\phi_R-\phi_N)}{(1-\phi_R)}s_E^2\right] - \phi_N(1-\phi_N)}{(1-\phi_N)(1+\phi_R-2\phi_N)} \tag{A1.8.}$$

The expression for s_n^2 is isomorphic and that of s_n^3 is obtained as $s_n^3 = 1 - s_n^1 - s_n^2$. The share of manufacturing activity located in region *1* is increasing in the share of expenditure accounted by this region:

[27] In this model, production spatial shifting does not induce expenditure spatial shifting (changes in s_E), as capital's owners are immobile and earn the average reward regardless where capital is employed.

$$\frac{\partial s_n^1}{\partial s_E^1} = \frac{\left(1+\phi_R - 2\phi_N^2\right)}{\left(1-\phi_R\right)\left(1+\phi_R - 2\phi_N\right)} \rangle\, 0 \qquad \text{(A1.9.)}$$

Appendix A1.C

Assume that proximity to region *3* differs across regions in the home country, i.e. $\delta^1 \neq \delta^2$. The solution to the model with asymmetric locational advantages is given by:

$$s_n^1 = \left[\frac{1+\phi_N^2}{\left(1+\phi_N^2-\phi_N^1-\phi_R\right)}\right] s_E^1 - \left[\frac{\phi_R - \phi_N^1\phi_N^2}{\left(1-\phi_N^1\right)\left(1+\phi_N^1-\phi_N^2-\phi_R\right)}\right] s_E^2 - \left[\frac{\phi_N^1 - \phi_R\phi_N^2}{\left(1-\phi_R\right)\left(1+\phi_R-\phi_N^1-\phi_N^2\right)}\right]\left(1-s_E^1-s_E^2\right) \qquad \text{(A1.10.)}$$

$$s_n^2 = -\left[\frac{\phi_R - \phi_N^1\phi_N^2}{\left(1-\phi_N^2\right)\left(1+\phi_N^2-\phi_N^1-\phi_R\right)}\right] s_E^1 + \left[\frac{1+\phi_N^1}{\left(1+\phi_N^1-\phi_N^2-\phi_R\right)}\right] s_E^2 - \left[\frac{\phi_N^2 - \phi_R\phi_N^2}{\left(1-\phi_R\right)\left(1+\phi_R-\phi_N^1-\phi_N^2\right)}\right]\left(1-s_E^1-s_E^2\right) \qquad \text{(A1.11)}$$

where $\phi_N^1 = \left(\delta^1\right)^{1-\sigma}$ and $\phi_N^2 = \left(\delta^2\right)^{1-\sigma}$. Assume, in particular, that region *1* is located closer to region 3 than region 2, i.e. $\delta^1 \langle\, \delta^2$; more specifically, $\phi_N^2 = \phi_R\phi_N^1$. Expressions now become:

$$s_n^1 = \left[\frac{1+\phi_R}{\left(1-\phi_R\right)\left(1-\phi_N^1\right)}\right] s_E^1 - \left[\frac{\phi_R - \phi_N^1}{\left(1-\phi_R\right)\left(1-\phi_N^1\right)}\right] s_E^2 - \left[\frac{\phi_N^1}{\left(1-\phi_N^1\right)}\right] \qquad \text{(A1.12.)}$$

$$s_n^2 = -\left[\frac{\left(1-(\phi_N^1)^2\right)\phi_R}{\left(1-\phi_R\phi_N^1\right)\left(1-\phi_R\right)\left(1-\phi_N^1\right)}\right] s_E^1 + \left[\frac{1+\phi_N^1}{\left(1-\phi_R\right)\left(1-(\phi_N^1)^2\right)}\right] s_E^2 \qquad \text{(A1.13.)}$$

Forces at work can be more easily seen assuming additionally that regions 2 and 3 are perfectly symmetric. In this case, the solution to the model implies that:

$$s_n^1 = \frac{1}{3} + \left[\frac{1+\phi_R\phi_N^1}{\left(1-\phi_R\right)\left(1-\phi_N^1\right)}\right]\left(s_E^1 - \frac{1}{3}\right) + \frac{2\phi_R\phi_N^1}{3\left(1-\phi_N^1\right)\left(1-\phi_R\right)} \qquad \text{(A1.14.)}$$

