INDUSTRIAL CORES AND PERIPHERIES IN BRAZIL

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ABSTRACT:

There is considerable evidence to demonstrate that the industrial localization in developing countries shows high level of spatial concentration, and the industrial decentralization is quite restricted to few isolated regions. The aim of this paper is to analyze the Brazilian case to identify the industrial cores and to find out whether Brazil follows this conventional view on industrial location in developing countries.

This study is based on a database that merges two sets of data: the first describes 35600 industrial firms, and the second has information on the economic, social and urban structure of 5507 cities (year 2000). Based on these datasets, the industrial cores and their respective peripheries are identified, classified, and discussed.

The conclusions are: (1) Brazil has several industrial cores with different scales, structures, and regional level of integration; (2) there are large regions with growing industrial peripheries that are strongly tied to the primary cores; these are what we called "spatial industrial agglomerations"; however, we also identified (3) regions that did not manage to build peripheries able to assimilate spillovers generated by its industrial centers; these are the "industrial enclaves", (4) and also regions that are fully marginalized of the industrialization.

Our main conclusion is: the Brazilian economic space is a mixed case. It is not a set of disconnected or isolated industrial islands, but it is still behind a full regional economic integration.

Key words: Brazil, Regional Economics, Industrial Agglomerations, Industry, and Regional Development.

JEL / JEL Classification: R11, R12, R23, R30, R58

1. INTRODUCTION

The objective of this article is to evaluate the pattern of localization of industrial enterprises in Brazil. Two of the major characteristics of the Brazilian economic space are its heterogeneity and fragmentation. The regional economies have generalized disparities in their subsystems of transportation, urban infrastructure, per capita income, labor competency, and innovative capability. For the research proposed herein, these are characteristics which affect the locational preferences of the organizations and their competitiveness abroad.[1]

The article has four sections. Section 1 discusses some of the theoretical and empirical aspects related to industrial localization and Brazil's particularities, in view of its territorial dimension and the fact that Brazil is a developing country that has gone through several constraints to grow. Section 2 seeks to identify the relevant industrial clusters by means of a typology based on the analysis of spatial correlations. Section 3 describes the econometric modeling and presents the models estimated for the industrial localization and industrial foreign trade. Section 4 comments on the implications of the study for regional and industrial development policies.

2. INDUSTRIAL LOCALIZATION IN BRAZIL

The heterogeneity of industrial localization in Brazil can be captured by various indicators. For this paper, n industrial database per municipality was used, which allows several sectoral and regional analysis. In one of these crosscuts, the industrial production base of each municipality was segmented into four sectors: capital goods and durable consumer goods industry (BCD), non-durable consumer goods (BCND), intermediate goods (BI), and the extraction industry (BE).[2]

Chart 1 shows municipality-based concentration curves resulting from this sectoral segmentation determined by the respective industrial value-added (IVA). The curves show the cumulative percentage of each sector, on a decreasing scale of individual contribution by municipality. The spatial concentration of these sectors has a clear hierarchy: manufacture of non-durable consumer goods is the least concentrated and the degree of concentration increases as one moves to the sectors of intermediate goods, capital goods and durable consumer goods and the extraction industry. The concentration of the extraction industry is basically explained by the heterogeneity and localized distribution of natural

[1] There is a vast literature discussing regional disparities, industrial restructuring and localization. Recent writing on these topics includes Azzoni & Ferreira (1999), Diniz (1994, 1996, 2000), Lemos et al (2003), Lemos et al (2005-a), and Pacheco (1999).

[2] In this text "firm" stands for "local production unit". A company may have several productions units, but the existence of local production units is what matters for this spatial analysis.

resources within the territory. Comparatively, the 150 major municipalities in the extraction industry account for 97% of its IVA, while this indicator is only 70% for the sector of non-durable consumer goods.

Chart 1: Concentration per Municipality (Sectoral IVA)

