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Economic Integration and Location of Manufacturing Activities: Evidence from MERCOSUR

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Abstract

Economic integration leads to a reallocation of resources across sectors and space. Location patterns resulting from North-North and North-South regional trade initiatives have been documented in several studies. However, empirical evidence on South-South agreements is rather limited. In this respect, MERCOSUR provides an interesting case study. This paper aims at answering the following questions: What are the main driving factors explaining location patterns in the Southern Cone? To what extent has the establishment of MERCOSUR affected location of economic activities? Using data for the period 1985-1998, we identify the determinants of manufacturing location patterns and assess their changes in the context of increased economic integration. We find that preferential trade liberalization has fostered the influence of factors underlined by the recent trade theories, such as economies of scale and input-output linkages, relative to comparative advantage considerations.

Keywords: Economic Integration, Location of Industrial Activities, MERCOSUR

JEL-Classification: F14, F15, L60

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1 Introduction

The multiplication of regional trade agreements is one of the most important features in the development of international relations in recent years (World Bank, 2000). The set of potential effects associated with trade arrangements ranges from the "traditional" effects, namely, the allocation and growth effects (Baldwin, 1994) to the "non traditional" effects, which include security, credibility-signalling, bargaining power, and coordination conditions (Fernández, 1998).

This broad spectrum includes of course location effects. Reduced trade costs are likely to result in a spatial reorganization of production. In particular, economic integration may induce a geographical concentration of economic activities at the sectoral level and even at the aggregate level (Ottaviano and Puga, 1998). The benefits from trade liberalization may thus spread unevenly over space giving rise to relative winners and relative losers. This may in turn affect the process of integration (Begg, Gudgin, and Morris, 1996).

The question whether and to what extent trade liberalization affects the location of economic activities is then policy relevant. Not surprisingly, this question has drawn the attention of academic research. There are diverse studies which have focused on *North-North* and *North-South* agreements. Thus, Brülhart and Torstensson (1996); Brülhart (1998a, 1998b, 2001); Haaland, Kind, Midelfart-Knarvik, and Torstensson (1999); Midelfart-Knarvik, Overman, Redding, and Venables (2000); and Midelfart-Knarvik, Overman, and Venables (2000) have examined the impact of deepened integration on the European economic geography, whereas Hanson (1996, 1998a, 1998b) has analyzed the spatial implications of NAFTA. However, empirical evidence on the location effects of *South-South* arrangements is almost absent. MERCOSUR provides an interesting case study. This regional integration agreement is undoubtedly one the most important trade initiative among developing countries (Laird, 1997). It has been established in 1991 by Argentina, Brazil, Paraguay, and Uruguay. Intra-regional trade was gradually liberalized between 1991 and 1994 for most sectors and a Common External Tariff was implemented by 1995 (Estevadeordal, Goto, and Saez, 2000).

This paper aims at filling the aforementioned gap in the empirical literature. We uncover the determinants of location patterns in the Southern Cone (Argentina, Brazil, and Uruguay) and assess the impact of MERCOSUR on these patterns. More precisely, we address two main questions: What are the main determinants of location patterns in the region? Did MERCOSUR have an impact on spatial developments?

The remainder of this paper is structured as follows. Sections 2 reviews the relevant theoretical literature with the purpose of deriving hypotheses to be tested with our empirical analysis. Section 3 describes the data set, while Section 4 presents a descriptive analysis of manufacturing location patterns in MERCOSUR over the period from 1985 to 1998. Section 5 examines determinants of manufacturing location and the influence of MERCOSUR using econometric techniques. Section 6 concludes.

2 Theoretical Framework

The starting point for understanding location of economic activity in the context of increased economic integration is the International Trade Theory. Depending on the underlying factors explaining the spatial patterns of economic activity and their change as trade liberalization proceeds, three strands of theoretical literature can be distinguished. First, the *Neoclassical Trade Theory* focuses on the role of factor endowments and factor intensities in explaining specialization and location patterns. Second, the *New Trade Theory* points to the advantage of large markets in attracting economic activities with increasing returns to scale. Third, the more recent *New Economic Geography* underscores that the advantage of large markets is endogenous and explains location of economic activity through agglomeration patterns fostered by labour mobility and input-output linkages between firms. In this section we review these theoretical approaches, and highlight their assumptions and main results. The objective is to provide a theoretical basis for the empirical analysis that we carry out in the following sections. In particular, this theoretical framework serves us to derive the hypotheses that we test afterwards.

2.1 The Neoclassical Theory

According to the *Neoclassical Trade Theory,* in a world of perfect competition, homogeneous products and constant returns to scale, the location of economic activities is determined exogenously by the spatial distribution of natural resources and production factors. The *Heckscher-Ohlin model*, explains the location of economic activity as the result of the interaction between country and industry characteristics (Venables, 2000). *Thus, activities settle in locations abundant in the factors those activities use most intensively.*

In this context, the spatial distribution of demand is essentially relevant for trade patterns, but not for locational patterns, unless trade costs are positive. In particular, if such costs are prohibitive, then the geographical configuration of industries mirrors that of the demand (Brülhart, 2001).

The *Neoclassical Trade Theory* predicts that a general trade opening induces activities to relatively concentrate in countries with the matching comparative advantages. On the other hand, *the launching of a preferential trade agreement among developing countries with different comparative disadvantages relative to the Rest of the World tends to induce a relocation of manufacturing to the country that, even with a comparative disadvantage relative to the world, has a comparative advantage within the newly created regional economic space, so that consumers in both countries would be increasingly supplied with manufactures stemming from such a country* (Venables, 1999, 2003).

Although relevant, comparative advantage is not sufficient to explain the high concentration of economic activity observed in reality (Ottaviano and Puga, 1998). In particular, there are many regions without obvious natural advantages which develop into economic centres (Krugman, 1998). Which other factors can then explain the existing locational patterns? The *New Trade Theory* makes an important contribution in this direction.

2.2 The New Trade Theory

The *New Trade Theory* points to the exogenous geographical advantage of large markets in explaining the location of activities with increasing returns to scale. In general, models within this theoretical approach assume that the world consists of two countries: a big central country and a small peripheral country. The absolute endowment with factors is larger in the central country in comparison with the peripheral country but both countries have the same relative endowment. Thus, there are no comparative advantages. In addition, these models assume that the production structure consists of two sectors. On the one hand, there is a perfectly competitive sector, which operates under constant returns to scale and whose output is costless traded. On the other hand, there is a monopolistically competitive sector with firms producing differentiated products under conditions of increasing returns to scale which are traded at a positive cost. Labour is assumed internationally immobile while firms are mobile.