Location of firms is driven by two main factors: a *home market effect* and a *geographical effect*. The *home market effect* is represented by the second term in the right hand side of Equation *(A1.13)*. If there are no size differences ($s_E^1 = s_E^2 = s_E^3$), this term equals zero. If region *1* is relatively large ($s_E^1 \rangle\, s_E^2 = s_E^3$), this term is positive as a result of the forces previously explained. Finally, if region *1* is relatively small ($s_E^1 \langle\, s_E^2 = s_E^3$), the home market effect is negative. The *geographical effect* is reflected by the third term in the right hand side of Equation *(A1.13)*. The positive sign of this term derives from the fact that, being placed at a "central" position, region *1* provides an easy access to other's region markets. If region *1* is relatively large and occupies a "central" position, then both effects reinforce. In turn, if region *1* is relatively small, then the effects move in opposite directions. In particular, the locational advantage outweighs the size disadvantage if:

$$s_n^1 \rangle\, \frac{1}{3} \Rightarrow s_E^1 \rangle\, \frac{1}{3} - \frac{2\phi_R\phi_N^1}{3\left(1+\phi_R\phi_N^1\right)} \qquad \text{(A1.15.)}$$

Appendix A1.D

Assume that selling locally each industrial output unit involves an intra-regional iceberg trade cost ρ^i and that, as before, selling in other region's market involves interregional trade costs τ and δ. An improvement in local infrastructure reflects in a reduction of ρ^i and an enhancement in interregional (international) infrastructure expresses in a decreases of τ (δ). Furthermore, suppose that intra-regional trade costs differ across regions and it is more costly to trade with an agent located in other region than with an agent situated in the same region. In particular, $\rho^1 < \rho^2 < \rho^3 < \delta < \tau$. The interior solution of the location condition for region 1 is now given by:

$$s_n^1 = \left[\frac{\left(\phi_I^2\phi_I^3 - (\phi_N)^2\right)}{\left(\phi_I^3 - \phi_N\right)\left(\phi_I^2 - \phi_R\right)}\right] s_E^1 - \left[\frac{\left(\phi_I^3\phi_R - (\phi_N)^2\right)}{\left(\phi_I^3 - \phi_N\right)\left(\phi_I^1 - \phi_R\right)}\right] s_E^2 - \frac{\phi_N\left(\phi_I^2 - \phi_R\right)}{\left(\phi_I^1\phi_I^2 - (\phi_R)^2\right) + \phi_N\left(2\phi_R - \phi_I^1 - \phi_I^2\right)}\left(1 - s_E^1 - s_E^2\right) \quad \text{(A1.16.)}$$

where, by analogy, $\phi_I^i \equiv \left(\rho^i\right)^{1-\sigma}$ represents the freeness of intra-regional trade in region *i.*

Location depends thus on relative market sizes (as measured by the regional share in total expenditure) and on relative infrastructure quality (as measured by the implied intra-regional trade costs). Given the size distribution, an improvement in domestic infrastructure fosters an inward relocation:

$$\frac{\partial s_n^1}{\partial \phi_I^1} = \left[\frac{\left(\phi_I^3\phi_R - (\phi_N)^2\right)}{\left(\phi_I^3 - \phi_N\right)^2\left(\phi_I^1 - \phi_R\right)}\right] s_E^2 + \frac{\phi_N\left(\phi_I^2 - \phi_R\right)\left(\phi_I^2 - \phi_N\right)}{\left[\left(\phi_I^1\phi_I^2 - (\phi_R)^2\right) + \phi_N\left(2\phi_R - \phi_I^1 - \phi_I^2\right)\right]^2}\left(1 - s_E^1 - s_E^2\right) \rangle\, 0 \quad \text{(A1.17.)}$$

