Mercosul and Regional Development in Brazil: A Gravity Model Approach

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Abstract: This paper assesses the impact of the Mercosul Preferential Trade Agreement on Brazil's regions by means of a gravity model, extended to include dummy variables for Mercosul and for a Brazilian region. The results show that the most significant regional impacts of Mercosul were on Brazil's Southern and Southeastern regions, whereas the North, Northeast and Center-West regions benefited much less from Mercosul in the period from 1990 to 1998. These results suggest that Mercosur may be aggravating regional disparities in Brazil.

1. Introduction

The interest in economic integration among countries has recently being renewed, as Free Trade Areas and other types of Preferential Trade Agreements (PTAs) are flourishing all over the world. The debate is very lively on whether regional economic integration ("regionalism") is welfare improving, and thus is a building block towards the achievement of free trade, or if it is welfare reducing, and thus is a stumbling block to achieve free trade. The main argument on the building block view is that regionalism is beneficial to the global trading system, and that outward-oriented economic integration ("open regionalism") is consistent with multilateral liberalization and is net trade creating on the whole (Bergsten 1996). Conversely, the stumbling block view of economic integration holds that regionalism is inward-oriented by its nature, is net trade diverting in most of the cases, and even if net trade creating it is viewed as threatening to the international trading system (Bhagwati and Panagariya 1996).

However, even if one accepts the premise that recent Preferential Trade Agreements are, on the majority, committed to open regionalism, and thus welfare improving for participating countries and the world as a whole, economic integration may affect unevenly the regions of participating countries. As relative prices change in these countries, they will increasingly specialize in the production of goods in which they have a comparative advantage; the regions that concentrate a large share of the booming or contracting industries will be more than proportionally affected by economic integration. Therefore economic integration may affect different regions of a country in a different way, thereby easing or aggravating regional disparities in a country (Bröcker 1988). Thus, it is very important that we have a better understanding on how economic integration impacts the economic structure of the regions comprising the participating countries.

Mercosul[1] is a customs union among four Latin American countries (Argentina, Brazil, Paraguay and Uruguay) that is seen as outward looking and significantly different from previous efforts of economic integration in Latin America (Braga, Safadi and Yeats 1994). As a result of the negotiations towards the customs union, Mercosul countries had lowered significantly their average tariff rates, specially Brazil (Edwards 1993), which had very high tariffs until the early 1990s. Moreover, Mercosul was preceded by a significant unilateral trade liberalization effort by its largest trading partners, Argentina and Brazil. The common external tariffs were implemented in January 1, 1995, and the participating countries phased out their internal tariffs according to a pre-determined schedule on a linear manner until zero tariff rates were achieved in December 31, 1994[2].

Brazil has five regions, and the distribution of production and income among them is very unequal[3]. The Southeast includes the three largest state economies, and one of them (São Paulo) has a Gross Regional Product equivalent to Argentina's GDP. Moreover, its income per capita on a PPP basis is by far the country's largest (see Table 1), similar to some of European Union countries in the lower income tier. The South has the fourth and fifth largest state economies, and had strong cultural and economic ties with Argentina, Uruguay and Paraguay even before the Mercosul agreement (all the three states on that region border Mercosul countries). The Northeast is the poorest region, with some of its states having a state regional product equivalent to the less developed countries in the world. The North is also a poor region, with most of its economy being sparsely linked and populated since the Amazon forest comprises most of its area. The Center-West is a transition region, with some forest land but most of it being savanna grasslands, with soil suitable to agriculture. As the opportunity cost of agriculture in the South and Southeast increased significantly, most of the agricultural production moved from those regions to the Center-West, causing a large growth in the latter's economy in the last twenty years.

Table 2 below shows Brazilian total trade by trade block from 1990 to 1998; it shows that the largest growth in total trade was with Mercosul countries during that time period. Table 3 shows Brazilian total trade by region from 1990 to 1998, which shows that the largest increase in total trade was for the South and Southeast regions. These stylized facts suggest that they may be connected, that

[1] Henceforth I will use the name Mercosul, the Portuguese version of the Common Market of the Southern Cone; also commonly used is Mercosur, the Spanish translation.

[2] However, a list of exceptions to the common external tariff and to the zero internal tariffs still exists. For two good overall accounts on Mercosul, see Brandão and Pereira (1996) and Florencio and Araujo (1995). For an evaluation of the achievements of Mercosul, see Laird (1997).

[3] For a good account on the recent evolution of the development of Brazil's regions see Affonso and Silva (1995)

is, that the large increase in total trade with Mercosul countries may have affected positively the regions South and Southeast. But that conclusion would be misleading based solely on these tables, since this simple model does not separate trade growth into its main components. Particularly, income and distance effects are known to have a large impact on trade growth (Frankel, Stein and Wei 1995). We need a model that explains trade in terms of its main determinant variables such as income and geographical distance, and we can then control for these two effects to determine the consequences of economic integration and regional variables on trading patterns.

The objective of this paper is to assess the impact of the Mercosul agreement on Brazil’s regions. By using a gravity model I show that, apart from income and distance effects, a large part of the trade of Brazilian states can be explained by a Mercosul effect and by a regional effect. These two effects combined produces a trade bias which I estimated and compared for all Brazil's five regions for the years 1990, 1994 and 1998, to see which region(s) had the largest increase in the trade bias (and thus positively affected) due to Mercosul in that time period.

In the next section I depict the theoretical foundations and empirical tests of the gravity model and alternative models to assess the regional impacts of economic integration. In section 3 I analyze the results from two econometric estimations: one is the standard gravity model with a Mercosul dummy variable included, and the other is the gravity model with both a Mercosul and a Region dummy variables included. In section 4 I present some implications and concluding remarks, along with suggestions for further research in this topic. An explanation of the data is included in the appendix section.

Table 1 - Brazil: Gross Regional Product per capita by Region, 1990, 1994 and 1998, US$

Region	1990	1994	1998	1990-1994 % Change	1990-1998 % Change
South	3,603	4,137	5,696	14.8	58.1
Southeast	4,649	5,762	6,610	23.9	42.2
North	1,627	1,791	2,900	10.0	78.2
Northeast	1,488	1,708	2,223	14.7	49.4
Center-West	3,013	3,504	4,418	16.3	46.6
Brazil	3,262	3,920	4,810	20.2	47.5

Source of data: IBGE; EBAP/FGV
Note: The regions are defined in the appendix section.