The typical result of such models is that increasing return sectors tend to settle in locations with good access to the markets of their respective products. This result derives from the interaction between scale economies and trade costs as follows. Under economies of scale, average costs fall as the level of production rises. This implies that producers have an incentive to spatially concentrate their activities, because in such a way they can operate at a more efficient level. However, the geographical concentration of production increases the costs of selling output to disperse customers. Thus, the presence of trade costs induces firms to concentrate in the country which has the larger market for their respective goods, since in this way they are able to avoid such costs in a larger fraction of their sales.

The location consequences of falling trade costs depend ultimately upon the interplay between market size and factor prices considerations.

Krugman (1980) and Krugman and Helpman (1985) find that, other things equal, *as trade costs fall towards zero, all increasing returns activities tend to concentrate in the larger country measured in terms of demand size*. Demand differences amplify differences in production structures. This basic analysis can be extended by including in the model a third country with the purpose of examining the consequences of a regional integration process, like in Torstensson (1995) and Brülhart and Torstensson (1996). Specifically, they assume two asymmetric countries with respect to size forming a customs union and a remaining one as the Rest of the World. They show that there is a U-shaped relationship between the share of industrial production located in the large country of the customs union and the deepness of the integration. This result relates to the changing interplay between the size-disadvantage of the smaller country within the bloc and its advantage in terms of market access to this country vis-à-vis the Rest of the World.

However, when factor markets considerations are conveniently introduced, as in Krugman and Venables (1990), *the tendency to locate in the larger market is stronger for values of trade costs that are neither too high nor too low, so that there exists an inverted-U shaped relationship between the degree of spatial concentration of industry in the central country and trade costs.* In other words, at intermediate levels of trade costs the number of manufacturing firms located in the large country due to its better market access is disproportionately large with respect to its share in world endowments (Amiti, 1998). The reason is that when trade costs are sufficiently high, location is mainly determined by product market competition, while when trade costs are sufficiently low the spatial result is fundamentally dictated by factor market competition.

The *New Trade Theory* cannot be seen as a complete theory of economic geography, because it assumes rather than explains international differences in manufacturing shares and income (Neary, 2001). Two main questions are left unanswered by this theory: Why *a priori* similar countries can develop very different production structures? Why do appear clear patterns of regional specialization, so that certain sectors have a tendency to locate in the same place? The *New Economic Geography* helps understanding such real world developments.

2.3 The New Economic Geography

The *New Economic Geography* extends the line of research initiated by the *new trade theory* assuming however that the geographical advantage of large markets is endogenous (Amiti, 1998). Thus the market size is explained within the model (Brülhart, 2001).

In the presence of increasing returns and trade costs, firms and workers tend to locate close to large markets. But, large markets are in turn those where more firms and workers locate (Baldwin, 1994; Ottaviano and Puga, 1998). This suggests that a cumulative causation mechanism is at work, leading to an endogenous differentiation process of initially similar regions (Brülhart, 1998a).

The *New Economic Geography* focuses on two main agglomeration mechanisms for modelling the cumulative causation process: interregional labour mobility (Krugman, 1991) and mobility of firms demanding intermediate inputs (Venables, 1996).[1]

The basic idea underlined by Krugman (1991) is that if factors, namely, industrial workers, are mobile across regions, the countervailing pressure against agglomeration exercised by the behaviour of factor markets would be eased, so that firms could exploit the demand linkages to each other workers and a persistent concentration would take place.[2]

Venables (1996) shows that the agglomeration could be induced by the presence of input-output linkages among firms. When imperfect competitive industries are linked through an input-output structure and trade costs are positive, the firms in the upstream industry are drawn to locations where there are relatively many firms of the downstream industry, because in this way they can reach their customers more easily (demand linkage). Moreover, the fact of having a larger number of upstream

[1] There are also inter-temporal mechanisms related to factor accumulation (Baldwin, 1999) and to input-output linkages with an innovative sector (Martin and Ottaviano, 2001).

[2] The crucial point is that for industry agglomeration to occur it must be possible for firms to draw resources from elsewhere, particularly from other regions or from other sectors, so that the factors supply becomes sufficiently elastic and consequently large increases in factor prices are avoided (Puga, 1998).

firms in a location benefits downstream firms, which obtain their intermediate goods at lower costs, by saving transport costs and also benefiting from a larger variety of differentiated inputs (cost linkage). Hence, the joint action of such linkages might result in an agglomeration of vertically linked industries and could give such an equilibrium location a certain inherent stability (Venables, 1996). In this sense, the above reasoning provides a rationale for the notion of industrial base. If location decisions of firms depend on those of other firms, some industries may be particularly important in maintaining firms in other upstream or downstream industries. Therefore, *industries for which demand comes to a large extent from the manufacturing sector itself and industries which use intensively manufactured intermediate inputs tend to locate in regions with large industrial bases.*

New Economic Geography models show that, under scale economies, labour migration and input-output linkages between firms lead to industry concentration in one region when trade costs between two initially identical regions are reduced. However, this might be only the beginning of the process. When relevant centrifugal forces related to the induced dynamics in factor markets are taken into account, the already mentioned inverted U-shaped pattern emerges again (Ottaviano and Puga, 1998). Thus, *at early stages of integration, concentration forces dominate and industries tend to cluster, but further integration, beyond a certain threshold, promotes a re-dispersion of industries towards the periphery, which offers lower factor costs.*

The *New Economic Geography* allows us also to address the location effect of infrastructure (Martin and Rogers, 1995; Baldwin, Forslid, Martin, Ottaviano, and Robert-Nicaud, 2003). The quality of infrastructure determines interregional and internal trade costs. Under this hypothesis, a bad infrastructure implies that a large proportion of produced and traded goods are not effectively consumed, but that they "disappear" in the transportation process. In this context, and in the presence of scale economies, *economic integration tends to generate a geographical concentration of firms in the region with better infrastructure*. The reason is that in such territories the effective price is lower and, therefore, the relative demand for goods produced there is higher.

3 Data

In this study, we use production value data for each manufacturing industry at *ISIC, Rev. 2, 3 digit-level*. These data is part of the *PADI* database produced by the Industry and Technological Development Unit at the United Nations' Economic Commission for Latin America and Caribbean

(ECLAC). It includes homogeneous statistical information for the period from 1985 to 1998 on an annual basis.[3]

We have also data that allow for a suitable characterization of countries and sectors. The definitions of these country and industry characteristics are presented in Table 1.

