Interstate and International Trade of Brazilian Regions: An Analysis Using the Gravity Model

ABSTRACT:

This paper analyzes the interstate and international trade of Brazilian regions in the period following trade liberalization. To carry out the analysis, the paper uses the gravity model methodology. The estimated trade models show that the border effect is still very significant for the foreign trade in Brazilian regions despite the process of economic openness that took place in the 1990s. The results show that the factors of resistance to the expansion of foreign trade still persist. Using a gravity model which considers the Brazilian states and the countries of the Southern Common Market (Mercosul) as a single market shows that the creation of this block increased trade in the region at the expense of other trading partners.

KEYWORDS

Trade Liberalization, Interstate Commerce, Gravity Model, Trade Flows.

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1 – INTRODUCTION

The costs of trade are an intriguing problem for scholars in international and regional economics. On the one hand, economic integration between countries under the aegis of regional agreements and even greater openness in multilateral negotiations has formally advanced over the postwar period and has accelerated since the 1990s. On the other hand, a strong bias for domestic trade persists in the international trading system.

From the viewpoint of academic research, studies have reported the significant importance of national borders, even in integrated markets. From the standpoint of policy makers the challenge is to reduce trade costs and promote greater integration both on a national scale (within countries) and internationally (between countries).

The factors affecting trade and reducing integration both on an international and a national scale are a challenge faced by countries, particularly those with significant regional disparities, as is the case of Brazil. Although economists recognize that under certain conditions, trade raises the well-being of countries or regions involved, increasing commercial exchange and promoting integration encounters not only formal resistance, such as trade barriers represented by tariffs, but also structural factors related to the costs of commerce, in its broadest sense, and in particular transportation costs. These factors not only affect trade between countries, but also trade between regions in a country, which may contribute to the maintenance of regional income disparities within countries.

The objective of this paper is to analyze the trade flows of Brazilian regions in order to better understand the boundary effect between the states and between them and the rest of the world, particularly trade with the Mercosul countries. The gravity model was used to estimate the elasticity of trade in Brazilian regions, as well as the border effect among states and between them and the rest of the world. This study aims to contribute to the literature on interstate trade flows and draw comparisons with other studies done in the field in order to identify relevant changes in trade patterns between the states after trade liberalization. Furthermore, the intention is to identify changes that occurred in the structure of trade of the Brazilian regions, bearing in mind that trade liberalization in the 1990s produced substantial changes to the country's economic structure and inter-regional relations.

Research on the issue of trade - between regions within a country and between countries - is relevant not only from an academic standpoint, but also from the aspect of economic policy formulation to promote trade and integration among countries and regions the same country.

To this end, the article is organized as follows. Following this introduction, section 2 discusses the theoretical aspects underpinning the gravity model and presents some empirical evidence at international level. In section 3 there is a literature review on the use of gravity models in Brazil. Section 4 presents the model to be estimated and the data used in the calculations. Section 5 presents the results and, finally, section 6 presents the conclusions.

2 – THE GRAVITY MODEL: THEORETICAL ASPECTS AND EMPIRICAL EVIDENCE

Using the gravity model to study the determinants of trade flows dates back to the sixties. Tinbergen (1962) and Linnemann (1966) were the pioneers in this field. These authors used what became known in the literature as the gravity model for their empirical structure, supported by the concept of gravity in classical mechanics. The idea of the model is very intuitive. On one hand, it asserts that trade flows are more intense between countries with greater economic density as represented by the gross domestic product; on the other hand, trade is constrained by resistance factors such as distance and other barriers.

As an empirical strategy, the gravity equation was very helpful, even before it received more rigorous theoretical foundations. The robustness of the experiments encouraged empirical research to provide theoretical foundations that supported the evidence. Possibly due to the results, the gravity model has established itself in recent years as a method of studying trade flows and, moreover, has proved to be appropriate for many other empirical exercises, such as the study of migration flows (HELLIWELL, 1997),the study of flows of direct foreign investment (EGGER; PFAFFERMAYR, 2004), and analysis of contagion during financial crises, among others.(ZHU, YANG, 2004).

In addition to adjusting well to empirical data, the gravity model can provide insight into those questions that are unresolved by conventional international trade theories. From this perspective, the gravity model can add to international trade theory, which seeks to explain trade in monopolistic competition models based on product differentiation and the existence of increasing returns of scales. In this case, trade occurs between countries with similar factor endowments and where the trade pattern is established as intra-industry.(Krugman, 1979, 1980).

The basic formulation of the gravity model associates the trade flows between two countries i and j, respectively, to the countries' income, as pull factors, and distance, as a resistance factor. Thus, trade flows T_{ij} between i and j are expressed by the following equation:

$$T_{ij} = \frac{Y_i Y_j}{D_{ij}} \qquad (1)$$

Where Y_i and Y_j represent the incomes of countries i and j, respectively, and D_{ij} the distance between i and j. The specification most commonly used in the estimation of the gravity model is the log-linear form:

$$\ln T_{ij} = \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln DIST_{ij} + \beta_4 \ln POP_i + \beta_5 \ln POP_j + \varepsilon_{ij} \qquad (2)$$

where Y_i represents the income of country (state) i, Y_j represents the income of the country (state) j, $DIST_{ij}$ is the distance between i and j, POP_i and POP_j represent, the populations of countries i and j, respectively.