Table 2 - Brazil: Total Trade by Trade Bloc, 1990, 1994 and 1998, US$ Millions

Trade Blocs	1990	1994	1998	1990-1994 % Change	1990-1998 % Change
Europe	15,800	22,200	33,102	40.5	109.5
North America	13,600	18,200	27,429	33.8	101.6
Mercosul	3,600	10,500	18,301	191.6	408.3
Rest of South America	2,300	4,100	6,372	78.2	177.0
Asia	6,700	12,000	12,765	79.1	90.5
Rest of the world	9,800	9,500	10,899	-3.0	11.2
World	51,800	76,500	108,868	47.6	110.1

Source of data: SECEX/DTIC; Receita Federal.
Note: The trade blocs are defined in the appendix section.

Table 3 - Brazil: Total Trade by Region, 1990, 1994 and 1998, US$ Millions

Region	1990	1994	1998	1990-1994 % Change	1990-1998 % Change
South	4,182	15,674	22,123	274.8	429.0
Southeast	23,709	47,821	69,584	101.7	193.5
North	2,791	4,763	5,983	70.6	114.3
Northeast	4,000	5,955	7,512	48.8	87.8
Center-West	739	1,459	2,161	97.4	192.4
Brazil	35,421	75,672	107,363	113.6	203.1

Source of data: SECEX/DTIC; Receita Federal.

2. Economic Integration and Regional Development: Literature Review

As mentioned earlier, economic integration schemes, such as a Free Trade Area or a Customs Union, are spreading to most parts of the world. Economic integration, although a second-best policy, is seen by some economists as a good intermediary step towards the achievement of free trade in the future. However, it is seen by others as an impediment towards the achievement of free trade[4]. In this paper I will not concentrate on the theoretical discussion on whether PTAs are beneficial or detrimental to achieving free trade; rather, my objective here is to assess the impact of PTAs on the regions of the partner countries. Thus I will assume that a PTA may have either beneficial or harmful overall effects, depending on whether the PTA is trade creating or trade diverting to participating countries and the world as a whole. I am assuming that the welfare effects of PTAs are mainly of a static nature in a Vinerian sense[5], and thus I am discarding any possible dynamic effects in participating countries of a PTA[6].

To estimate empirically the static effects of economic integration arrangements, there are two main classes of models: first the ex-ante techniques, in which the effects of economic integration are determined before an actual agreement is signed by the partner countries. As examples, the Price Elasticities approach, the Import Demand Regression approach, and the large Computational General Equilibrium models, could be mentioned. Conversely, an ex-post technique estimates the effects of economic integration after it occurs; the Import Growth approach and the gravity model are the best examples of this category of techniques. The gravity model was used in this paper as an ex-post method that evaluates the effects of Mercosul after it took full effect in December 31, 1994. By adding a preferential trade agreement dummy variable and a regional dummy variable, the gravity model can be used to estimate the regional impact of economic integration. Also, models based on input-output tables can be used to estimate the effects of changes in trading patterns on the economic structure of a region.

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[4] The literature on whether regional trade arrangements are welfare improving or welfare reducing is vast. For a good overview on regional trade agreements since 1947 see Pomfret (1988).

[5] Viner (1950) noted that, while a customs union between some (and not all) countries would create trade and thus have positive effects on welfare, trade diversion might offset these positive effects. These net effects from trade creation and trade diversion are known as the static effects of economic integration.

[6] Of course, in many cases, these dynamic effects can be considerably large. For example, the dynamics effects of NAFTA in Mexico through investments, new technology dissemination and economies of scale are probably much larger than a possible negative net effect from static effects. For the purpose of simplification, I assume that the effects of a PTA are mostly static effects.

2.1 - Theoretical Foundations of the Gravity Model

The gravity model was first proposed independently by Tinbergen (1962) and Pöyhönen (1963), and later refined by Linnemann (1966). Tinbergen's original aim was to account for the factors that explained the size of trade flows between two countries. These factors were of three types: one type include the factors related to the total potential supply of the exporting country. A second type include the factors related to the total potential demand of the importing country; these two types were basically the size of Gross Domestic Product of the exporting and importing country, respectively. Linnemann later added the size of the populations of the two trading countries to reflect the role of scale economies. Finally the third set of factors was the resistance to trade, be it natural or artificial trade resistance. Natural trade resistance was defined as the obstacles to trade imposed by nature, such as costs of transportation, transport time etc., whereas artificial barriers are those imposed by governments, such as tariffs, quantitative restrictions, exchange controls, etc. Dummy variables were also included in the model, specially one for preferential trade arrangements. Thus, the original model was the following:

$$X_{ij} = a_0 (Y_i)^{a1} (Y_j)^{a2} (N_i)^{a3} (N_j)^{a4} (Dist_{ij})^{a5} (Pref)^{a6} (e_{ij}), \qquad (1)$$

where X_{ij} is the dollar value of exports from country i to country j; Y_i is the nominal value of country i's GDP); Y_j is the nominal value of country j's GDP; N_i is the population of country i; N_j is the population of country j; $Dist_{ij}$ is the distance between the commercial centers of the two countries, and is used as a proxy for the trade resistance variables; Pref is a dummy variable which equals to 1 if both countries belong to a specific preferential trade area and zero otherwise; and e_{ij} is the error term. The coefficients a_0 through a_6 are to be estimated by the regression.