Table 1 about here

A detailed description of the dataset indicating aggregation, country coverage, time coverage, and sources and a discussion on particular aspects related to the construction of the variables are included in the Appendix.

4 Descriptive Analysis

Brazil is the largest country within the bloc. It has accounted for roughly 70% of overall manufacturing activity in the Southern Cone over the period from 1985 to 1998. The share of this country has declined slightly after 1991. Uruguay seems to have witnessed a more pronounced decrease in its share over the same years. The opposite is true for Argentina.

Figure 1 about here

Of course, there are noticeable cross-sectional differences. The question then arises: Which are the specific sectors in which the particular countries have gained or lost shares over time? Table 2 shows for each country the sectors with largest increases (decreases) in MERCOSUR's total manufacturing production value shares over the sub-periods 1985-1990 and 1995-1998. This summary classification allows us to assess the production structures before and after the entry into force of MERCOSUR.

Table 2 about here

Argentina has increased their shares in leather products, while Brazil and Uruguay registered decreases. The opposite is true for professional and scientific instruments. Brazil and Uruguay expanded their shares, whereas Argentina lost relative importance within the bloc. The higher share of Argentina in pottery, china, and earthenware comes essentially at the expense of the smaller country, Uruguay, while the higher share in other non-metallic minerals at the expense of Brazil.

A more general picture of the changing production structures across countries can be obtained looking at the correlations between the share of each country in each industry and the score in selected

[3] In the case of Uruguay, available data correspond to the period 1971-1996. Data for 1997 and 1998 were obtained applying sectoral variation rates calculated from a production database for Uruguay kindly provided by Marcel Vaillant.

industry characteristics. We estimate these correlations over the sub-periods: 1985-1990, 1991-1994, and 1995-1998, i.e. the period before MERCOSUR, the transition period towards a free trade area, and the customs union period, respectively. Results are reported in Table 3.

Table 3 about here

As expected the two countries with higher specialization in agriculture activities, Argentina and especially Uruguay, have higher shares in industries which use intensively agriculture inputs. They show, however, opposite trends. The tendency is increasing in the case of Uruguay and decreasing in the case of Argentina.

Similarly, Brazil, the country with the largest industrial base in the region, has a higher relative importance in sectors which use intensively manufactured inputs and sell a large fraction of their output to manufacturing firms.

Argentina exhibits a higher and increasing share in industries which are intensive in transport costs. The opposite is true for Brazil. Finally, Argentina and Uruguay have witnessed larger shares in sectors with increasing returns after the launching of MERCOSUR.

The above correlations are suggestive but, because of their bivariate nature, they cannot be considered a rigorous examination of the determinants of industry location. Therefore, we turn to a formal econometric analysis in the next section.

5 Econometric Analysis

The location of manufacturing activity is the resultant of multivariate interactions between industry and country characteristics (Midelfart-Knarvik, Overman, Redding, and Venables, 2000). Industries and country differences are multi-dimensional. Thus, industries have distinct intermediate input structures, different biases in the main destination of their sales, might be subject to increasing returns to scale of varying degree, and may face different trade costs. On the other hand, countries differ in their industrial base, their physical infrastructure, and their endowments such as the abundance of agriculture products and the skill level of their population. The spatial distribution of industries is determined by the interaction between these characteristics. Therefore, in this section, we use both industry and country characteristics as explanatory variables for the spatial distribution of industries. The questions we investigate are the following: What are the main determinants of location patterns in the Southern Cone? Did the establishment of MERCOSUR have an impact on the geographical

configuration of the manufacturing sector across member countries? In order to answer these questions, we carry out an econometric analysis based on several model specifications. First, we describe the main hypotheses to be tested. Second, we define the selected model specification. Third, we report and discuss our main empirical results.

5.1 Main Hypotheses

Manufacturing location patterns in MERCOSUR are described by the distribution of country shares in the total production value for each industry in this bloc.

Formally, the production value of industry *k* in country *i* at time *t* is denoted by $x_{ik}(t)$. This value is expressed as a share of the total production value in the industry:

$$s_{ik}(t) \equiv \frac{x_{ik}(t)}{\sum_{i} x_{ik}(t)} \tag{1}$$

The approach that we follow in order to explain these shares has been used by Ellison and Glaeser (1999); Midelfart-Knarvik, Overman, Redding, and Venables (2000); Midelfart-Knarvik, Overman, and Venables (2001); Volpe Martincus (2004); and Traistaru, Nijkamp, and Longhi (2003). The general idea is that industries that use intensively a given "factor" tend to locate in countries that are relatively abundant in this "factor".[4] Thus, if countries differ in their endowments of educated population, then industries which use intensively well educated workers will be drawn to countries with relatively high shares of these workers. This suggests explaining the location patterns through a set of interactions resulting from a specific pairing of industry characteristics and country characteristics. The particular correspondence of these characteristics is defined according to the theories reviewed in Section 2. These interactions terms will be considered next in detail.

Table 4 about here

Table *4* presents the country and industry characteristics, and their interactions used in the econometric analysis. The dimensions on which variables vary is also specified.

The first two interaction variables aim at controlling for the contribution of *comparative advantage* considerations. The general hypothesis is that industries tend to locate in those countries that are

[4] Torstensson (1997) and Brülhart and Trionfetti (2004) also use interaction terms between country and industry characteristics to explain trade patterns among developed countries and location patterns in Europe, respectively.

relatively abundant in the factors they use intensively in their production processes. In particular, we can derive the following hypotheses with respect to comparative advantages:

Hypothesis 1: Industries that use intensively agriculture inputs tend to locate in countries in which agriculture accounts for an important share of total production.[5]

Hypothesis 2: Industries that use intensively skilled workforce tend to be drawn to countries which are relatively well endowed with skilled labour.

The next interaction terms capture several aspects related to the interplay between trade costs, scale economies, and input-output linkages, as highlighted in the *New Trade Theory* and the *New Economic Geography*. From the predictions of these theories, we can formulate the following hypotheses:

Hypothesis 3: Industries with increasing returns to scale tend to locate in countries with high market potentials.

Hypothesis 4: Industries which rely highly on industrial intermediate inputs tend to locate in countries ensuring a better access to a relatively large industrial base and thus to their relevant providers.[6]

Hypothesis 5: Industries for which the manufacturing sector itself is an important user of their products find advantageous to locate in countries providing a better access to a relatively large industrial base and hence to a significant demand source.