However, several authors have tried to back up the empirical regularities of the gravity model with microeconomic foundations. In this respect, Anderson (1979) shows that the gravity equation can be derived from a system of costs and homothetic preferences. Krugman (1980) presents a model of trade in an environment of monopolistic competition and transportation costs. Deardorff (1995) shows that the gravity equation may be derived from the Heckscher-Ohlin model. Krugman (1980) anticipates the problem of domestic bias in trade, an idea widely held in the trade literature. Obstfeld and Rogoff (2000) identify trade costs as the origin of several unsolved problems in international economics, including the problem of domestic bias. Hummels (2001), in turn, seeks to model transportation costs directly. Bergstrand (1985) derives the gravity equation, first by that assuming preferences have Constant Elasticity of Substitution (CES) and the Armington product differentiation model - by origin country - and then generalizing the gravity model to show that it can be derived either in a Heckscher-Ohlin type environment or in a Helpman-Krugman type context, with product differentiation. Bergstrand (1989) and Feenstra, Markusen and Rose (2001) show that the gravity model can be derived from a variety of models. Both in models with differentiated products and imperfect competition (DIXIT-Norman, 1980; Krugman, 1979, 1980; Helpman-Krugman, 1985) and in the Armington model - differentiation by country of origin. Moreover, the gravity equation can also be derived using a reciprocal dumping model, with or without entry barriers.

Following the classic studies of Tinbergen (1962) and Linnemann (1966), many other empirical studies have emerged using the gravity model. Aitken (1973) uses the gravity model to assess the impact of the European Economic Community (EEC) and European Free Trade Association (EFTA) on regional trade flows during the period 1959-67.The results showed that both the EEC and the EFTA resulted in the creation of gross trade. However, the creation of commerce in the EEC was greater than in the EFTA.

One successful application of the gravity model is the assessment of the effects of trade on a national scale or between states in a federation. From this perspective, the work of McCallum (1995), Evans (2003) and Anderson and Van Wincoop (2003) for U.S. and Canadian economies is noteworthy. In Brazil, the pioneering work of Hidalgo and Vergolino (1998) stands out, using the gravity model to study the commercial relations between the Northeast region of Brazil and the rest of the country and the world.

MacCallum's results (1995) caused some concern due to the high bias present in the trade between Canadian provinces, around twenty times greater than trade between these provinces and American states. Helliwell (1997) estimated the border effect through a gravity equation for Canada-United States trade and compared it with the trade between OECD countries, finding a much smaller border effect between OECD countries.

Recently, a literature has developed that tries to recover the determinants of spatial relations. The idea that transportation costs are the root cause of a number of problems in the international economy was suggested by Obstfeld and Rogoff (2000).The central issue is the introduction of trade costs (transportation, tariffs and non-tariff barriers, among others) as an explanatory factor for various international economic problems, in particular the problem of domestic bias.

Rose (2000, 2001) has devoted a great deal of effort to study the impacts of trade agreements and currency unions on trade flows. The results show that a common currency is a strong driver of trade. Using the same currency almost doubles trade between the countries involved.[1]

In a series of papers on U.S. trade, Wall (1999, 2000) and Cheng and Wall (2005) used the fixed effects approach to assess the impacts of U.S. trade policy. Wall (1999, 2000) and Cheng and Wall (2005) found robust results for the usual variables of the gravity model. Cheng and Wall (2005) raise concerns about the issue of heterogeneity. They argue that the gravity model's estimates are biased when heterogeneity is not controlled. In order to compare the advantages and disadvantages of each estimation method, the authors compared various specifications. Among all the estimated models, the fixed effects model showed the most satisfactory results.

The general specification of the gravity model in a fixed effects approach can be calculated from the equation (3) below. In this general formulation, the volume of trade between countries i and j in year t is determined by the following equation:

$$\ln X_{ijt} = \alpha_0 + \alpha_t + \alpha_{ij} + \beta'_{ijt} Z_{ij} + \varepsilon_{ijt} \qquad (3)$$

where X_{ijt} represents the exports from country i to country j in year t and $Z'_{ijt} = [z_{it}, z_{jt} \ldots]$, it is a 1xkvector of explanatory variables for the gravity model (Gross Domestic Product (GDP), population, distance etc.) and β_{ijt} is a parameter vector. The intercept has three parts: one common to all years and countriesα_0, a specific one for each year and common to all partners, α_t, and a specific one for each pair of countries and common for all the years, α_{ij}. The term ε_{ijt} represents the normally distributed errors with a zero mean and constant variance. The estimated fixed effect models are variations on the model specified by equation (3). According to Feenstra (2004), as the fixed effects approach generates efficient estimates, it is to be preferred for its computational simplicity.