However, the gravity model's main weakness is its lack of a solid theoretical microeconomic foundation; Linnemann has shown how the gravity equation could be derived theoretically from a quasi-Walrasian general equilibrium model, but crucial to that derivation was an assumption of separate demand functions for imports for each trading partner, assumption which was not justified by Linnemann (Deardorff 1984). Another critique to Linnemann's theoretical explanation of the gravity model is presented by Anderson (1979). Linnemann saw the gravity equation as a reduced form from a four-equation partial equilibrium model of export supply and import demand. Prices are always excluded since they merely adjust to equate supply and demand. Anderson[7] see this explanation as "loose", and that it does not explain either the multiplicative functional form of the gravity equation. Anderson (1979) presents an alternative theoretical model to explain the gravity equation based on a Cobb-Douglas expenditure system. It assumes identical homothetic preferences across regions, and products differentiated by country of origin. “The gravity model constrains the pure expenditure system by specifying that the share of national expenditure accounted for by spending on tradables is a stable unidentified reduced-form function of income and population. Moreover, the share of total tradable goods expenditure accounted for by each tradable good category across regions is an identified (through preferences) function of transit cost variables. In this manner, partial identification is achieved” (Anderson 1979). This theoretical explanation accounts for the multiplicative form of the gravity equation, allows for an interpretation of distance and identifies its coefficient; and presents an efficient estimator for the gravity model (although at a possible cost of bias).

Anderson's approach left unresolved some issues. First, it does not explain the unidentified part of the equation, the function specifying that trade's share of budgets is dependent on income and population. Furthermore, his explanation did not include price variables; Bergstrand (1985) extends the theoretical foundations of the gravity equation by incorporating price variables to the gravity model. He presented a general equilibrium world trade model from which a gravity equation is derived. This model is obtained from a utility- and profit-maximizing agent behaviour in N countries assuming a single factor of production in each; by adding some other assumptions, including perfect international product substitutability, he arrives at a gravity equation such as (1). But if trade flows are differentiated by origin as evidence suggests, then the typical gravity equation is misspecified, omitting price variables. He then amends his model to include an econometric version that contains price variables.

Bergstrand (1989) further extends the theoretical foundations of the gravity equation by incorporating factor-endowment and non-homothetic taste variables. The model is a general equilibrium world trade model with two differentiated-product industries, two factors (capital and labor), and N countries. A representative consumer maximizes a Cobb-Douglas utility function subject to a income constraint; the resulting demand functions relate bilateral trade flows to national income, per capita income, and prices. Exporter income and per capita income are interpreted as national output in terms of units of capital and the country's capital-labor ratio. Changes in importer income and per capita income are interpreted as alterations of expenditure capabilities and taste preferences. And “this

[7] Other authors shared this same critical view of Linnemann's theoretical explanation of the gravity model. See, for

framework yields a gravity-like equation that is consistent with the modern theories of inter-industry and intra-industry trade" (Bergstrand 1989).

2.2 - Empirical Tests of the Gravity Model

In spite of its theoretical problems, the gravity equation has been very successful in explaining trade empirically; the estimation of the equation above by Linnemann, fitted to the trade of 80 countries, explained some 80 percent of the variance of the data. Bergstrand's (1989) generalized gravity equation explained empirically between 40 and 80 percent of the variation across countries in one-digit SITC trade flows. The empirical success of the gravity equation is attributed to its ability to incorporate most of empirical phenomena observed in international trade[8]. The gravity equation has also proved useful as the basis for tests of other propositions. For example, Leamer (1974) used it to test the importance of factor endowments and other country characteristics as they affect international trade. And McCallum (1995) used the gravity equation to evaluate the impact of the Canada-United States border on regional trade patterns.

It has also been used pervasively in models that try to assess the welfare effects of regional economic integration. The literature on the empirical tests of the gravity model used for regional integration is very large; starting in the late 1960s, many studies evaluated the effects of the EEC. But the first large empirical estimation of the effects of the EC using a gravity model was done by Aitken (1973). In that study he evaluated the effects of the EEC and the EFTA regional integration agreements by estimating the parameters of the gravity model cross-section data from 1951 to 1967; the EEC and EFTA coefficients become positive in 1959 and 1961, respectively, and stayed positive and experienced cumulative growth until 1967; since the EEC was implemented in 1958 and EFTA in 1960, this implies that these arrangements were net trade creating.

Two other important studies that applied the gravity model to the trading bloc question were Frankel (1992) and Frankel and Wei (1992). These studies, looking at the period from 1980 to 1990, found that there are intra-regional trade biases in the EC, in the Western Hemisphere, and to a lesser extent in East Asia, but the greatest intra-regional bias was in the APEC grouping[9]. These results were

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example, Leamer and Stern (1970), p. 146.

[8] Empirical phenomena such as the large volume of trade among industrialized countries; intra-industry trade; ease of adjustment of trade liberalization; and the relationship between country size and export shares (Deardorff 1984).

[9] For a definition of these regional groupings, see Frankel, Stein and Wei (1995).

extended in Frankel and Wei (1993a, 1993b) by providing further economic and econometric extensions to the original gravity equation. They included pairs of countries that were undertaking zero trade; they corrected for heteroscedasticity based on the size of the countries; they extended the time period 15 years farther back; and they included bilateral exchange rates. With these extensions, the results turned out to be robust. Frankel, Stein and Wei (1995) further extended those results; they included a variable for a pair of countries that spoke the same language; they broke the Western Hemisphere group into sub-regional groupings, such as Mercosul, NAFTA, and the Andean Pact; they included a factor-endowment term; they tested for trade diversion; they reported separate results for trade in manufactured products; they tested whether customs unions had different effects from free trade areas; they entered GNP in product format (instead of each one separately, as in the traditional gravity model), justifying that this is consistent with the modern theory of trade under imperfect competition; and they included a GNP per capita variable, to account for the large volume of trade among developed countries. Again, these extensions produced robust results and further confirmed the presence of large intra-regional trade biases.