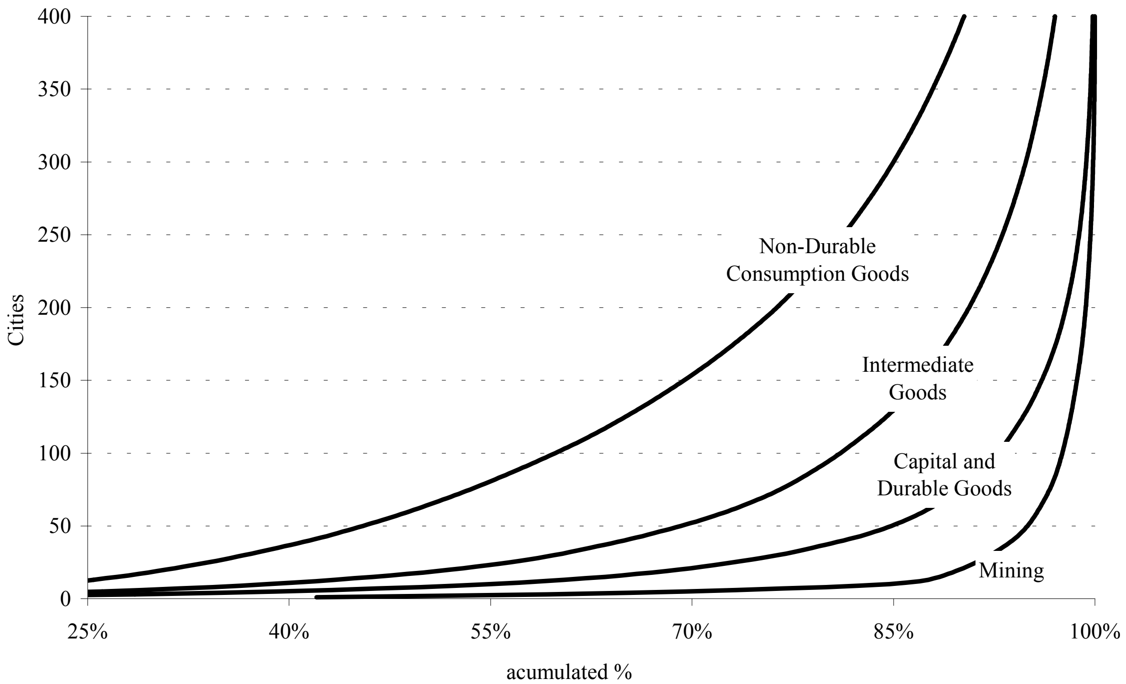


Chart 2: Concentration per Municipality – Industrial Foreign Trade and Local Indicators

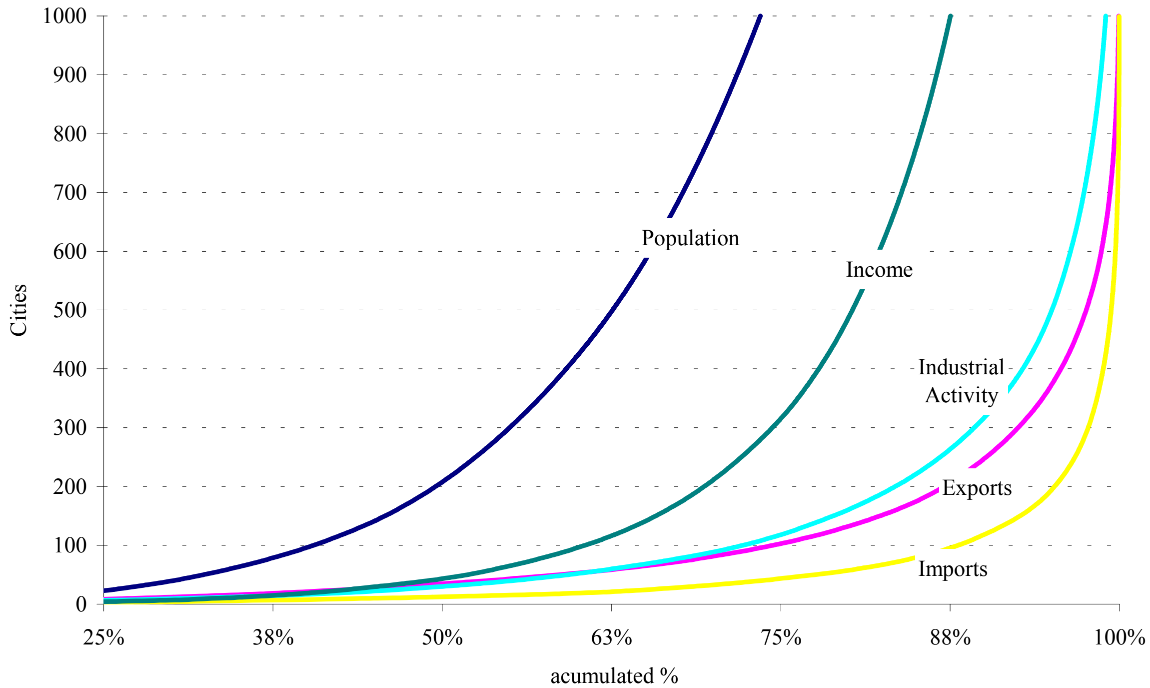


Chart 2 shows municipality-based concentration curves for industrial foreign trade (exports and imports) for a set of 1000 major municipalities covered by each indicator, and compares them to the concentration of population and the concentration of industrial activity based on the IVA. Distribution of exports is quite similar to IVA distribution and both are more concentrated than distribution of population. Distribution of imports per municipality is even more concentrated: 99% of all imports are concentrated in the 400 municipalities ranked as top industrial importers.