Firms that use intensively transport services tend to locate in countries with better infrastructure, since this implies a lower effective price for the purchaser and therefore a higher relative demand for goods produced in such territories. Therefore, the following hypothesis can be tested:

Hypothesis 6: Transport intensive industries tend to locate in countries with relatively good infrastructure.

Finally, different internal trade impediments across sectors might affect differently the intensity of the interaction between country and industry characteristics. We thus derive and test the following last hypothesis:

Hypothesis 7: Intra-bloc tariffs may strengthen the importance of factors highlighted by a group of theories, namely the new trade theories (economies of scale and input-output linkages), relative to factors suggested by other theories, namely the Neoclassical Theory (comparative advantage).

[5] Following Midelfart-Knarvik, Overman, Redding, and Venables (2000), agriculture production is taken as an exogenous measure of "agriculture abundance".

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

5.2 Model Specification

The dependent variable is the share of a country in total manufacturing production value in each industry, s_{ik}. Note that this ratio can only take values within [0,1], so that the dependent variable is truncated. As a consequence, estimation with OLS will lead to biased estimates. Therefore, we perform a logistic transformation, similar to Balassa and Noland (1989) and Torstensson (1997). The variable becomes $ln[s_{ik}/(1-s_{ik})]$ and ranges in $(-\infty,+\infty)$.

The dependent variable is expressed as a function of country characteristics, industry characteristics, and their interaction. Formally, we estimate the following model:

$$\ln\left(\frac{s_{ikt}}{1-s_{ikt}}\right) = \sum_j \beta(j)\left(\varpi_{it}(j) - \overline{\varpi}(j)\right)\left(\theta_{kt}(j) - \overline{\theta}(j)\right) + \varepsilon_{ikt}$$
$$\ln\left(\frac{s_{ikt}}{1-s_{ikt}}\right) = \alpha + \sum_j \left(\beta(j)\varpi_{it}(j)\theta_{kt}(j) - \beta(j)\overline{\theta}(j)\varpi_{it}(j) - \beta(j)\overline{\varpi}(j)\theta_{kt}(j)\right) + \varepsilon_{ikt} \quad (2)$$

$\varpi_i(j)$ is the level of the *jth* characteristic in country *i* and $\theta_k(j)$ is the industry *k* value of the industry characteristic paired with the country characteristic. The upper bar denotes a reference value.

The coefficients to be estimated are the $\beta(j)$ s, which measure the importance of the interaction, -$\beta(j)\overline{\theta}(j)$ and -$\beta(j)\overline{\varpi}(j)$, which amount to level effects in the interaction and a constant α, which contains the sum (over *j*) of the products of all level effects. Thus, for example, if *j*=skill, $\varpi_i(skill)$ is the abundance of skilled workers in country *i*, $\theta_k(skill)$ is the skill intensity of industry *k* and $\beta(skill)\rangle 0$, then industries with skill intensity greater than $\overline{\theta(skill)}$ tend to locate in countries with skill abundance greater than $\overline{\varpi(skill)}$ and out of countries whose skill's abundance is lower than this level.

Equation *(2)* is estimated in the first place by OLS, pooling across industries, and, in principle, across years. The regression analysis includes 27 industries, 3 countries, and 14 years, 1985-1998.[7] Therefore, the sample contains 1,134 observations. Moreover, we condition on the standard deviation of the underlying variables in order to make comparison across variables more appropriate, so that the coefficients that will be presented are standardized ones. Notice that there are three potential sources of heteroscedasticity: across countries, across industries, and across time.[8] Hence, White's heteroscedastic consistent standard errors are reported and used for hypothesis testing. We

[7] The industry "Other products", which is a residual component, was dropped out.
[8] The White's general test was carried out to test for heteroscedasticity (Greene, 1997). Unlike other usual tests, such as the Goldfeld-Quandt and Breusch-Pagan, it does not require to specify the nature of heteroscedasticity. In this case, it suggests that indeed there exists heteroscedasticity. The corresponding chi-square statistic is highly significant.

additionally test the robustness of our results controlling for groupwise heterocedasticity and cross-sectional correlation, as suggested in Beck and Katz (1996). We also include dummy variables to control for industry, country, and time effects. On the other hand, we are aware of potential endogeneity in our model. Specifically, skill intensive industries tend to locate in skill abundant countries, but causation can run also in the opposite direction: by settling in a country, industries employing highly qualified workers may end up changing its relative skill abundance through induced migration. A similar reasoning also applies to firms with input-output linkages, as suggested by the *New Economic Geography.* Therefore, we have also used lag values for the explanatory variables.

5.3 Basic Results

Estimation results are reported in Tables 5.1. and 5.2.. They show a clear pattern of matching between specific country characteristics and specific industry characteristics, which confirms the priors derived from theory. Notice that results using lagged values are basically the same. (Table *5.2.*). Thus, endogeneity does not seem to be a matter of concern.[9]

Tables 5.1. and 5.2. about here

First, industries that use intensively agricultural inputs tend to be located in countries that are relatively abundant in agricultural output as measured by the share of agriculture in national GDP. Similarly, industries that use intensively skilled labour tend to be located in countries that are relatively abundant in this factor.

Further, industries with increasing returns to scale tend to locate in countries with larger market potentials. In addition, sectors which use intensively industrial intermediate inputs tend to locate in countries with larger industrial market potentials, while industries whose output is mainly demanded by the manufacturing sector itself tend to choose the same location.

Finally, industries that are intensive in transport services tend to locate in countries providing a better physical infrastructure.

[9] We report estimation results using one-period lagged values for the explanatory variables. Results using 2-, 3-, and 4-period lagged values provide a similar picture. They are available from the authors upon request.

5.4 Increased Economic Integration

The establishment of MERCOSUR might have induced changes in manufacturing location patterns and, in particular, it might have altered the relative importance of their determinants over time. In order to test for this possible structural break, we have created a dummy variable which takes the value 1 for the MERCOSUR period, 1991-1998, and 0 otherwise. Then we have interacted this dummy with the explanatory variables previously used and included them in the regression equation. The test statistics indicates that the interacting terms are jointly significant. Therefore, the relative influence of the different determinants seems to have changed as regional integration proceeded. Further, as already mentioned, the evolution of MERCOSUR can be split out in two mains phases: the transition towards a FTA from 1991 to 1994 and the customs union period from 1995 onwards. Average and cross-sectional openness differ substantially across these two periods. Thus, we have replicated the structural break test, this time creating a dummy variable which takes a value of 1 for 1995-1998 and 0 otherwise (1991-1994). The test statistics also shows a break in 1995.[10] Consequently, we have run also separate regressions for sub-periods that mirror the history of MERCOSUR: 1985-1990 (preparation period), 1991-1994 (transition period), and 1995-1998 (customs union period). Results are presented in Tables 6.1. and 6.2.[11]

Table 6.1. and 6.2. about here

It is noteworthy that the correspondence between agricultural intensity and agricultural abundance weakens as trade becomes freer. In the last sub-period, Brazil becomes the country with the largest share of agriculture in GDP. This is due to faster declines of agriculture share in the other countries.[12] We also observe a declining trend for the matching between skill intensity and skill abundance. This might be related to the relative convergence across industries in qualification requirements detected in the data.