3 – THE EMPIRICAL EVIDENCE OF THE GRAVITY MODEL FOR BRAZIL

The use of the gravity model to study international economic issues in Brazil is relatively recent. Vergolino and Hidalgo (1998) pioneered the use of the gravity model to study trade flows and the border effect in Brazil. Recently, the model has been widely used in Brazil to study various trade issues. Vergolino and Hidalgo (1998) estimated the gravity model to consider trade flows from the Brazilian northeast region to the rest of the country and the world using data for 1991. The estimated model introduces a dummy variable to capture the border effect. The results were satisfactory from a statistical point of view. The results showed a high elasticity of exports relative to the gross regional product. Besides showing the relevance of the existence of borders, domestic trade flows are more significant than those directed to the rest of the world. The results placed the frontier effect for the Northeast at 1.5 and 11 for Brazil, reflecting the excessive preference for local trade compared to trade with other Brazilian regions and the international market, respectively. Silva, Fair and Magalhães (2004) found similar results for trade between the Northeast region and Brazil in a sample of 20 countries.

In order to evaluate the evolution of trade flows between 44 countries and in particular the effects of

1 See also Rose and Van Wincoop (2001) and Glick and Rose (2002).

the preferential agreements of six blocks, Piani and Kume (2000) estimated a gravity model for the period 1986-1997.In addition to the model's basic variables (the product of the countries involved, distance), relative distance variables and dummy variables were incorporated to provide the effects of borders, common languages and regional trade agreements. The results were consistent as the expected signs and statistically significant in most cases. Estimates were made for the period 1986/97 and for the sub-periods 1986/88, 1989/91, 1992/94 and 1995/97.

Many studies have tried to estimate the effects of trade agreements between economic blocks. The last two decades of the twentieth century were characterized on one hand by the opening up of trade in many previously closed countries and at the same time, the formation of regional trade blocs.[2] On a lesser scale, some studies assess the regional impacts of trade liberalization. There are several aspects that could be considered, such as changes in industrial structure and, consequently, in the structure of regional exports.

Castilho (2005) uses the fixed effects approach at a country and products level to estimate the gravity model per sector at the SH2 aggregation level (two-digit SH classification).The objective was to evaluate the impact of barriers to Mercosul exports to the European Union (EU) in view of negotiations on a regional Mercosul agreement (EU).The results were not very encouraging. Many of the estimated parameters were not significant and some had signs contrary to what was expected. With regard to the sensitivity to trade barriers, the results were as follows: of the 98 sectors considered, the estimates were significant and had the expected sign in 37.Regarding non-tariff barriers, of the 98 sectors, 65 had some type of non-tariff protection, of which 21 showed significant results and expected sign.

Porto and Canuto (2002) estimated a gravity model to assess the impacts of the Mercosul on the regions and the sectors of economic activity in the period 1990-2000.The authors found positive effects of the Mercosul on the trade of the Brazilian regions. They demonstrate that the southern and southeastern regions are the main beneficiaries of the Mercosul. Azevedo (2004) measured the effects of Mercosul on trade flows between member states and between them and the rest of the world. Azevedo (2004) estimated a gravity equation with international data for the period 1987-1998 and had partially favorable results in terms of the model's predictions.

Paz and Franco Neto (2003) used the gravity model to estimate the effects of national borders on trade flows between Brazilian states and between them and foreign markets. The results regarding the impact of the Mercosul on bilateral trade flows are ambiguous because they depend on the treatment of observations with a zero value. In addition to the ordinary least squares model, excluding zero observations, the authors implemented a model following Wall (2000), that suggests treating the dependent variable as the volume of trade between two partners added to the unit, which eliminates the problem of zero observations. Another alternative is to implement the Tobit model for censored data. For the Mercosul, although the regressions have the expected signs, there is no statistical significance.

In another study, Azevedo, Portugal and Barcellos Neto (2006) evaluated the effects of the creation of the Free Trade Area of the Americas (FTAA) on trade flows for countries in the region, especially the Mercosul. The authors estimated a linear model by ordinary least squares and a Tobit model to handle null values of the dependent variable. Many of the estimated coefficients were significant and showed the expected signs.

An issue of great importance, though little explored as a research problem, is the regional impact of trade liberalization. This question becomes even more important when taking into account the structural diversity of the Brazilian economy resulting from the spatial distribution of its production factors. Asymmetries in the regional productive structures are reflected in the foreign trade of the regions and, furthermore, in their differing capacity to absorb the shock of trade liberalization. A major difficulty faced by research in this area is the scarcity of data and in some cases, the irregularity and quality of its production.

2 Castilho (2001) comments a large list of articles the evalue the impactos from commercial agreements about the Brasilian economy, as Alca, Mercosul-European Union, envolving diferents methodologies.

4 – THE ESTIMATED MODEL AND DATA USED

The fixed-effects model is used as it seeks to circumvent some of the problems of cross-section models. The most frequent criticism of cross-section models is that their estimates do not control for heterogeneity. To illustrate the problem, suppose that country i has two countries, j and s, as trading partners that are identical in income, distance and population. Nonetheless, contrary to expectations, it may be that bilateral trade between them and country i is distinct. This is a common criticism made of cross-section estimates. The problem lies in the existence of other factors affecting bilateral trade that are not captured by traditional gravity model variables, but are partially captured by dummy variables.