Appendix A1.E

Following Baldwin *et al.* (2003) input-output linkages are introduced assuming that the production of a typical variety requires a unit of capital, labor, *and* intermediate inputs. Thus, the cost function becomes:

$$C(x_j) = \pi + a_M x_j P_P \quad \text{(A1.18.)}$$

where $P_P \equiv w^{1-\mu}\left(\Delta n^T\right)^{\frac{\mu}{1-\sigma}} with\, \Delta \equiv \left(\int_0^{n^T} p_i^{1-\sigma} di\right) \Big/ n^T$ is the producer price of the Cobb-Douglas aggregate of labor and the bundle of intermediates C_M and remaining variables have been previously defined.[28] Equations governing demand patterns and capital mobility remain the same. As before, a set of normalizations is introduced:

$$a_A = 1 \Rightarrow p_A^1 = p_A^2 = p_A^3 = w^1 = w^2 = w^3 = 1 \quad ; \quad p^{11} = P^{11} \Rightarrow p^{12} = \tau P^{12}, p^{12} = \delta P^{13}$$

$$Fixed\,cost = 1 \Rightarrow K^T = n^w \quad ; \quad K^T = 1 \Rightarrow n^T = 1 \Rightarrow n^1 + n^2 + n^3 = 1\, and\, n^i = s_n^i \quad ; \quad a_M = 1 - (1/\sigma) \quad ; \quad L^T = 1 - \mu$$

Maximized operating profits are now given by:

$$\frac{\pi^1}{\overline{\pi}} = \left(\Delta^1\right)^{\mu}\left(\frac{s_E^1}{\Delta^1} + \frac{\phi_R s_E^2}{\Delta^2} + \frac{\phi_N s_E^3}{\Delta^3}\right) \quad \text{(A1.19.)}$$

$$\frac{\pi^2}{\overline{\pi}} = \left(\Delta^2\right)^{\mu}\left(\frac{\phi_R s_E^1}{\Delta^1} + \frac{s_E^2}{\Delta^2} + \frac{\phi_N s_E^3}{\Delta^3}\right) \quad \text{(A1.20.)}$$

$$\frac{\pi^3}{\overline{\pi}} = \left(\Delta^3\right)^{\mu}\left(\frac{\phi_N s_E^1}{\Delta^1} + \frac{\phi_N s_E^2}{\Delta^2} + \frac{s_E^3}{\Delta^3}\right) \quad \text{(A1.21.)}$$

where both producer price index P_p and consumer price index *p* are $P_p = p = \Delta^{\mu/(1-\sigma)}$ and

$$\Delta^1 = s_n^1\left(\Delta^1\right)^{\mu} + \phi_R s_n^2\left(\Delta^2\right)^{\mu} + \phi_N s_n^3\left(\Delta^3\right)^{\mu} \qquad s_E^1 = s_L^1 + \mu\beta\left(s_n^1 - s_L^1\right) + \mu\beta\frac{\pi^1 - \overline{\pi}}{\overline{\pi}} s_n^1$$

[28] For the sake of simplicity the shares of total expenditures that firms and consumers devote to industrial goods are assumed to be the same, μ. Further, the elasticity of substitution σ is the same for final demand as well as for intermediate demand.

$$\Delta^2 = \phi_R s_n^1 (\Delta^1)^\mu + s_n^2 (\Delta^2)^\mu + \phi_N s_n^3 (\Delta^3)^\mu \qquad s_E^2 = s_L^2 + \mu\beta (s_n^2 - s_L^2) + \mu\beta \frac{\pi^2 - \overline{\pi}}{\overline{\pi}} s_n^2$$

$$\Delta^3 = \phi_N s_n^1 (\Delta^1)^\mu + \phi_N s_n^2 (\Delta^2)^\mu + s_n^3 (\Delta^3)^\mu \qquad s_E^3 = s_L^3 + \mu\beta (s_n^3 - s_L^3) + \mu\beta \frac{\pi^3 - \overline{\pi}}{\overline{\pi}} s_n^3$$

Notice, first the recursion in the definition of the Δs which is now the solution of a system of equations. These recursions make impossible to get a closed form solution for the location variables s_n^i.