Table 1 shows some figures about regional distribution of industrial activities that are indicative of international insertion and concentration. IVA concentration is remarkable in the Southeast Region, especially in the State of São Paulo. The flows of industrial foreign trade are even more concentrated in these areas: the State of São Paulo receives more than 50% of all imports. The table also shows three industrial location quotients, based on a classification that reflects the innovative capability and competitiveness of each industry: firms which innovate, differentiate products, and are price makers(A), firms that specialize in standardized products and are price takers (B), firms that do not differentiate products, do not export, are price takers (C). In Brazil, 26% of all industrial value-added is generated by firms type A, 66% type B and approximately 8% type C.[3]

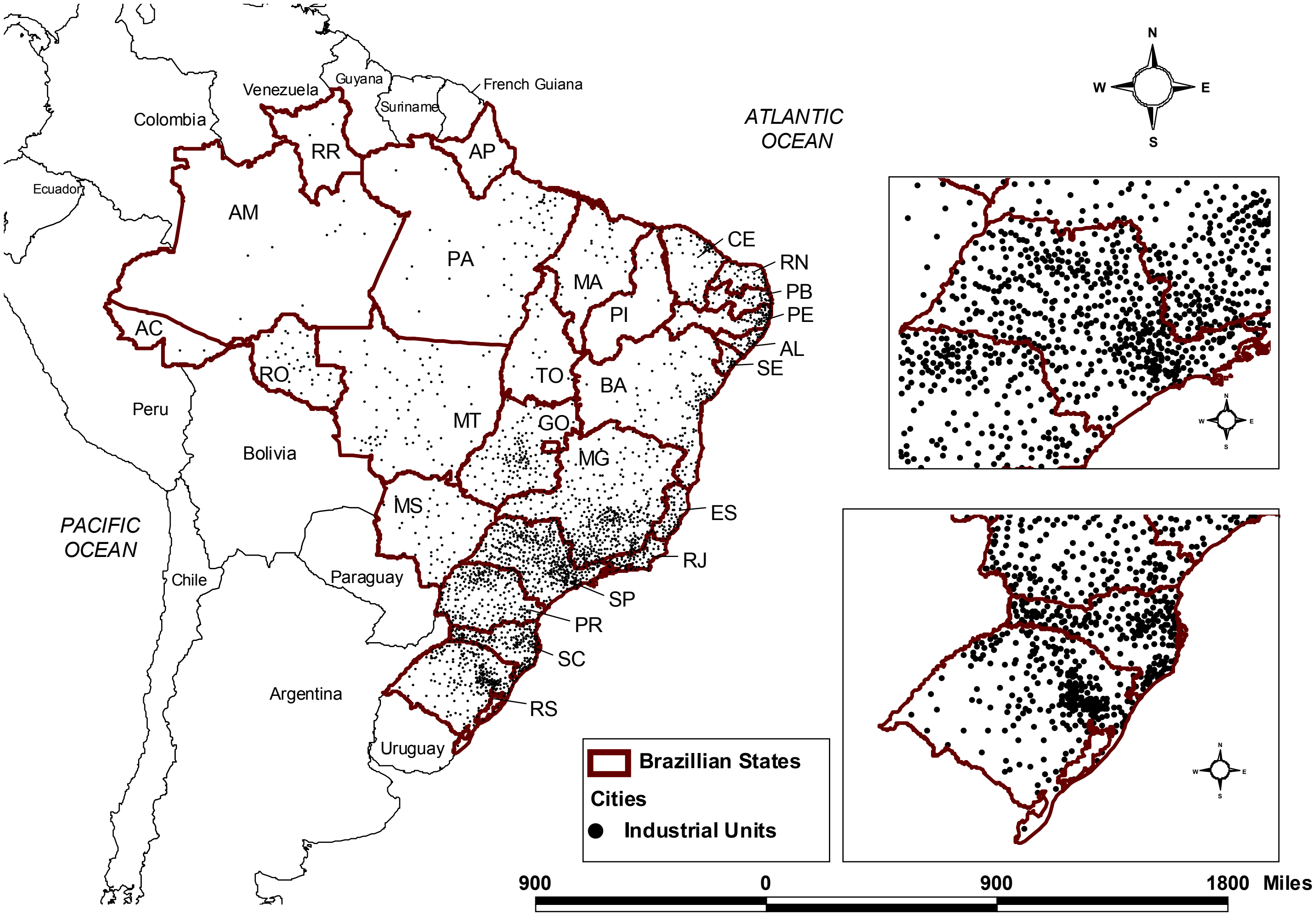
The location quotients show regional concentration vis-à-vis the national average concentration. The data show that the Southeast Region and the State of São Paulo are the areas with the largest concentration of innovative companies (A), while type B and C companies prevail in the remainder of the country. The coefficient of locational differentiation suggests that within each state and region the distribution of industrial activity is heterogeneous. For instance, in the State of São Paulo industrial spaces have a per capita income 68% higher than its non-industrial spaces, while in the Northeastern Region this difference reaches 115%. Figure 1 shows the locations of municipalities with industrial activity, highlighting industrial agglomerations in the State of São Paulo and in the South Region of Brazil. The following section will attempt to map the main industrial agglomerations in Brazil, based on the IVA and using the municipalities as an observation unit.