The model to be estimated is specified in equation (4) below. The observations used refer to bilateral trade between the 26 Brazilian states plus the Federal District and a sample of 51 countries that represent around 95% of Brazilian exports. The bilateral trade flow between the states and their major trading partners was modeled as the sum of exports from the state plus the absolute value of imports from the trading partner. In addition, the value of the unit of bilateral trade was added to allow a logarithmic specification, in the case of the value of trade being null. The following equation was estimated by the ordinary least squares for the period analyzed.

$$\ln(1 + X_{ijt}) = \alpha + \beta_1 \ln GDP_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln DIST_{ij} + \beta_4 \ln POP_{it} + \beta_5 \ln POP_{jt} + \beta_6 BORD_{ij} + \beta_7 MERC + \varepsilon_{ijt} \quad (4)$$

Where X_{ijt} represents the flow of trade between state i and a state or country j in year t, GDP_{it} is the gross domestic product of state i in year t, GDP_{jt} represents the gross domestic product of the partner state or country j. $DIST_{ij}$ is the distance between state i and state / country j, POP_i, is the population of state i, POP_j is the population state or country j, $BORD_{ij}$ is a dummy variable that has a value 1 if the trading partner is a state or part of the Brazilian Northeast region, the variable $MERC$ was introduced to capture any effects of the Mercosul, α, β_1 and β_7 are the parameters to be estimated and ε_{ij} is a term for normally distributed error.

The data used to estimate the model were obtained from the sources described below. Data on international trade, at the level of Brazilian states, were obtained from the Bureau of Foreign Trade (Secex), the Ministry of Development, Industry and Commerce (MDIC), using the Alice System, which provides trade data from 1989 onwards, thus having the advantage of covering the period prior to trade liberalization and the major events that followed in the nineties. The Gross Domestic Products (GDP) of the states are estimates provided by the Brazilian Institute of Geography and Statistics (IBGE).In Brazil, there are difficulties with the availability of data regarding trade between states. Although not exclusive to the country, this limits more in-depth studies on trade between the regions. In this study, data on interstate commerce was obtained from the interstate commerce matrix constructed by Vasconcelos and Oliveira (2006).[3] Population data and the countries' GDPs were obtained from the World Development Indicators provided by the World Bank. The World Factbook, produced by the Central Intelligence Agency (CIA) was used to obtain the distance between countries, as well as data on frontiers. To measure distance, the great circle rule was used to calculate the shortest distance between two points on a spherical surface, based on measurements of the coordinates of the points of origin and destination. This measure has the advantage of unifying the measures of distance between all locations. (WORLD. .., 2012).

5 – RESULTS

In order to analyze the trade flows of the Brazilian regions after trade liberalization, a model of interstate commerce for the North, Northeast and South-East was estimated; the South and Southeast regions were aggregated due to the growing complementarily of these regions [4].

3 See also Vasconcelos (2001a, 2001b).

4 This criterion was used also in Silveira (2005).

The estimated model considers the main variables of the gravity model: the gross domestic product and population as factors that attract partners and the distance between them as a resistance factor for trade, it also seeks to measure the border effect. Regional border effects and the existence of contiguity between states are also evaluated. In addition, a dummy variable is employed to capture the effect of the formation of the Mercosul on Brazilian states.

In the absence of national borders, ceteris paribus, trade is determined by the factors of attraction and the resistance to trade flows between partners. However, the border is an important factor in trade relations between regions and countries. As already mentioned, some empirical studies using the gravity equation have documented the presence of the border effect on trade in northeastern Brazil.(HIDALGO, VERGOLINO, 1998; SILVA, FAIR, Magalhães, 2004).

In this study, the gravity model is estimated taking into account a sample of the states' bilateral trade plus a set of 51 countries representing, on average, 95 percent of Brazilian exports. The results, presented in the following tables, tend to favor the gravity model's hypothesis. First, there is an analysis of the results related to trade between the Brazilian Northeast region and the rest of the world (Table 1). The model 1 in Table 1 shows the simplest form of the gravity model. The results show adequacy with the model's assumptions, in other words, trade between two countries or regions is determined by pull factors - trading partners' income or products - and by resistance factors to trade as represented by distance. Therefore, the results appear to be as expected. One common result is that the domestic product has a greater elasticity than the trading partner's product. In this case, the elasticity of trade in relation to the domestic product is 3.34, indicating that the increase of one percentage point in domestic product increases trade flow by 3.34 percentage points. In turn, the elasticity in relation to the trading partner is 1.55 percentage points, indicating that the trading partner's product has a lesser effect on the flow of the bilateral trade than the domestic product, although it is above a unit. The coefficient of the variable $\log(\mathrm{Dist}_{ij}) = -3.65$ – distance logarithm - also has the expected sign and is statistically significant. This coefficient reflects the various costs that reduce commercial activity.

Regarding the population variable, it is noteworthy that there is no consensus on the expected sign of its coefficient. It can be argued that a big population may indicate a large market, which, in principle, encourages trade. On the other hand, the population may also be a factor reducing per capita income, and therefore exercising an opposite effect. The estimates obtained for the population coefficients are not as significant as the product or the distance.

An extremely interesting variable is the dummy BORD Brazil, which aims to capture the effect of the national border on trade in the Northeast. In models 2 and 3, the dummy variable has the value 1 for trade between the northeastern states and other Brazilian states and zero if not. As the results show, the border effect - the coefficient of the dummy variable BORD Brazil - proves to be statistically significant.