Appendix A1.F

From equation (A1.12.), the following spatial effect of trade liberalization under asymmetric locational advantages can be determined:

$$\frac{\partial s_n^1}{\partial \phi_N^1} = \frac{1+\phi_R}{(1-\phi_R)(1-\phi_N^1)^2} s_E^1 + \frac{1}{(1-\phi_N^1)^2} s_E^2 + \frac{1}{(1-\phi_N^1)^2} \Rightarrow \frac{\partial s_n^1}{\partial \phi_N^1} \rangle\ 0 \ if \ s_E^1 \ \rangle\ \frac{1-\phi_R}{2\phi_R} s_E^3 \qquad \text{(A1.22.)}$$

Assuming additionally that regions *2* and *3* are symmetric in size, this derivative becomes:

$$\frac{\partial s_n^1}{\partial \phi_N^1} = \frac{1-(\phi_R)^2}{(1-\phi_R)^2 (1-\phi_N^1)^2} \left(s_E^1 - \frac{1}{3} \right) + \frac{2}{3} \frac{\phi_R (1-\phi_R)}{(1-\phi_R)^2 (1-\phi_N^1)^2} \ \rangle\ 0 \Rightarrow s_E^1 \ \rangle\ \frac{1}{3} - \frac{2\phi_R}{3(1+\phi_R)} \qquad \text{(A1.23.)}$$

Therefore, reduced international trade costs result in a re-location towards region *1* if the market size of this region is not too small.

Appendix A1.G

It can be shown for the general model that the impact of differentiated infrastructure qualities increases as international trade costs decrease if, as usually the case, trade barriers within the country are substantially lower than trade barriers with foreign countries.[29] A simpler, more revealing expression can be derived assuming a scenario where international trade flows have been completely liberalized, i.e., $\phi_N = \phi_R$ and regions *2* and *3* are perfectly symmetric regarding size and domestic infrastructure, i.e., $s_E^2 = s_E^3 \ and \ \phi_I^2 = \phi_I^3 = \phi_I$. In this case, the solution of the location condition is:

$$s_n^1 = \frac{1}{3} + \frac{3\left[\left(\phi_I^1 \phi_I - (\phi_R)^2\right) + \phi_R \left(\phi_I^1 - \phi_R\right)\right]\left(s_E^1 - 1/3\right) + 2\phi_R \left(\phi_I^1 - \phi_I\right)}{3\left(\phi_I^1 - \phi_R\right)\left(\phi_I - \phi_R\right)} \qquad \text{(A1.24.)}$$

An improved domestic infrastructure leads to the following inflow of firms into region *1*:

$$\frac{\partial s_n^1}{\partial \phi_I^1} = \frac{\phi_R \left(1 - s_E^1\right)}{\left(\phi_I^1 - \phi_R\right)^2} \ \rangle\ 0 \qquad \text{(A1.25.)}$$

The relocation effect becomes stronger as interregional trade costs decline:

$$\frac{\partial \left(\frac{\partial s_n^1}{\partial \phi_I^1} \right)}{\partial \phi_R} = \frac{\left(1 - s_E^1\right)\left(\phi_I^1 + \phi_R\right)}{\left(\phi_I^1 - \phi_R\right)^3} \ \rangle\ 0 \qquad \text{(A1.26.)}$$

[29] This result can be obtained from the author upon request.

Appendix A1.H

Assume that region *1* concedes a subsidy *x* proportional to operating profits for firms located in its territory. This can be interpreted as a tax break for these firms. The location condition becomes now: $\pi^1(1+x)=\pi^2=\pi^3$.The solution set for the general model with subsidies contains highly complicated expressions which are unrevealing. Therefore, I report the shares of industrial activity in regions *1* and *2* evaluated at the point where trade has been completely liberalized between the home country and the foreign country, i.e., $\phi_N=\phi_R$:

$$s_n^1=\frac{[1+\phi_R(1-2\phi_R)]s_E^1(1+x)+2(\phi_R)^2x-\phi_R(1-\phi_R)}{\{[1+\phi_R(1-2\phi_R)]s_E^1-2\phi_R(1-\phi_R)\}x+(1-\phi_R)^2} \qquad \text{(A1.27.)}$$

$$s_n^2=\frac{[1+\phi_R(1-2\phi_R)]s_E^2+2(\phi_R)^2x-\phi_R(1-\phi_R)-[(1+2\phi_R)\phi_R(s_E^1+2s_E^2)-2(\phi_R)^2]x}{\{[1+\phi_R(1-2\phi_R)]s_E^1-2\phi_R(1-\phi_R)\}x+(1-\phi_R)^2} \qquad \text{(A1.28.)}$$