The tendency of sectors with increasing returns to locate in countries with larger market potentials and, when groupwise heterocedasticity and cross-sectional correlation are controlled for, that of

[10] Estimation results with interacting time dummies and statistics of the structural break tests are available from the authors upon request.

[11] Reported results are based on OLS estimations with White-corrected standard errors and Beck and Katz's panel corrected standard errors. We have also run Prais-Winsten regressions with panel corrected standard errors and thus controlled also for serial correlation. Results convey the same message as those with OLS. They are not presented to save space, but are available from the authors upon request.

[12] Amiti (2001) shows that industries may end up located in countries without a matching comparative advantage when there are other competitive reasons for location: the convenience to be settled closer to providers of other intermediate inputs or to customers.

sectors using intensively industrial intermediate inputs to settle in countries with larger industrial market potentials becomes stronger as trade liberalization deepens. On the other hand, the demand linkage, i.e., the matching between industrial market potential and the importance of the manufacturing sector as a buyer of sectoral output does not display a clear temporal pattern. However, the intensity of this effect is clearly larger during the 1990s.

Finally, as expected from the theory, the propensity of industries which are transport intensive to locate in countries with appropriate infrastructure has increased over time.

Linking our econometric results with the theoretical framework, we can conclude that factors suggested by the *New Trade Theory* and the *New Economic Geography*, in particular the interaction among market potential and economies of scale, have gained importance as location determinants *relative* to comparative advantage considerations.

The previous econometric analyses have assessed the impact of preferential trade liberalization using a "dummy variables approach". To evaluate the effects explicitly we would need data on preferential tariffs at the sectoral level. We have therefore constructed a proxy for the preference tariff variable, which measures the degree of intra-bloc trade impediments in each sector. More precisely, we have applied the liberalization schedule set in the Treaty of Asunción on the Brazilian MFN tariffs with some exemptions, such as textiles-wearing apparel, footwear, paper, and iron and steel. Tariffs on these sectors were then automatically reduced from 1995 onwards according to the Adaptation Regime to the Customs Union We have included this variable and interacted it with the original set of explanatory variables. Estimations results are reported in Table 7.

Table 7 about here

The results shown in Table 7 indicate, in concordance with our previous findings, that low intra-bloc tariffs increase the intensity of the correspondences underlined by the new trade theories. In particular, reduced trade barriers accentuate in a significant way the tendency of increasing returns industries to locate in countries with larger market potentials as well as that of industries selling a substantial part of their output to the manufacturing sector itself to settle in countries with broad industrial bases. The same is true for the propensity of transport intensive industries to locate in countries with better physical infrastructure. The opposite is valid for the interactions involving comparative advantage factors.[13]

[13] A similar message comes out from a regression including original variables interacted with the preferential margins. Results are available from the authors upon request.

6 Concluding Remarks

Argentina, Brazil, Paraguay, and Uruguay have engaged actively in unilateral and preferential trade liberalization initiatives during the last 20 years. These initiatives have resulted in significant changes in the spatial distribution of economic activities. This paper has uncovered the determinants of these changing manufacturing location patterns over the period 1985-1998 in Argentina, Brazil, and Uruguay.

Our econometric analysis of determinants of manufacturing location defined by the distribution of country shares in each industry indicates that: a) industries intensive in agricultural inputs are located in countries abundant in agriculture output measured as a share of agriculture to national GDP; b) skills intensive industries tend to be located in countries abundant in skilled labour; c) industries with increasing returns to scale tend to locate in countries with large market potentials; d) industries whose output is mainly demanded by the manufacturing sector tend to locate in countries with large industrial market potential; e) industries facing high transport costs tend to locate in countries providing a better physical infrastructure.

In order to distinguish the role of increased economic integration on changing manufacturing location patterns, we re-estimated the above model for three sub-periods corresponding to the integration progress within MERCOSUR: 1985-1990 (preparation period), 1991-1994 (transition period), 1995-1998 (customs union period).

Increased integration appears associated with a stronger effect of the interactions between increasing returns of scale and market potential, the intensity in industrial intermediate inputs and large industrial market potential, and transport intensity and infrastructure. Furthermore, we find declining effects of the interactions involving agriculture and education.

From our econometric analysis, we conclude that factors suggested by the *New Trade Theory* and the *New Economic Geography,* in particular the interaction between market potential and economies of scale, have gained importance as location determinants relative to comparative advantage considerations. In order to strengthen the formal support for this conclusion, we include in our model an additional control variable reflecting preferential tariffs and we interact it with the original set of explanatory variables. Our estimation results are in line with the previous findings and suggest that low intra-bloc tariffs increase the intensity of the interactions underlined by the new trade theories. In particular, reduced tariffs within the bloc reinforces the tendency of increasing returns industries to

locate in countries with large market potentials as well as that of industries selling a substantial part of their output to the manufacturing sector itself to settle in countries with broad industrial bases. The same is true for the propensity of transport intensive industries to locate in countries with better physical infrastructure. Interactions suggested by comparative advantages, in particular, those involving skill and agricultural intensity, seem to weaken with increased economic integration.