Two issues stand out. First is the magnitude of the coefficient 6.38, which is surprisingly high and creates an effect of 589.93{exp(6.38)=589.92}This means that trade between Brazilian states and the federal district is 589.92 times greater than with other countries. The coefficients estimated by Hidalgo and Vergolino (1998) for the year 1991 are around 11. Second, with trade liberalization and the coefficient of greater economic openness, it would be expected that the effect of the national border was reduced. However, the results reported herein are consistent with those found by Paz and Franco Neto (2003), which, in the most comprehensive work on international trade and interstate commerce in Brazil, found results close to those presented here. According to Paz and Franco Neto (2003), a possible explanation for the studies that found a smaller border effect is the exclusion of observations with a zero value. Furthermore, these authors identified an increase in the coefficient representing the border effect over the years. The authors found a value of 4.58{exp(4.58)=97.51} for a sample of 192 countries and 27 Brazilian states. Silva, Justo and Magalhães (2004) found average values for the dummy border coefficient the Northeast region in trade with Brazil and a further 20 business partners of around 2{exp(2)=7.38}.

When considering the variable of the Mercosul bloc, which was created in 1991, the hypothesis that

Brazil and therefore the states form a single market was accepted. Thus, the fourth model was estimated with a dummy variable that has a value equal to the unit for the states plus Argentina, Paraguay and Uruguay (MERCOSUL countries), and zero otherwise. The results indicate that trade between the states and the Mercosul country is higher than for the other partner countries. However, there is controversy about the effects of regional trade agreements, as these can lead to gains in trade and trade diversion. The first occurs when the increase in trade between member countries occurs by increased specialization based on efficiency. The second case occurs when the increase in trade is based on the substitution of cheaper imports from countries outside the agreement with imports from member countries, due to barriers imposed on extra-bloc countries. The results reinforce some evidence regarding the creation and diversion of trade in the Mercosul. Yeats (1998) showed that part of the growth of trade among Mercosul member countries is due to trade diversion.

Again, the high value found for the coefficient of the boundary variable 1074.91{exp(6.91)=1074.91} is noteworthy, which indicates that trade between the Brazilian states plus the Mercosul countries would be 1074.91 times greater than trade with other countries. In fact, this result is very high, although consistent with the results found by Paz and Franco Neto (2003).

Table 1 – Estimates of Northeastern Trade with Brazil and the Rest of the World

Exploratory variable	Model			
	1	2	3	4
Log(Pibi)	3,34* (0,77)	3,36* (0,71)	3,36* (0,71)	3,36* (0,71)
Log(Pibj)	1,55* (0,16)	1,88* (0,16)	1,88* (0,16)	1,90* (0,16)
Log(Popi)	-0,66 (0,95)	-0,66 (0,89)	-0,65 (0,89)	-0,67 (0,89)
Log(Popj)	-4,27* (0,19)	-0,24*** (0,18)	-024 (0,18)	-0,20 (0,18)
Log(Distij)	-3,65* (0,26)	-2,24* (0,39)	-2,28* (0,41)	-1,88* (0,39)
BORD Brazil		6,38* (0,65)	6,35* (0,66)	
BORD Northeast		-1,61** (0,83)	-1,53** (0,84)	-0,80 (0,85)
Contig			-0,36 (1,02)	0,03 (1,02)
MERCOSUL				6,98* (0,66)
R2	0,34	0,42	0,42	0,44
N. observations	693	693	693	693

Source:Prepared by the Authors.

Notes:1) The number in parentheses is the standard error, 2) The equations were estimated by OLS with White's robust standard errors of, 3) The equations were estimated with a non-reported constant term,; 4) (*) indicates the 1% probability level of significance (**) indicates a 5% probability level of significance (***) denotes a 10% probability level of significance.

A dummy variable was introduced into the model to determine the importance of the regional border. This variable has the value 1 when the trade is between the states of the region and zero otherwise. The estimated coefficient shows a negative sign, which means that trade between the northeastern states is weaker than trade with all the Brazilian states. That is, belonging to the Northeast is not a reason for the existence of more vigorous trade in the region. A similar result was found by Silva, Justo and Magalhães (2004). However, the coefficient was only statistically significant in one case. Considering the fact that the Northeast region has a very low openness coefficient this result is surprising.

Estimates of the trade model for the North region are presented in Table 2. The results show that the domestic product has a very strong effect on trade in the region. Model 2 introduces a dummy variable that captures the national border effect, BORD Brazil, which has the value 1 for trade between one state and another, and zero otherwise. The estimated coefficient is very high and statistically significant. The North's trade with other Brazilian states is 1118.8{exp(7.02)=1118.8} times larger than with the rest of the world. The coefficient estimated for the border with the northern region's states themselves is a low 1.9{exp(0.69)=1.9} but has no statistical significance.

Whilst borders with the other states in the North have no statistical significance, the dummy variable that captures contiguity between states has statistical significance.