2.3 - Economic Integration and Regional Development

All of these studies mentioned in the previous subsection dealt with testing the overall impacts of economic integration arrangements, i.e., they assessed the welfare impacts in the countries as a whole. But none of those studies considered how economic integration affected the different regions of a country. In fact, very few studies have tried to evaluate the regional impacts of economic integration. The most comprehensive of those is the one by Bröcker (1988); the author uses a variant of the gravity model to estimate the impact of the EEC and EFTA on the regions of four countries in Northern Europe: Germany, Norway, Sweden, and Denmark. The author extends a partial equilibrium Vinerian approach of calculating static effects of integration to a spatial world: he introduces transportation costs, and he formulates the model for regions instead of nations. He also relaxes some very restrictive assumptions, such as Viner's elasticity assumptions, and the homogeneity assumption. The resulting interregional trade model is a modified heterogeneous market model, which builds on Viner (1950), Samuelson (1952) and Enke (1951); the system of equations derived from the model is a doubly constrained gravity model, which is inelastically constrained on the demand side and elastically constrained on the supply side. The empirical implementation of the model is very data-intensive, as it needs data for regional supply, regional demand, international and interregional trade flows among regions, and distance among regions. Using 1970 data, the impacts of integration in Europe were evaluated for a total of 73 regions and 36 industries. The results were the following: most of Norway's regions lost from the formation of EFTA, with virtually no effect from the EEC formation; Sweden's regions benefited from EFTA, while EEC had negligible negative effects on those regions; Denmark's regions also gained from EFTA, while having small negative effects from the EEC; and in Germany the adverse effects of EFTA were minimal, while positive effects for some regions and negative effects for others were nearly balanced from the formation of the EEC.

Other types of models can also be used to associate changes in international and interregional trade flows with changes in regional economic structures. One set of models is based on input-output tables, such as the interregional input-output (IRIO) model or the multiregional input-output (MRIO) model. "The IRIO models are extremely data-intensive, in that the region and industry of origin and destination for every product needs to be specified. So MRIO models have been used instead, in that they are less data-intensive: the regional inputs are specified only by the region purchasing the product, not by the region producing it, and the trade flows are specified only on a region-by-region basis. Thus, for the MRIO model, the purchasing industry in the region is not known" (Polenske 1997). The first type of MRIO model is the column-coefficient version, as in Polenske (1980), in which the inflow of a given commodity into a region is assumed to vary in proportion to the total consumption of the product in that region. A second type of MRIO model is the gravity-model coefficient version, in which the trade flows depend upon the amount produced in the origin region, amount consumed in the destination region, and the transfer costs between the two regions. Polenske (1970) implemented this model for Japan using 1963 data. She estimated interregional trade flows, final demand percentage changes by industry and by region, and output percentage changes by industry and by region. She compared actual 1963 regional output figures with estimated figures calculated in the model, and the model gave reasonable predictions. These models based on input-output tables have not been used yet to assess the impacts of economic integration on regions. A potential problem of applying MRIO models with this aim is that they are very data intensive, requiring input-output tables for the country and for all the regions involved, which are often not available.

3. Econometric Models and Results

In order to assess the impacts of Mercosul in the regional development in Brazil, I chose the gravity model in its standard format, as opposed to the gravity model in Bröcker's format, or one of the input-output models (all discussed in the previous section). My approach is to add two dummy variables to the standard gravity model, one for the Mercosul trade agreement, and another for a region in Brazil. I then estimate the joint trade bias of both Mercosul and belonging to a certain region in Brazil by looking at both the Mercosul and the region coefficients.

The advantage of this approach is that the effects at the aggregate level of Mercosul in each of Brazil's regions can be estimated, using relatively less data than the other models. Bröcker's gravity model, although provides a more detailed impact at the industry level, needs a lot of data that was unavailable to me at this time. The input-output models are even harder to estimate because they are very data intensive, and require a large set of input-output tables, as mentioned before.

In the next subsection, I will first use a gravity model with the Mercosul dummy only, compare alternative formats of the reduced form model, and then present the results for the years 1990 and 1998. After choosing one model, in subsection 3.2 I will include the "region" dummy variable and present the results for 1990, 1994 and 1998, and compare the results for those two years to evaluate how the impacts of the Mercosul agreement on the Brazilian regions evolved over time.

3.1 - Main Model

In this section, the basic model to be estimated in its reduced form is the following:

$$\log X_{ij} = \log a_0 + a_1 \log Y_i + a_2 \log Y_j + a_3 \log N_i + a_4 \log N_j + a_5 \log Dist_{ij} + a_6 Adj + a_7 Mercosul + \log e_{ij} ,$$

where X_{ij} is the dollar value of exports[10] from the state (country) i to country (state) j, Y_i is the nominal value of state i's GRP (country i's GDP), Y_j is the nominal value of country j's GDP (state j's GRP), N_i is the population of state (country) i, N_j is the population of country (state) j, $Dist_{ij}$ is the distance between the commercial centers of the state and the country, Adj is a dummy variable which equals to

1 if the state and the country are adjacent, and Mercosul is a dummy variable that equals to 1 if the country belongs to Mercosul, and 0 if that is not the case (of course, all the states also belong to Mercosul since Brazil is part of Mercosul). This model is similar to the one estimated by Aitken (1973), with the only difference being that I replaced his dummy variables for the European Union and EFTA with the Mercosul dummy variable.

Besides this main model (which I call equation 1 in Table 4 below), I estimated alternative presentations of the original gravity equation. First, the gravity model as in McCallum (1995) and in Bergstrand (1985), which have the same model as my basic model except the populations variables. I estimated this model as equation 2 in Table 4. Equation 3 in Table 4 is the original gravity model without the dummy variables: I included this equation to see whether there were significant changes on the coefficients of the income, population and distance variables if I removed the dummy variables from the model. Next I estimated the basic model with a NAFTA regional dummy in lieu of the Mercosul dummy, an European Union (EU) dummy in lieu of the Mercosul dummy, and all the three economic integration dummies at the same time (equations 4, 5, and 6, respectively, in Table 4).

Then I estimated the basic gravity equation presented in Frankel, Stein and Wei (1995): their basic model included total trade (exports plus imports) as the dependent variable (unlike the basic model above). Moreover, they used the product of GDP in country i and GDP in country j in the place of the income variables, and the product of GDP per capita in country i and in country j in the place of the population variables. They also had variables for distance and adjacency, as well as economic integration dummy variables (for the European Union, for East Asia, and for the Western Hemisphere). I then estimated the regression of total trade with the product of GDPs, product of GDPs per capita, and the adjacency and Mercosul dummies, as well as the NAFTA and EU dummies; this model is shown in Table 4 as equation 7.