Table 1

Explanatory Variables		
Country characteristics	**Definition**	**Source**
Agriculture abundance	Agriculture as a share of state GDP	ECLAC
Human capital abundance	Share of population older than 25 years with at least high school attainement	Barro and Lee (2000)
Market potential	Measure of market access, based on GDP and distances	Own elaboration on ECLAC and CEPII
Industrial market potential	Measure of market access, based on GDP and distances	Own elaboration on ECLAC and CEPII
Infrastructure	Kilometers of paved routes per 100 km2	Own elaboration on World Bank
Industry characteristics	**Definition**	**Source**
Agriculture intensity	Agriculture inputs as a share of production value	Own elaboration on IBGE
Human capital intensity	Workers with at least secondary school as a share of total labour force	Own elaboration on MW
Economies of scale	Number of workers per establishment	Own elaboration on MW
Industrial intermediate consumption	Industrial intermediates as a share of production value	Own elaboration on IBGE
Sales to industry	Sales to industry as a share of total demand	Own elaboration on IBGE
Transport intensity	Transport margin as a share of total supply	Own elaboration on IBGE

Abbreviations:

ECLAC	Economic Commission for Latin America and Caribbean
IBGE	Brazilian Institute of Geography and Statistics
MW	Brazilian Ministry of Works
CEPII	Centre d´Estudes Prospectives et d´Informations Internationales

Figure 1

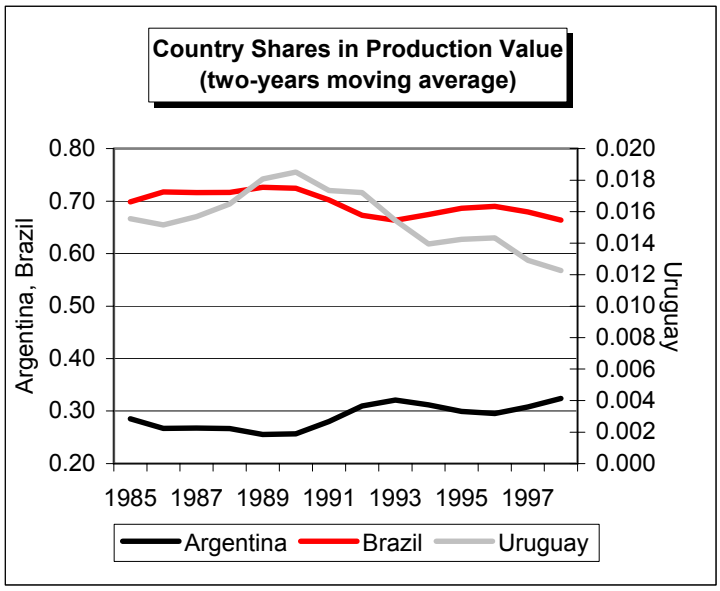

Table 2

MERCOSUR - Sectors with the highest share increases and decreases by country

Country/Year	Expanding sectors	Contracting sectors
Argentina	Leather Products	Non-ferrous Metals
	Other Non-metallic Minerals	Professional and Scientific Instruments
	Pottery, China, and Earthenware	
Brazil	Professional and Scientific Instruments	Leather Products
	Non-ferrous Metals	Other Non-metallic Minerals
	Rubber Products	Paper products
Uruguay	Printing and Publishing	Leather Products
	Furniture	Rubber Products
	Professional and Scientific Instruments	Pottery, China, and Earthenware

Table 3

Country Shares and Industry Characteristics

	Argentina			Brazil			Uruguay		
	1985-1990	1991-1994	1995-1998	1985-1990	1991-1994	1995-1998	1985-1990	1991-1994	1995-1998
Agriculture intensity	0.507*	0.401*	0.358*	-0.517*	-0.446*	-0.400*	0.451*	0.604*	0.626*
Skill intensity	0.300*	0.110	-0.007	-0.296*	-0.082	0.025	0.212*	-0.124	-0.160*
Scale economies	0.292*	0.362*	0.335*	-0.281*	-0.372*	-0.356*	0.146*	0.331*	0.439*
Intermediate consumption	-0.364*	-0.234*	-0.188*	0.363*	0.257*	0.217*	-0.256*	-0.333*	-0.386*
Sales to industry	-0.104	-0.096	-0.083	0.157*	0.139	0.113	-0.389*	-0.373*	-0.322*
Transport intensity	0.143*	0.220*	0.231*	-0.134*	-0.212*	-0.217*	0.050	0.099	0.053

Note: * denotes significant at least at 10% level

Table 4

Regressions				
Category	**Explanatory variables**		**Name**	**Dimension**
Country characteristics	Agriculture abundance		ags	S.T
	Human capital abundance		edus	S.T
	Market potential		mp	S.T
	Industrial market potential		mpi	S.T
	Infrastructure		inf	S.T
Industry characteristics		Agriculture intensity	agi	.IT
		Human capital intensity	edui	.IT
		Economies of scale	scn	.IT
		Industrial intermediate consumption	ici	.IT
		Sales to industry	si	.IT
		Transport intensity	transp	.IT
Interaction terms	Agriculture abundance	* Agriculture intensity	agsi	SIT
	Human capital abundance	* Human capital intensity	edusi	SIT
	Market potential	* Economies of scale	mpscn	SIT
	Industrial market potential	* Industrial intermediate consumption	mpiici	SIT
	Industrial market potential	* Sales to industry	mpisi	SIT
	Infrastructure	* Transport intensity	inftransp	SIT

Note:

S.T: Variables that vary across countries and years, but not across industries.

.IT: Variables that vary across industries and years, but not across countries.

SIT: Variables that vary across countries, industries, and years.

Table 5.1.

Determinants of Location Patterns						
	(1) Ints	(2) Ints	(3) Ints	(4) Ints	(5) Ints	(6) Ints
agsi	0.240	0.275	0.267	0.240	0.275	0.267
	(0.090)***	(0.092)***	(0.093)***	(0.168)	(0.155)*	(0.155)*
edusiah	0.145	0.159	0.155	0.145	0.159	0.155
	(0.077)*	(0.076)**	(0.077)**	(0.051)***	(0.051)***	(0.052)***
mpscn	0.408	0.557	0.591	0.408	0.557	0.591
	(0.144)***	(0.132)***	(0.134)***	(0.119)***	(0.099)***	(0.103)***
mpiici	0.621	0.609	0.600	0.621	0.609	0.600
	(0.316)**	(0.305)**	(0.305)**	(0.146)***	(0.139)***	(0.139)***
mpisi	0.735	0.754	0.758	0.735	0.754	0.758
	(0.232)***	(0.223)***	(0.225)***	(0.192)***	(0.191)***	(0.191)***
inftransp	0.290	0.333	0.344	0.290	0.333	0.344
	(0.072)***	(0.069)***	(0.069)***	(0.035)***	(0.028)***	(0.030)***
Adj. R2	0.88	0.89	0.89			
Obs.	1134	1134	1134	1134	1134	1134
I. Effects	Yes	Yes	Yes	Yes	Yes	Yes
C. Effects	No	Yes	Yes	No	Yes	Yes
T. Effects	No	No	Yes	No	No	Yes

(1)-(3): Robust standard errors in parentheses((4)-(6): Panel-corrected standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5.2.