In model 4, the dummy for the national border was replaced by a dummy that assumes a value of 1 for

Table 2 – Estimates of Commerce of Northern Brazil and the Rest of the World (1999)

Explanatory variable	Model			
	1	2	3	4
Log(Pibi)	4,71* (0,65)	2,71* (0,67)	2,76* (0,67)	4,56* (0,60)
Log(Pibj)	1,80* (0,15)	1,96* (0,15)	1,95* (0,15)	2,11* (0,14)
Log(Popi)	-0,72 (0,76)	0,91 (0,74)	0,82 (0,74)	-0,79 (0,69)
Log(Popj)	-1,66* (0,19)	-0,88* (0,19)	-0,90 (0,19)	-0,91* (0,19)
Log(Distij)	-3,62* (0,36)	-2,32* (0,38)	-2,15* (0,40)	-1,48* (0,44)
BORD Brasil		7,02* (0,75)	7,00* (0,75)	
BORD Norte		0,69 (0,75)	0,07 (0,09)	0,71 (0,83)
Contig			2,19* (0,71)	2,64* (0,78)
MERCOSUL				8,15* (0,90)
R2	0,53	0,61	0,61	0,61
N. observations	538	538	538	538

Source: Prepared by the Authors

Notes:1) The number in parentheses is the standard error, 2) The equations were estimated by OLS with White's robust standard errors, 3) The equations were estimated with a constant non-reported term; 4) (*) indicates the 1% probability level of significance(**) indicates a 5% probability level of significance (***) denotes a 10% probability level of significance.

states in Brazil and the Mercosul countries and zero otherwise.That is, it is assumed that this is a single market. The estimated coefficient is surprisingly high and statistically significant. Trade between Brazil and the Mercosul countries is much greater than with other trading partners 3463.4{exp(8.15)=3463.4}.

For the afore mentioned reasons, the South and Southeast regions were aggregated, so that for the purpose of estimating the pattern of trade they are treated as a single region. The results obtained are shown in Table 3. Model 1 estimates a standard trade flow gravity equation against the logarithm of domestic GDP, the GDP of the trading partner, the state's population and the trading partner's population and also the distance between the state and its trading partner. The results show that the variables of the gravity model explain a significant portion of South-Southeast trade. The results obtained for the South-East show that national borders matter for bilateral trade. The estimated coefficient for the national boundary *dummy* variable is shown to be statistically significant. On the other hand, the variable boundary between the states of the region has no statistical significance. The estimated coefficient for the dummy national border was 1.10, which means that the region's trade with Brazil is 3.0{exp(1.10)= 3.0} times larger than with other countries.

The third model includes a *dummy* variable to take contiguity into account, that is, it considers the hypothesis that states sharing a common border may have a greater incentive to trade. The estimated coefficient for the variable of contiguity has a negative sign and a very low value. However, there is no statistical significance.

Table 3 – Estimates of Trade with South and Southeast Brazil and Rest of the World (1999)

Explanatory variable	Model			
	1	2	3	4
Log(Pibi)	1,17* (0,27)	0,88* (0,23)	0,87* (0,23)	1,04* (0,23)
Log(Pibj)	0,69* (0,03)	0,76* (0,03)	0,76* (0,03)	0,84* (0,03)
Log(Popi)	-0,28 (0,31)	0,02 (0,26)	0,02 (0,27)	-0,12 (0,26)
Log(Popj)	0,13* (0,04)	-0,10* (0,04)	-0,10* (0,04)	-0,06** (0,03)
Log(Distij)	-1,68* (0,04)	-1,42* (0,07)	-1,43* (0,08)	-0,82* (0,08)
BORD Brasil		1,10* (0,19)	1,10* (0,20)	
Bord Sul-Sudeste		0,12 (0,15)	0,16 (0,15)	0,78* (0,20)
Contig			-0,05 (0,16)	-0,12 (0,23)
MERCOSUL				2,65* (0,20)
R2	0,70	0,73	0,73	0,77
N. observations	539	539	539	539

Source: Prepared by the Authors.

Notes:1) The number in parentheses is the standard error, 2) The equations were estimated by OLS with White robust standard errors, 3) The equations were estimated with a constant term, non-reported; 4) (*) indicates the 1% probability level of significance(**) indicates a 5% probability level of significance (***) denotes a10% probability level of significance.

Finally, in order to verify the effect of the Mercosul on trade in the region, a dummy variable was introduced that assumes a value of 1 if the trade takes place between a Brazilian state and Mercosul countries, and zero otherwise. So, the national border was replaced by a Mercosul dummy. The estimated coefficient was statistically significant, indicating that trade among Brazilian states and the Mercosul countries is 14.15{exp(2,65)=14.15} greater than with other countries.

6 – CONCLUSIONS

The results based on the estimation of the model suggest that a relevant part of the trade of Brazilian regions can be explained using the gravity model. On one hand, in the model of trade between each region and the other states and the trade of each region with the rest of the world, (in a sample of 51 countries), the estimations show that the ratio of the elasticity of trade in the region to gross domestic product of the region is greater than the ratio of gross domestic product to the trading partner. On the other hand, the border effect was highly significant in economic and statistical terms. The results of the border effect appear to be higher than those found in previous studies.(HIDALGO; VERGOLINO, 1998).