Subsidies induce re-location towards the conceding region:

$$\frac{\partial s_n^1}{\partial x}=\frac{s_E^1(1-s_E^1)(1+2\phi_R)^2}{[(1+s_E^1x-\phi_R)-2x\phi_R(1-s_E^1)]^2}\rangle\, 0 \qquad \text{(A1.29.)}$$

It can be shown that this derivative is increasing in s_E^1 for intermediate trade costs if s_E^1 is large enough.[30]

Appendix A1.I

Assume that region 2 also grants a subsidy. Solving the location condition $\pi^1(1+x_1)=\pi^2(1+x_2)=\pi^3$ and evaluating the resulting expressions for s_n^1 and s_n^2 at $\phi_N=\phi_R$ and $x_1=x_2=x$, the difference between both shares is given by:

$$s_n^1-s_n^2=\frac{(1+2\phi_R)[1+x-\phi_R(1-x)](s_E^1-s_E^2)}{(1-\phi_R)[((1+2\phi_R))(s_E^1+s_E^2)x+1-\phi_R(1+x)]} \qquad \text{(A1.30.)}$$

which is zero if regions are symmetric in size. Analogously, one can think on fiscal measures compensating size differentials. In this sense, assume that smaller regions start to grant tax breaks. As a consequence, they may initially experience some locational share gains. Larger regions then react by also conceding tax breaks. In order to minimize their revenue losses, they only need to do it in such a way that just neutralizes the smaller regions' policies. This, of course, implies lower subsidies.

[30] The derivation of this result is available from the author upon request.

Appendix A2

Table A2.A

Variable	Definition	Time Coverage	Source of Raw Data
Agriculture abundance	$ags_i \equiv \frac{Agriculture\ GDP_i}{GDP_i}$	1990-1998	IPEA
Human capital abundance	$edus_i \equiv \frac{Population\ with\ at\ least\ sec.\ school_i}{Population_i}$	1990-1998	IBGE
Average manufacturing wage	$mws_i \equiv Average\ number\ of\ reference\ wages$	1990-1998	RAIS/MW
Population	$pop_i \equiv \sum_{h \neq i} \frac{Population_h}{distance_{ih}} + \frac{Population_i}{distance_{ii}}$	1990-1998	IBGE/DNER
Industrial GDP	$inds_i \equiv \sum_{h \neq i} \frac{Industrial\ GDP_h}{Distance_{ih}} + \frac{Industrial\ GDP_i}{Distance_{ii}}$	1990-1998	IPEA/DNER
Market potential	$mp_i \equiv \sum_{h \neq i} \frac{GDP_h}{Distance_{ih}} + \frac{GDP_i}{Distance_{ii}}$	1990-1998	IPEA/ DNER
Infrastructure	$inf_i \equiv \frac{Kilometers\ of\ paved\ routes_i}{\left(Area / 100\ km^2\right)_i}$	1990-1998	GEIPOT/ IBGE
Distance to Buenos Aires	$dist_i \equiv Distance\ to\ Bs.As._i$ (calculated as shown below)	-	IGM/ IBGE/CEPII
Subsidy policy	$sub_i \equiv Subsidy\ Policy\ Index_i$ (calculated as shown below)	1995, 1998	PP/CNI
Agriculture intensity	$ags_j \equiv \frac{Agriculture\ inputs_j}{Production\ value_j}$	1990-1998	IBGE
Human capital intensity	$edui_j \equiv \frac{Employees\ with\ at\ least\ sec.\ school_j}{Employees_j}$	1990-1998	IBGE
Labor intensity	$lcva_j \equiv \frac{Labour\ compensation_j}{Value\ added_j}$	1990-1998	IBGE
Final demand bias	$fd_j \equiv \frac{Demand\ by\ households_j}{Total\ demand_j}$	1990-1998	IBGE
Industrial intermediate consumption	$ici_j \equiv \frac{Industrial\ inputs_j}{Production\ value_j}$	1990-1998	IBGE
Sales to industry	$si_j \equiv \frac{Intermediate\ demand\ by\ industries_j}{Total\ demand_j}$	1990-1998	IBGE
Economies of scale	$scn_j \equiv \frac{Employees_j}{Number\ of\ establishments_j}$	1990-1998	RAIS/MW
Trade intensity	$trad_j \equiv \frac{Exports_j + Imports_j}{Production\ value_j}$	1990-1998	IBGE
Tax intensity	$ti_j \equiv \frac{Taxes_j}{Supply\ value_j}$	1990-1998	IBGE