Determinants of Location Patterns (Lagged Values)				
	(1)		(2)	
	CV	**LV**	**CV**	**LV**
agsi	0.213	0.265	0.213	0.265
	(0.100)**	(0.089)***	(0.195)	(0.168)
edusiah	0.147	0.153	0.147	0.153
	(0.079)*	(0.088)*	(0.050)***	(0.062)**
mpscn	0.414	0.427	0.414	0.427
	(0.150)***	(0.148)***	(0.127)***	(0.121)***
mpiici	0.690	0.586	0.690	0.586
	(0.339)**	(0.331)*	(0.159)***	(0.150)***
mpisi	0.818	0.852	0.818	0.852
	(0.253)***	(0.248)***	(0.208)***	(0.187)***
inftransp	0.299	0.317	0.299	0.317
	(0.074)***	(0.076)***	(0.034)***	(0.033)***
Adj. R2	0.88		0.88	
Obs.	1053	1053	1053	1053
I. Effects	Yes	Yes	Yes	Yes
C. Effects	No	No	No	No
T. Effects	No	No	No	No

(1) Robust standard errors in parentheses

(2) Panel-corrected standard errors in parentheses

CV=Contemporaneous values/LV=Lagged values (1 year)

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6.1.

Determinants of Location Patterns									
	1985-1990	1991-1994	1995-1998	1985-1990	1991-1994	1995-1998	1985-1990	1991-1994	1995-1998
	Ints	Ints	Ints	Ints	Ints	Ints	Ints	Ints	Ints
agsi	0.656	-0.224	-0.590	0.698	-0.207	-0.619	0.697	-0.207	-0.619
	(0.119)***	(0.316)	(0.302)*	(0.121)***	(0.316)	(0.310)**	(0.123)***	(0.314)	(0.312)**
edusiah	0.622	0.248	0.066	0.684	0.248	0.074	0.679	0.246	0.076
	(0.320)*	(0.178)	(0.107)	(0.316)**	(0.178)	(0.105)	(0.319)**	(0.180)	(0.106)
mpscn	0.326	0.708	0.880	0.316	0.693	0.945	0.319	0.699	0.952
	(0.182)*	(0.246)***	(0.396)**	(0.168)*	(0.250)***	(0.393)**	(0.167)*	(0.252)***	(0.393)**
mpiici	0.338	0.768	1.152	0.259	0.749	1.075	0.264	0.746	1.080
	(0.490)	(0.855)	(0.878)	(0.480)	(0.862)	(0.882)	(0.484)	(0.865)	(0.889)
mpisi	0.842	1.798	1.209	0.808	1.799	1.315	0.807	1.820	1.311
	(0.355)**	(0.739)**	(0.709)*	(0.348)**	(0.739)**	(0.711)*	(0.350)**	(0.743)**	(0.715)*
inftransp	0.214	0.444	0.399	0.218	0.439	0.406	0.218	0.441	0.407
	(0.129)*	(0.133)***	(0.135)***	(0.126)*	(0.134)***	(0.134)***	(0.126)*	(0.134)***	(0.134)***
Adj. R2	0.89	0.88	0.88	0.90	0.88	0.88	0.90	0.88	0.88
Obs.	486	324	324	486	324	324	486	324	324
I. Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
C. Effects	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
T. Effects	No	No	No	No	No	No	Yes	Yes	Yes

Robust standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 6.2.

Determinants of Location Patterns									
	1985-1990	1991-1994	1995-1998	1985-1990	1991-1994	1995-1998	1985-1990	1991-1994	1995-1998
	Ints	Ints	Ints	Ints	Ints	Ints	Ints	Ints	Ints
agsi	0.656	-0.224	-0.590	0.698	-0.207	-0.619	0.697	-0.207	-0.619
	(0.158)***	(0.395)	(0.141)***	(0.151)***	(0.402)	(0.135)***	(0.152)***	(0.402)	(0.135)***
edusiah	0.622	0.248	0.066	0.684	0.248	0.074	0.679	0.246	0.076
	(0.265)**	(0.078)***	(0.036)*	(0.260)***	(0.078)***	(0.037)**	(0.262)***	(0.078)***	(0.037)**
mpscn	0.326	0.708	0.880	0.316	0.693	0.945	0.319	0.699	0.952
	(0.110)***	(0.137)***	(0.114)***	(0.107)***	(0.142)***	(0.108)***	(0.107)***	(0.141)***	(0.109)***
mpiici	0.338	0.768	1.152	0.259	0.749	1.075	0.264	0.746	1.080
	(0.295)	(0.208)***	(0.205)***	(0.278)	(0.211)***	(0.215)***	(0.280)	(0.208)***	(0.214)***
mpisi	0.842	1.798	1.209	0.808	1.799	1.315	0.807	1.820	1.311
	(0.118)***	(0.739)**	(0.316)***	(0.125)***	(0.738)**	(0.277)***	(0.125)***	(0.733)**	(0.278)***
inftransp	0.214	0.444	0.399	0.218	0.439	0.406	0.218	0.441	0.407
	(0.050)***	(0.044)***	(0.026)***	(0.051)***	(0.044)***	(0.027)***	(0.050)***	(0.044)***	(0.028)***
Obs.	486	324	324	486	324	324	486	324	324
I. Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
C. Effects	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
T. Effects	No	No	No	No	No	No	Yes	Yes	Yes

Panel corrected standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Table 7

Regressions with Preferential Tariffs		
	(1)	**(2)**
	Ints	**Ints**
agsi	-0.019	-0.019
	(0.203)	(0.292)
edusiah	0.054	0.054
	(0.092)	(0.038)
mpscn	0.634	0.634
	(0.216)***	(0.197)***
mpiici	0.701	0.701
	(0.585)	(0.293)**
mpisi	1.431	1.431
	(0.437)***	(0.304)***
inftransp	0.389	0.389
	(0.097)***	(0.056)***
ptagsi	0.471	0.471
	(0.163)***	(0.208)**
ptedusiah	0.710	0.710
	(0.204)***	(0.246)***
ptmpscn	-0.592	-0.592
	(0.271)**	(0.339)*
ptmpiici	-0.225	-0.225
	(1.311)	(0.868)
ptmpisi	-0.998	-0.998
	(0.431)**	(0.349)***
ptinftransp	-0.148	-0.148
	(0.118)	(0.064)**
Obs.	1134	1134
I. Effects	Yes	Yes
C. Effects	No	No
T. Effects	No	No

(1) Robust standard errors in parentheses

(2) Panel corrected standard errors in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