However, the model did not show satisfactory results as a model of trade of the regions, considering the border effect of the region itself both on trade in each region within Brazil and other countries and regarding trade in each region with other regions of the country.

One interesting result was the estimation of the effect of the creation of the Mercosul on trade among Brazilian states. The Mercosul effect was analyzed using a dummy variable. The result had high statistical and economic significance, which reflects the growth of trade in the block and the possible creation and diversion of trade. Trade between Mercosul members increased significantly after the creation of the block. The results presented herein show that the market formed by Mercosul countries became more integrated.

The results show the differences cited by Paz and Franco Neto (2003) regarding the definition of the dependent variable and the issue of the treatment of zero observations, which significantly change the coefficient of the border effect. An important fact identified in the estimates was the increase of the border effect for trade of the Northeastern States with Brazil and the rest of the world. This effect was evidenced in Peace and Franco Neto (2003) in the context of Brazil's trade with the outside world. Indeed, while the Brazilian economy became more integrated domestically and with the Mercosul countries, it seems that the resistance factors to trade with other countries were not reduced. In a way this result is surprising because during the last decade, the world economy in general, and the Brazilian economy, in particular, have become more open. The trade equations show that the border continues to be important despite the opening of the economy. On the other hand, the formation of the Mercosul favored the expansion of the domestic market and the formation of an expanded market with the characteristics of an integrated market.

Finally, it is easy to see the great difference in trade among Brazilian regions, a direct result of their productive structures. The estimation of the gravity model for the Brazilian regions in its relations with foreign countries showed a great difference regarding the value of trade elasticity in relation to GDP and distance. The results show that the less developed the region of the country, the greater the elasticity of trade in relation to gross domestic product and also the greater the resistance to trade.

REFERENCE

AITKEN, N. D. The effect of the EEC and EFTA on European trade: a temporal cross-section analysis. **The American Economic Review**, v. 63, n. 5, p. 881-892, 1973.

ANDERSON, J. E. A theoretical foundation for the gravity equation. **The American Economic Review**, v. 69, n. 1, p. 106-116, 1979.

ANDERSON, J. E.; VAN WINCOOP, E. Gravity with gravitas: a solution to the border puzzle. **The American Economic Review**, v. 93, n. 1, p. 170-192, 2003.

AZEVEDO, A. F. Z. de. O efeito do Mercosul sobre o comércio: uma análise com o modelo gravitacional. **Pesquisa e Planejamento Econômico**, v. 34, p. 307-339, 2004

AZEVEDO, A. F. Z. de; PORTUGAL, M. S.; BARCELLOS NETO, E P. Impactos comerciais da área de livre comércio das Américas uma aplicação do modelo gravitacional. **Revista Economia Contemporânea**, Rio de Janeiro, v. 10, n. 2, p. 237-267, 2006.

BERGSTRAND, J. H. The generalized gravity equation, monopolist competition, and the factor-proportions theory in international trade. **Review of Economics and Statistics**, v. 71, n. 1, p. 143-153, 1989.

______. The gravity equation in international trade: some microeconomics foundations and empirical evidence. **Review of Economics and Statistics**, v. 67, n. 3, p. 474-481, 1985.

CASTILHO, M. R. **O acesso das exportações do Mercosul ao mercado europeu**. Rio de Janeiro: IPEA, 2001. (Text for discussion-IPEA, n. 851).

______. Integração regional e internacional do Mercosul: uma medida de integração e de acesso a mercados a partir da estimação do efeito-fronteira. In: ENCONTRO NACIONAL DE ECONOMIA-ANPEC, 34., 2005, Natal. **Anais...** Natal, 2005.

CHENG, H. I.; WALL, H. J. Controlling for heterogeneity in gravity models of trade and integration. **Federal Reserve Bank of St. Louis Review**, v. 87, p. 49-63, 2005.

DEARDORFF, A. V. **Determinants of bilateral trade:** does gravity work in a frictionless world?. Cambridge, MA: National Bureau of Economic Research, 1995. (NBER Working Paper, n. 5377).

DIXIT, A. K.; NORMAN, E V. **Theory of international trade**. Cambridge, MA: Cambridge University Press, 1980.

EGGER, P.; PFAFFERMAYR, M. Distance, trade and FDI: a Hausman-Taylor SUR approach. **Journal of Applied Econometrics**, v. 19, p. 227-246, 2004.

EVANS, C. L. The economic significance of national border effects. **The American Economic Review**, v. 93, n. 4, p. 1291-1312, 2003.

FEENSTRA, R. **Advanced international trade:** theory and evidence. Princeton: Princeton University Press, 2004.

FEENSTRA, R. C.; MARKUSEN, J. R.; ROSE, A. K. Using the gravity equation to differentiate among alternative theories of trade. **Canadian Journal of Economics**, v. 34, p. 430-447, 2001.

GLICK, R.; ROSE, A. K. Does a currency union affect trade?: the time-series evidence. **European Economic Review**, v. 46, p. 1125-1151, 2002.

HELLIWELL, J. F. **National borders, trade and migration**. Cambridge, MA: National Bureau of Economic Research, 1997. (Working Paper, n. 6027).