Finally, I dealt with two potential econometric and specification problems. The first problem addressed is the possibility of simultaneity, since the dependent variable (exports) is a component of one of the regressors (GDP); thus by an accounting identity, the included regressor is correlated with the disturbance term (McCallum 1995). I estimated the original model in equation 8 with the logarithm of the population variables, N_i and N_j , replacing the logarithm of GDP variables, Y_i and Y_j (thus the

[10] This approach assumes that both trade flows (exports and imports) are equivalent in dollar values (both in FOB value, for example); thus, the exports from a country to a state equals the imports of that state from that country.

former are instruments variables of the latter[11]). The second potential problem is heteroscedasticity; I reestimated all the previous 8 equations using heteroscedasticity-consistent standard errors; these standard errors are reported in Table 4.

The results for the year 1998 are presented in Table 4. We first notice that the coefficients for GDPs (Y_i and Y_j), for the distance ($Dist_{ij}$), and for the Mercosul dummy are relatively stable when we compare the 8 estimation equations: they all have the expected sign and are significant. Moreover, the range in which they vary across models is relatively narrow: Y_i ranges from 0.71 to 1.37, Y_j from 1.25 to 1.36, $Dist_{ij}$ from -2.17 to -0.54, and Mercosul ranges from 1.23 to 2.12. Also, the coefficients for GDP and distance are consistent with the estimates from other authors: Aitken (1973) reports the following ranges for the coefficients: 1.069 to 1.215 for Y_i, 0.74 to 1.0 for Y_j, -0.509 to -0.383 for $Dist_{ij}$ (this study did not include a variable for Mercosul). Similarly, McCallum (1995) reports that Y_i varied from 1.15 to 1.36, Y_j from 0.96 to 1.09, and $Dist_{ij}$ from -1.52 to -1.23[12].

A second finding is that the population coefficients did not seem to be stable: while N_i was significant in five of the estimated equations, it was not in the others. Moreover, its coefficient ranged from -0.35 to 1.47, a much larger variation than for the previous variables. This coefficient had the expected sign in only one case.[13] N_j was significant in only one case (equation 8), and it never had the expected sign. Similarly, the adjacency variable was significant only in equation 8, and it had the expected sign.

The most important finding for this study was the coefficient of the Mercosul variable: not only was it significant and had the expected sign, but it was relatively large. For example, in equation 1 its value was 2.12; this means that, using equation 1 as the model, the Brazilian states traded 8.3 times more ($e^{2.12} = 8.3$) with Mercosul countries than with other countries in 1998, ceteris paribus. Therefore the Mercosul trade bias is 8.3. Interestingly, the trade bias with Brazil's largest trade partners, NAFTA (mainly the U.S.) and European Union, is less than or close to one. For NAFTA, for example, the trade bias is 0.27 ($e^{-1.30} = 0.27$) for equation 4, and for EU the trade bias is practically one for equation 5 (note, however, that the EU coefficient is not significant in equations 5 and 6). Thus, Mercosul had by far the largest coefficent of the economic integration dummy variables, and the trade bias with Mercosul countries was very large for the Brazilian states as a whole in 1998.

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[11] This was possible since income and population were found to be highly correlated for these data. For example the correlation between Y_i and N_i was about 0.94 for the year 1998.

[12] Note, however, that these authors estimated those coefficients using trade flows among countries, whereas in this study I used trade flows between countries and Brazilian states.

[13] Aitken (1973) reported negative coefficients for the population coefficients.

Table 4 - Gravity Equation Coefficients Estimates for the Trade Flows between Brazilian States and Brazil's Major Trading Partners, 1998

	Equation							
Independent variable	1	2	3	4	5	6	7	8
Y_i	0.91* (0.13)	1.22* (0.05)	0.89* (0.13)	0.71* (0.14)	0.86* (0.14)	0.79* (0.13)	1.37* (0.09)	-
Y_j	1.36* (0.13)	1.28* (0.05)	1.33* (0.13)	1.16* (0.14)	1.30* (0.14)	1.25* (0.13)	-	-
N_i	0.48* (0.19)	-	0.40* (0.19)	0.76* (0.20)	0.42* (0.20)	0.72* (0.20)	-0.35* (0.21)	1.47* (0.07)
N_j	-0.15 (0.18)	-	-0.20 (0.19)	0.14 (0.20)	-0.18 (0.20)	0.08 (0.20)	-	1.51* (0.07)
$Dist_{ij}$	-1.22* (0.20)	-1.28* (0.20)	-2.17* (0.15)	-2.14* (0.17)	-2.10* (0.18)	-1.38* (0.20)	-1.58* (0.29)	-0.54* (0.23)
Adj	0.75 (0.60)	0.67 (0.60)	-	0.36 (0.62)	0.62 (0.63)	0.54 (0.60)	0.23 (0.86)	2.00* (0.66)
Mercosul	2.12* (0.29)	2.09* (0.29)	-	-	-	1.86* (0.33)	1.23* (0.47)	1.88* (0.33)
NAFTA	-	-	-	-1.30* (0.24)	-	-0.86* (0.28)	-1.43* (0.40)	-
EU	-	-	-	-	0.03 (0.20)	-0.07 (0.23)	-0.39* (0.33)	-

Sources of data: see appendix.
* Significant at the 5% level, one-tail test.
Notes: X_{ij} is the dependent variable. Standard errors are given in parentheses. All variables except dummies are expressed in natural logarithms; estimation by ordinary least squares. Definitions of the equations are given in section 2.1. Number of observations = 527

The results for the year 1990 are presented in Table 5. The same basic results regarding the coefficients of the independent variables are similar to the results for 1998: the coefficients for Y_i , Y_j , and $Dist_{ij}$ were significant, had the expected sign, and had a relatively narrow range, in line with the finding of other authors; the coefficients for N_i and N_j were once again erratic, being insignificant most of the time and with unexpected sign; and the adjacency variable was again insignificant. However, in 1990, the Mercosul coefficient was insignificant in two cases (equations 6 and 7). Moreover, the coefficient was substantially lower than in 1998. For example, this coefficient in equation 1 was 0.75, thus yielding a trade bias of 2.11. This significantly lower trade bias was expected, since 1990 is a pre-Mercosul year, confirming our hypothesis that the Brazilian states as a group started to trade a lot more with Mercosul countries as this trade agreement was implemented. Nonetheless, a trade bias of 2.11 is still significant. In fact, this result is explained by the fact that three out of the four Mercosul countries had partial liberalization agreements with each other prior to 1990[14]. Finally we notice that once again that the NAFTA and EU coefficients are negative (and insignificant, in the case of EU), resulting thus in less than unity trade biases.