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Appendix

1. Data

Data availability				
Variable	**Aggregation**	**Country coverage**	**Period**	**Source**
Production value	ISIC. Rev. 2, 3digits	Argentina, Brazil, Uruguay	1985-1998	PADI/ECLAC
	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Employment	ISIC. Rev. 2, 3digits	Argentina, Brazil, Uruguay	1985-1998	PADI/ECLAC
	IBGE Subsector Classification	Brazil	1985-1998	RAIS/Ministry of Works
Value added	ISIC. Rev. 2, 3digits	Argentina, Brazil, Uruguay	1985-1998	PADI/ECLAC
	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Number of establishments	IBGE Subsector Classification	Brazil	1985-1998	RAIS/Ministry of Works
Workers qualification	IBGE Subsector Classification	Brazil	1985-1998	RAIS/Ministry of Works
Intermediate inputs	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Sales to industry	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Agricultural inputs	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Final demand	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Intermediate demand	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Total demand	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Total supply	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Transport costs	IBGE Subsector Classification	Brazil	1985, 1990-1998	IBGE
Tariffs	IBGE Subsector Classification	Brazil	1987-1998	Kume, Piani, Souza (2000)
Total GDP	Country	Argentina, Brazil, Uruguay	1985-1998	PADI/ECLAC
Industrial GDP	Country	Argentina, Brazil, Uruguay	1985-1998	PADI/ECLAC
Skill level of population	Country	Argentina, Brazil, Uruguay	1985, 1990, 1995, 1999	Barro and Lee (2000)
Agricultural production	Country	Argentina, Brazil, Uruguay	1985-1998	ECLAC
Infrastructure	Country	Argentina, Brazil, Uruguay	1985-1998	World Bank

Our database includes variables at the industry level: value added, employment, the number of establishments, qualifications of workers, intermediate intensity, sales to industry, final demand, agricultural inputs, total supply, transport costs; and MFN tariffs; and variables at the country level: total GDP, industrial GDP, skill level of population, agricultural production, and infrastructure.
Employment and value added data for each country and for each manufacturing industry at the *ISIC Rev.2* at 3 digit – level, and total and industrial GDP are taken from the *PADI* database. Similar data is also available for Brazil in terms of the *IBGE* (Brazilian Statistical Bureau)-Subsector Classification.
Information on the number of establishments and hence on average establishment size, which is employed as a proxy for scale economies, as well as data on the qualification level of workers in each sector for the period 1985-1998 come from the *RAIS* database (Annual Social Information Report).
Data on intensity in consumption of manufactured intermediate inputs, sales to industry as a share of total demand, final demand also as a share of total demand, total supply, labour compensation, agricultural inputs, and transport costs are derived from the Brazilian input-output tables published by the *IBGE*. Tariff data for each manufacturing sector are taken from Kume, Piani, and Braz de Sousa (2000).
The data for several variables, such as the number of establishments, qualifications of workers, intensity of use of intermediate inputs, were available only for Brazil. Similar statistical information for Argentina and Uruguay was not found. In the case of Argentina, there are data only for a few particular years.[15] A simple inspection of such available data suggests that using the Brazilian data should not be, however, significantly misleading.[16]
The data which are only available for Brazil are reported according to the *IBGE* subsector classification. In order to get comparable figures, we have mapped them into the *ISIC Rev. 2* Classification using a concordance table supplied by the *IBGE*. Furthermore, our econometric analysis focuses on the period 1985-1998. However, our tariff data are available beginning with 1987. We assume that sectoral tariffs rates in 1985 and 1986 did not significantly differ from those in 1987.[17]
Finally, the data on remaining country characteristics, namely, skill level of population, agricultural production, and infrastructure were obtained from publications and databases of international organizations available on the web. Notice that information on the skill level of population is available on a five-years interval basis: 1985, 1990, 1995, and 1999. We have extrapolated the values for the remaining years.

2. Variables

Market Potential and Industrial Market Potential
The market potential of a country is captured through the index proposed by Keeble et al. (1986). Formally:

$$MP_i(t) \equiv \sum_{j \neq i} \frac{Y_j(t)}{d_{ij}} + \frac{Y_i(t)}{d_{ii}}$$

where *i* is the country under examination , *j* corresponds to remaining countries in the bloc, Y_i is the GDP (industrial GDP) of country *i*, d_{ij} measures the distance between the most important cities from an economic point of view in countries *i* and *j* and d_{ii} is the intra-state distance, given by 1/3 (1/6) of the radius of a circle with the same area as the country *i* (Leamer, 1997). The value of the measure is higher, the higher the own GDP (industrial GDP), viewed as a proxy for own market size, the lower the own area, and the lower the distance to the main markets of other countries.[18]

[15] Information on the number of establishments is only available for the years 1985 and 1994 from the National Economic Census. Data on intermediate intensity exist also for 1997 (Input-output table published by the INDEC).
[16] For example, the Spearman-rank correlation coefficient for establishment size between Argentina and Brazil was 0.57 in 1985 and 0.66 in 1994, in both cases significant at the 1% level. On the other hand, the simple correlation between Argentinean and Brazilian external tariffs for the *ISIC* Classification at 4 digits was 0.68 in 1992 and 0.77 in 1994 (Sanguinetti and Sallustro, 2000).
[17] Kume, Piani, and Souza (2000) indicate that the Brazilian import policy at the starting year of their study, 1987 was essentially based on a tariff structure set in 1957.
[18] Different measures of internal distances are used due to the different degrees of spatial concentration of overall economic activity and manufacturing activity.

Distances

Distance between cities have been estimated using the formula of geodesic distances by CEPII. Formally, the distance between two points *i* and *j* is given by:

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

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

Economies of Scale

Measuring scale economies is problematic, since they might be product-specific, plant-specific or due to multi-plant operations (Amiti, 1998). Here, following Kim (1995) and Amiti (1998), economies of scale are captured by establishment size, i.e. the average number of employees per establishment in the industry in question. Average firm size is a good proxy for economies of scale only under strong conditions: there prevails a long-run equilibrium, so that firms have adjusted to get zero profits; there are no differences in strategic behaviour across firms; and firm size is not co-determined with spatial concentration.

There are other possible measures, such the one developed by Pratten (1988) and extensively used by other authors. Pratten ranked industries "in order of the importance of the economies of scales for spreading development costs and for production costs". The classification bases on two criteria: engineering estimates of the minimum efficient plant scale relative to the industry's output, and estimates of the cost gradient below the minimum efficient scale. Thus, the ranking is based on observed plant size but also on (unexploited) potential for scale economies (Brülhart, 1998b). However, estimations are exclusively based on information about developed countries. For that reason its use for developing countries could be inconvenient.

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