Abbreviations: *IBGE*: Brazilian Institute of Geography and Statistics; *IPEA*: Institute of Applied Economic Research; *MW*: Ministry of Works; *DNER*: National Department of Routes; *IGM*: Military Geographical Institute (Argentina); *GEIPOT*: Brazilian Firm of Transport Planning; *CNI*: National Confederation of Industries; *PP*: Piancastelli and Perobelli (1996); *CEPII*: Centre d'Estudes Prospectives et d'Informations Internationales.

Intra-state distances (d_{ii})

Intra-state distance is given by 1/3 of the radius of a circle with the same area as the state *i* (Leamer, 1997).

Distance to Buenos Aires (dist)

Distances between state capitals and Buenos Aires (taken as the main economic centre of Argentina) could not be obtained. I estimated these distances using the formula of geodesic distances by CEPII. Formally, the distance between two points *i* and *j* is given by:

$$d_{ij} = 6370 * ar\cos\begin{bmatrix} \cos(lat_j/57{,}2958) * \cos(lat_i/57{,}2958) * \cos(\min(360 - abs(long_j - long_i), abs(long_j - long_i)/57{,}2958) \\ + \sin(lat_j/57{,}2958) * \sin(lat_i/57{,}2958) \end{bmatrix}$$

where *lat* is latitude and *long* means longitude.

Intensity measures and demand biases (agi, lcva, fd, ici, si, trad, ti)

The data used to calculate the intensity measures have been taken from the National Account System of Brazil elaborated by the *IBGE*. These data do not exactly match the disaggregation used here so that I mapped into it.

The *RAIS* Classification includes the following manufacturing sectors: Non-metallic minerals; Metallurgy; Mechanics; Electrical and Communication Equipment; Transport Equipment; Wood; Furniture; Paper; Printing and Publishing; Rubber; Leather and Hides; Chemicals; Pharmaceuticals; Perfumes, Soaps, and Candles; Plastics; Textiles; Clothing and Footwear; Food Products; Beverages; Tobacco; and Other Products.

Trade costs – Tradability (trad)

Usually, models refer to trade costs in a general way, i.e., they are conceived as broad impediments to transactions, including man-made barriers (i.e., tariffs). Therefore, I used an indicator of industry output tradability as an indicator for the inverse of the foreign trade costs severity for each sector. The evolution of this indicator reflects well the opening policy by Brazilian government, both unilaterally and regionally.

Economies of scale (scn)

Measuring scale economies is problematic. They might be product-specific, plant-specific or due to multi-plant operations (Amiti, 1999). Here, following Kim (1995) and Amiti (1999), economies of scale are captured by establishment size, i.e., the average number of employees per establishment in the industry in question.

There are other possible measures, like the one developed by Pratten (1988) and extensively used by other authors. Pratten ranked industries "in order of the importance of the economies of scales for spreading development costs and for production costs". However, estimations are exclusively based on information about developed countries. For that reason the use of Pratten's measure for a developing country such as Brazil can be misleading.

Subsidy policy (sub)

The variable *sub* (subsidy policy) amounts to an index of "fiscal aggressiveness" in trying to attract firms. A higher value of the index means higher "aggressiveness" in stimulating the location of activities.

The index *sub* measures how generous are the incentives provided by the different states in order to induce the settlement of industries. I constructed this index by working out the tables on state subsidy policies in Piancastelli and Perobelli (1996) and CNI (1998). I took the data in the first publication as representative for the first half of the decade and I assumed that the data included in the second publication is valid for the remaining period. I normalized the information on diversity of instruments and conditions on conceded benefits (percentage of tax reductions, duration, remission period, interest rate, and magnitude of foreseen monetary correction) making the average scores equal to 100 and then averaged into a summarizing measure.

Appendix A3

Figure A3.A

Source: Brazil’s Embassy in London (United Kingdom) (www.brazil.co.uk)

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