[14] Brazil signed partial trade liberalization agreements with Argentina in 1985 and in 1988, and one with Uruguay in 1986. Similarly, Uruguay and Argentina had a partial liberalization agreement prior to 1990.

Table 5 - Gravity Equation Coefficients Estimates for the Trade Flows between Brazilian States and Brazil's Major Trading Partners, 1990

	Equation							
Independent variable	1	2	3	4	5	6	7	8
Y_i	0.81* (0.16)	0.93* (0.05)	0.80* (0.15)	0.67* (0.16)	0.82* (0.16)	0.77* (0.17)	1.10* (0.10)	-
Y_j	1.17* (0.15)	1.12* (0.05)	1.15* (0.15)	1.03* (0.16)	1.17* (0.16)	1.13* (0.16)	-	-
N_i	0.19 (0.23)	-	0.18 (0.23)	0.47 (0.24)	0.13 (0.25)	0.33 (0.25)	-0.04 (0.22)	1.10* (0.09)
N_j	-0.08 (0.23)	-	-0.09 (0.23)	0.17 (0.24)	-0.12 (0.24)	0.05 (0.24)	-	1.37* (0.09)
$Dist_{ij}$	-1.56* (0.25)	-1.59* (0.24)	-1.87* (0.18)	-1.88* (0.20)	-1.84* (0.21)	-1.78* (0.25)	-1.58* (0.31)	-0.76* (0.24)
Adj	0.09 (0.69)	0.05 (0.68)	-	-0.09 (0.69)	0.07 (0.69)	-0.15 (0.69)	0.19 (0.87)	1.30 (0.72)
Mercosul	0.75* (0.37)	0.74* (0.37)	-	-	-	0.04 (0.40)	0.41 (0.50)	0.42* (0.39)
NAFTA	-	-	-	-1.02* (0.28)	-	-1.25* (0.34)	-1.04* (0.41)	-
EU	-	-	-	-	-0.11 (0.24)	-0.51 (0.28)	-0.22 (0.34)	-

Sources of data: see appendix.
* Significant at the 5% level, one-tail test.
Notes: X_{ij} is the dependent variable. Standard errors are given in parentheses. All variables except dummies are expressed in natural logarithms; estimation by ordinary least squares. Definitions of the equations are given in section 2.1. Number of observations = 485

3.2 - Main Model with "Region" dummy

In this section, I will estimate the basic model from section 3.1 (equation 1 in table 4), and include a dummy variable representing a Brazilian region. Since the eight equations estimated in the previous subsection yielded similar results for the coefficients, and the eight different models had similar explanatory power, it is safe to choose equation 1 to be used in this section. Thus, the model estimated is the following:

$$\log X_{ij} = \log a_0 + a_1 \log Y_i + a_2 \log Y_j + a_3 \log N_i + a_4 \log N_j + a_5 \log dist_{ij} + a_6 Adj + a_7 Mercosul + a_8\, Region + \log e_{ij}\ ,$$

where the all the variables are the same as in section 3.1 and Region is one of the following five Brazilian regions: South (S), Southeast (SE), North (N), Northeast (NE), and Center-West (CW). Thus, if Region is the South region, then the dummy variable equals to 1 if the state belongs to the South, and 0 if that is not the case. See the data appendix for the mapping of all Brazilian states onto their respective regions. I ran five regressions for the equation above for 1990, 1994 and 1998, where in each regression the Region variable takes one of the five possible values described above.

The Mercosul coefficient indicates the increase in trade for Brazilian states by trading with a Mercosul country. The Region coefficient indicates the increase in trade for a state from a certain region by trading with the world as a whole. If we look at the joint effect of both Mercosul and Region coefficients we can therefore estimate the combined effect of a state belonging to a certain region and of trading with a Mercosul country. For example, if we are interested in assessing the impacts of Mercosul in the South, we should look at the regression where the Region variable equals the South, and we should calculate the trade bias effect of both Mercosul and Region coefficients, i.e., $e^{(Mercosul+Region)}$, where Mercosul+Region is the sum of the coefficients for the Mercosul and Region variables. For each region, I then compared the results of the regression for 1990 with the results for 1994 and 1998 to see how the trade bias effect changed overtime with the implementation of the Mercosul agreement. We can thus compute an estimate of the impact of Mercosul in each one of the Brazilian regions[15].

[15] I had similar results as in the previous subsection with respect to the stability of the coefficients of GDP, population, distance, and adjacency variables, so I will thus concentrate here on the analysis of the Mercosul and Region coefficients.

The results for the years 1990, 1994 and 1998 are shown in table 6. We first notice that the Mercosul coefficients increased significantly from 1990 to 1998 for all the five regions[16]. The largest coefficients in 1998 were those of the regions South and Northeast (2.16 for both regions in the year 1998, as opposed to 1.64 and 1.70, respectively, in 1994, and 0.79 and 0.76 in 1990). Nonetheless, the coefficients for the other three regions also increased substantially (from 0.50 in 1990 to 1.93 in 1998 in the Southeast, from 0.75 to 2.07 in the same period in the North, and from 0.68 to 2.03 in the Center-West region). The trade bias effect for Brazilian states trading with a Mercosul country is given by $e^{Mercosul}$, where Mercosul is the coefficient of the Mercosul dummy variable. Thus the trade bias due solely to Mercosul increased for all Brazilian regions, as reported in Table 5: the trade bias due to Mercosul increased from 2.20 to 8.67 in the period from 1990 to 1998 for a state in the South, from 1.65 to 6.89 for a state in the Southeast, from 2.11 to 7.92 for a state in the North, from 2.13 to 8.67 for a state in the Northeast, and from 1.97 to 7.61 for a state in the Center-West.