HELPMAN, E.; KRUGMAN, P. **Market structure and foreign trade:** increasing returns, imperfect competition and the international economy. Cambridge, MA: MIT Press, 1985.

HIDALGO, A. B.; VERGOLINO, J. R. O Nordeste e o comércio inter-regional e internacional: um teste dos impactos por meio do modelo gravitacional. **Revista Economia Aplicada**, v. 2, n. 4, p. 707-725, 1998.

HUMMELS, D. **Towards a geography of trade costs**. West Lafayette: Purdue University, 2001. Mimeo.

KRUGMAN, P. Increasing returns, monopolistic competition, and international trade. **Journal of International Economics**, v. 9, n. 4, p. 469-479, 1979.

______. Scale economies, product differentiation and the pattern of trade. **American Economic Review**, v. 70, p. 950-959, 1980.

LINNEMANN, H. **An econometric study of international trade flows:** contributions to economic analysis. Amsterdam: North-Holland, 1966.

MCCALLUM, J. National borders matter: Canada-U.S: regional trade patterns. **The American Economic Review**, v. 85, n. 3, p. 615-623, 1995.

OBSTFELD, M. E; ROGOFF, K. **The six major puzzles in international macroeconomics:** is there a common cause?. Berkeley: University of California, 2000.

PAZ, L. S.; FRANCO NETO, A. Brazilian border and Mercosul integration effects: an exploratory assessment using the gravity model. In: CONGRESSO NACIONAL DE ECONOMIA, 32., 2003, Porto Alegre. **Anais...** Porto Seguro: ANPEC, 2003.

PIANI, G.; KUME, O. **Fluxos bilaterais de comércio e blocos regionais:** uma aplicação do modelo gravitacional. Rio de Janeiro: IPEA, 2000. (Text for discussion).

PORTO P. C. S.; CANUTO, O. Mercosul: gains from regional integration and exchange rate regimes. **Economia Aplicada**, v. 6, n. 4, p. 657-680, 2002.

ROSE, A. K. Currency unions and trade: the effect is large. **Economic Policy**, v. 33, p. 449-461, Oct. 2000.

ROSE, A. K.; VAN WINCOOP, E. National money as a barrier to international trade: the real case for currency union. **The American Economic Review**, v. 91, n. 2, p. 386-390, 2001.

SILVA, M. V. B.; JUSTO, W. R.; MAGALHÃES, A. M. Comércio interestadual e comércio internacional do Brasil e do Nordeste: uma abordagem do modelo gravitacional. In: ENCONTRO DE ECONOMIA DO NORDESTE, 2004, Fortaleza. **Anais...** Fortaleza, 2004.

SILVEIRA, R. Concentração industrial regional, especialização geográfica e geografia econômica: evidências para o Brasil no período 1950-2000. **Revista Econômica do Nordeste**, Fortaleza, v. 36, n. 2, p. 524-545, abr./jun. 2005.

TINBERGEN, J. **Shaping the world economy:** suggestions for an international economy policy. Nova York: Twentieth Century Fund, 1962.

VASCONCELOS, J. R. **Matriz do fluxo de comércio interestadual de bens e serviços no Brasil:** 1998. Brasília, DF: IPEA, 2001a. (Text for discussion-IPEA, n. 783).

______. ______. Brasília, DF: IPEA, 2001b. (Text for discussion-IPEA, n. 817).

VASCONCELOS, J. R.; OLIVEIRA, M. A. **Análise da matriz por atividade do comércio interestadual no Brasil:** 1999. Rio de Janeiro: IPEA, 2006. (Text for discurssion-IPEA, n. 1159).

WALL, H. J. **Gravity model specification and the effects of the Canada-US border**. St. Louis: Federal Reserve Bank of St. Louis, 2000. (Working Paper, 024A).

______. Using the gravity model to estimate the costs of protection. **Federal Reserve Bank of St. Louis Review**, v. 81, p. 33-40, 1999.

WORLD atlas & map library. Avaible in: <http://www.infoplease.com/atlas/>. Access in: 2009.

ZHU, L.; YANG, J. **The role of physic distance in contagion:** a gravity model for contagious financial crises. Washington, DC: The George Washington University, 2004. Mimeo.

YEATS, A. Does Mercosur's trade performance raise concerns about the effects of regional trade arrangements?. **The World Bank Economic Review**, v. 12, n. 1, p. 1-28, 1998.

ANNEX A – LIST OF COUNTRIES CONSIDERED IN THE SAMPLE

South Africa	United Arab Emirates	Malaysia
Germany	Ecuador	Mexico
Angola	Spain	Nigeria
Saudi Arabia	United States	Norway
Algeria	Philippines	Netherlands
Argentina	Finland	Paraguay
Australia	France	Peru
Austria	Greece	Poland
Belgium	Hong Kong	Portugal
Bolivia	India	United Kingdom
Canada	Indonesia	Russian Federation
Chile	Iran	Sweden
China	Iraq	Switzerland
Singapore	Ireland	Thailand
Colombia	Israel	Taiwan
Korea, Rep. Of (South)	Italy	Turkey
Egypt	Japan	Uruguay

Table 1A – List of Countries Considered in Sample

Source: Prepared by the Authors.