The coefficient for the Region variable behaved differently. It increased only for the Regions South (from 1.14 in 1990 to 1.36 in 1998), Northeast (from –0.67 to –0.53) and Center-West (from -1.84 to -1.03); note, however, that in spite of the increase, the Region coefficient for the Center-West and for the Northeast remained negative. This coefficient decreased from 1.57 to 1.40 in the Southeast and from zero to -0.50 in the North. The trade bias effect for a Brazilian state belonging to a certain region from trading with the world as a whole is given by e^{Region}, where Region is the coefficient of the Region dummy variable. This bias increased for the South (from 3.12 to 3.90 in Table 5), for the Northeast (from 0.51 to 0.59) and for the Center-West (from 0.16 to 0.36), and it decreased for the Southeast (from 4.81 to 4.06) and for the North (from 1.00 to 0.61).

Finally, the joint effect of the Mercosul and Region dummy is analyzed as mentioned before. The trade bias effect for a Brazilian state belonging to a certain region trading with a Mercosul country is given by $e^{(Mercosul+Region)}$, where Mercosul+Region is the sum of the coefficients for the Mercosul and Region variables. In this manner we can estimate the effects of the Mercosul trade agreement in the trading patterns of the five Brazilian regions. We first notice that Mercosul had a very large impact in the South: its trade bias increased from 6.86 in 1990 to 21.06 in 1994 and to 33.78 in 1998; that is, trade between a state in the Brazilian South (a region that borders all the Mercosul countries) in 1998 was more than 30 times larger than trade with other countries. Another impressive impact of Mercosul was in the Region Southeast: the trade bias increased from 7.93 in 1990 to 17.62 in 1994 and to 27.94

[16] A Chow test was not carried out here, since there are only three data points considered a few years apart (1990, 1994 and

in 1998. Although large, the Southeast region saw its trade bias towards Mercosul partners being surpassed by the region South. Moreover, the region North, Northeast, and Center-West had increases in trade bias from 2.11 in 1990 to 4.81 in 1998, from 1.08 to 5.10, and from 0.31 to 2.72, respectively. From this analysis we conclude that the most significant regional impacts of Mercosul were on its South and Southeast regions, which already had the largest bias towards trade with Mercosul countries in 1990. The North, Northeast and Center-West regions saw an increase in trade bias towards those trade partners, but not as significant.

1998), as it would have made sense to perform it if I had several cross-section data sets available.

Table 6 - Gravity Equation Coefficients Estimates for the Trade Flows between Brazilian States and Brazil's Major Trading Partners including a Region Dummy, 1990, 1994 and 1998

	Region South			Region Southeast			Region North			Region Northeast			Region CenterWest		
Independent variable	1990	1994	1998	1990	1994	1998	1990	1994	1998	1990	1994	1998	1990	1994	1998
Y_i	0.73*	0.64*	0.79*	0.62*	0.51*	0.74*	0.82*	0.74*	0.92*	0.58*	0.44*	0.73*	1.02*	0.92*	1.01*
	(0.16)	(0.16)	(0.13)	(0.15)	(0.16)	(0.13)	(0.16)	(0.16)	(0.18)	(0.17)	(0.18)	(0.15)	(0.15)	(0.16)	(0.13)
Y_j	1.08*	1.01*	1.26*	0.97*	0.88*	1.21*	1.17*	1.10*	1.38*	0.92*	0.82*	1.19*	1.42*	1.33*	1.48*
	(0.15)	(0.15)	(0.12)	(0.15)	(0.16)	(0.13)	(0.16)	(0.16)	(0.13)	(0.17)	(0.18)	(0.14)	(0.15)	(0.16)	(0.13)
N_i	0.26	0.57*	0.57*	0.23	0.62*	0.52*	0.19	0.48*	0.41*	0.46	0.87*	0.68*	-0.14	0.23	0.32
	(0.23)	(0.22)	(0.18)	(0.22)	(0.22)	(0.18)	(0.23)	(0.23)	(0.19)	(0.25)	(0.25)	(0.20)	(0.22)	(0.23)	(0.18)
N_j	-0.02	0.22	-0.08	-0.02	0.26	-0.13	-0.08	0.14	-0.21	0.22	0.50*	0.04*	-0.49*	-0.19	-0.33
	(0.22)	(0.22)	(0.18)	(0.22)	(0.22)	(0.18)	(0.23)	(0.23)	(0.18)	(0.25)	(0.25)	(0.19)	(0.22)	(0.23)	(0.18)
$Dist_{ij}$	-1.43*	-1.17*	-1.07*	-1.24*	-0.97*	-0.94*	-1.57*	-1.31*	-1.18*	-1.31*	-1.01*	-1.04*	-1.73*	-1.49*	-1.34*
		(0.24)	(0.20)	(0.24)	(0.25)	(0.20)	(0.23)	(0.24)	(0.20)	(0.26)	(0.26)	(0.21)	(0.24)	(0.24)	(0.20)
	(0.24)														
Adj	-0.57	-0.14	-0.06	0.93	1.54*	1.48*	0.08	0.69	0.73	0.16	0.82	0.79	-0.09	0.49	0.63
	(0.69)	(0.69)	(0.61)	(0.68)	(0.69)	(0.60)	(0.69)	(0.69)	(0.60)	(0.69)	(0.69)	(0.60)	(0.66)	(0.67)	(0.59)
Mercosul	0.79*	1.64*	2.16*	0.50	1.42*	1.93*	0.75*	1.54*	2.07*	0.76*	1.70*	2.16*	0.68	1.46*	2.03*
	(0.36)	(0.35)	(0.29)	(0.36)	(0.34)	(0.29)	(0.37)	(0.35)	(0.29)	(0.37)	(0.35)	(0.29)	(0.35)	(0.34)	(0.29)
Region	1.14*	1.41*	1.36*	1.57*	1.43*	1.40*	0.00	-0.17	-0.50*	-0.67*	-0.74*	-0.53*	-1.84*	-1.48*	-1.03*
	(0.28)	(0.28)	0.25)	(0.26)	(0.27)	(0.22)	(0.28)	(0.26)	(0.21)	(0.24)	(0.24)	(0.19)	(0.27)	(0.26)	(0.21)
Trade Bias from Mercosul **	2.20	5.15	8.67	1.65	4.13	6.89	2.11	4.66	7.92	2.13	5.47	8.67	1.97	4.31	7.61
Trade Bias from Region ***	3.12	4.09	3.90	4.81	4.18	4.06	1.00	0.84	0.61	0.51	0.47	0.59	0.16	0.22	0.36
Joint Trade Bias from Mercosul & Region ^	6.86	21.06	33.78	7.93	17.62	27.94	2.11	3.91	4.81	1.08	2.57	5.10	0.31	0.94	2.72

Sources of data: see appendix.
*Significant at the 5% level, one-tail test.
**Center West region.
***Calculated as $e^{Mercosul}$
^ Calculated as e^{Region}
^^ Calculated as $e^{(Mercosul + Region)}$
Notes: X_{ij} is the dependent variable. Standard errors are given in parentheses. All variables except dummies are expressed in natural logarithms; estimation by ordinary least squares. Number of observations = 485 for 1990 data, and 527 for 1994 data.

4. Conclusions, Implications and Further Research

In this paper I presented a model that shows the aggregate impacts of Mercosul in Brazil's regions, a model that controls for income and distance effects and concentrates on the economic integration and regional effects on the Brazilian states' trading patterns. I showed in last subsection that the most significant positive regional impacts of Mercosul were on Brazil's Southern and Southeastern regions, whereas the North, Northeast and Center-West regions benefited much less from Mercosul in the period from 1990 to 1998. The coefficients for Mercosul in equation 1 in tables 4 and 5 show that Brazilian states tended to trade 2.1 times more with Mercosul countries in 1990, and that increased to 8.3 times in 1998; that is, Mercosul was net trade creating[17], and Brazilian states as a whole benefited from Mercosul. But my results in section 3.2 imply that a Preferential Trade Agreement such as Mercosul impacts differently the regions of participating countries: the South traded 34 times more with Mercosul countries in 1998, the Southeast traded 28 times more with Mercosul countries, the North 5 times, the Northeast 5 times, and the Center-West trade twice as much with Mercosul countries than with other countries. Thus, a PTA that is welfare improving for the country as a whole may increase welfare in only a few regions of the partner countries. This implies that the debate on the welfare implications of PTAs should go one level below and look at changes in welfare from PTAs at the regional level.

This study also showed that the regions that benefited the most from Mercosul are the most developed regions of Brazil. A study by Diniz (1992) showed that the recent pattern of concentration of production (specially manufacturing) in Brazil is one in which production is moving away from the most developed state in the Southeast (São Paulo) and towards the other states of the Southeast and South; this new pattern of polygonized regional development (that is, production is concentrated on a polygonal area that comprises the Southern and Southeastern states) is one in which development is still concentrated on those two regions, with very little direct benefit for the other three less developed regions. Thus my results show that Mercosul may be contributing to increase regional disparities in Brazil, since the regions that benefit from it the most are the ones already more developed, and Mercosul may be contributing to exacerbate the polarized regional development in the South-Southeast polygon and thus aggravate regional disparities in Brazil.

[17] This is true to the extent that higher trade bias in Mercosul will improve welfare in the South and Southeast due to the increase in exports. We used, as in the literature, trade bias as a proxy for changes in welfare effects.

This study can be extended in several ways. First, the time-path of Mercosul could be portrayed, tracing the its regional effects from the early 1990s until today by showing how the Mercosul and Region coefficients evolved on a yearly basis. Second, this study estimates the impacts at an aggregate level; to assess the impact on the region's economic structure on a more detailed level, it is necessary to see how the industries that comprised the regional economic structure were affected. To evaluate industry impacts, we can estimate the current gravity model using data at the industry level (for the one-digit SIC level, for example), use an input-output model, or estimate the output effects at the industry level for each region using Bröcker's model (cited in section 2.3). Another possible extension is to add to the original gravity model in section 3.1 other variables to see if the explanatory power of the model increases. Such variables may include natural distance (as opposed to logarithm of distance) and distance squared (as in McCallum 1995); variables that reflect differences in resource endowments (as in McCallum 1995 and Bergstrand 1989); and price variables such as GDP deflator, exchange rates, and export/Import unit value index) to the original gravity model (as in Bergstrand 1985).

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Data Appendix

The Brazilian regions and the economic blocs are defined as follows for the purposes of this paper. The five regions map onto 27 states in the following manner. Region South is comprised of the states of Paraná, Santa Catarina, and Rio Grande do Sul. The Southeast is comprised of São Paulo, Rio de Janeiro, Minas Gerais and Espírito Santo. The North is comprised of seven states: Acre, Amazonas, Rondonia, Roraima, Pará, Amapá, and Tocantins. The Northeastern region includes Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, and Bahia. The Center-West includes the states of Mato Grosso, Mato Grosso do Sul, Goiás, and Distrito Federal (which includes the country's capital city, Brasília).

The economic blocs are defined for this paper as in Thorstensen et al. (1994). Europe includes the EU and EFTA countries. North America contains the United States, Canada and Mexico. Mercosul includes Argentina, Paraguay and Uruguay, besides Brazil. Asia consist of Japan, Hong Kong, South Korea, Taiwan, Singapore, Malaysia, Thailand, Indonesia, Philippines, and China. Finally, Rest of South America is defined as Chile, Bolivia, Venezuela, Colombia, Ecuador and Peru.

The data for this paper was obtained from the following sources. Export data was provided SECEX/DTIC, the Foreign Trade office of the Brazilian Ministry of Industry, Commerce and Tourism. Import data was obtained from Receita Federal, the tax and tariff collecting agency of Brazil's Ministry of Finance. The Gross Regional Product data for the Brazilian states was given by EBAP/FGV, the Public Administration school of Getúlio Vargas Foundation. The population for the Brazilian states was provided by IBGE, the Brazilian Institute for Geography and Statistics of the Ministry of Planning. The Gross Domestic Product and the population for the countries in the sample was obtained from STARS CD-ROM from the World Bank. Finally, the distance data was extracted from the World Atlas MPC CD-ROM.