[3] It must be stressed that the industrial databases used in this research understimate the importance of firms C in Brazilian industry. The databases have information only about those companies with more than 20 workers, thus small firms that respond for a significant share of industrial production are not included in the research. Thus, the reader should consider the behavior of firm C as a proxy of local industrial production that do not reach international markets, are intensive in non-qualified labor, and supply just regional markets.

Table 1. Spatial Indicators - Industry (Brazil, 2000)

State/Macro-Region	IVA (% share)	Exports (% share)	Imports (% share)	QLA	QLB	QLC	Differential Locational Coefficient [a]
Acre (AC)	0.005	0.000	0.000	-	0.08	12.65	1.73
Amapa (AP)	0.022	0.006	0.002	-	1.13	3.30	1.02
Amazonas (AM)	3.405	2.351	8.117	1.44	0.91	0.26	2.90
Para (PA)	1.300	4.072	0.426	0.01	1.37	1.14	1.90
Rondonia (RO)	0.079	0.089	0.005	0.12	0.89	5.01	1.19
Roraima (RR)	0.002	0.001	0.000	-	0.40	9.78	1.45
NORTH	**4.812**	**6.519**	**8.550**	**1.02**	**1.04**	**0.60**	
Alagoas (AL)	0.588	0.260	0.161	0.05	1.18	2.66	2.71
Bahia (BA)	4.100	3.206	4.432	0.45	1.26	0.61	2.47
Ceara (CE)	1.293	0.732	1.066	0.21	1.26	1.38	2.61
Maranhao (AC)	0.351	0.256	0.140	0.07	1.22	2.24	2.53
Piaui (PI)	0.067	0.054	0.029	0.01	0.88	5.46	2.54
Rio Grande do Norte (RN)	0.611	0.248	0.515	0.02	1.34	1.40	2.46
ParaIba (PB)	0.341	0.144	0.195	0.30	1.11	2.46	2.60
Sergipe (SE)	0.401	0.205	0.363	0.01	1.25	2.19	2.53
Pernambuco (PE)	1.143	0.371	0.798	0.24	1.10	2.70	2.13
NORTHEAST	**8.895**	**5.475**	**7.700**	**0.29**	**1.23**	**1.43**	
Distrito Federal (DF)	0.237	0.004	0.051	0.15	1.04	3.56	-
Tocantins (TO)	0.018	0.003	0.000	-	1.03	4.15	1.86
Mato Grosso (AC)	0.443	0.347	0.042	0.26	1.14	2.27	1.41
Mato Grosso do Sul (MS)	0.303	0.263	0.093	0.03	1.30	1.72	1.44
Goias (GO)	1.085	0.911	0.424	0.71	0.91	2.76	1.66
CENTER-SOUTH	**2.086**	**1.528**	**0.610**	**0.45**	**1.03**	**2.61**	
Espirito Santo (ES)	1.969	5.089	0.734	0.10	1.33	1.18	1.35
Minas Gerais (MG)	9.599	11.738	6.676	0.74	1.05	1.40	1.88
Rio de Janeiro (RJ)	9.668	4.032	9.951	0.65	1.16	0.81	1.78
Sao Paulo (SP)	44.739	46.909	51.689	1.37	0.88	0.81	1.68
SOUTHEAST	**65.974**	**67.769**	**69.050**	**1.14**	**0.96**	**0.91**	
Parana (PR)	6.040	5.850	6.200	1.09	0.95	1.13	1.77
Rio Grande do Sul (RS)	7.984	8.721	6.349	0.72	1.11	0.97	1.66
Santa Catarina (SC)	4.210	4.138	1.541	1.03	0.98	1.07	1.41
SOUTH	**18.233**	**18.709**	**14.090**	**0.91**	**1.03**	**1.05**	
BRAZIL	**100.00**	0.000		25.93 [b]	66.56 [b]	7.51	2.60

Figure 1: Industrial Activity in Brazil (2000)



3. INDUSTRIAL AGGLOMERATIONS IN BRAZIL

The estimate of the correlation of the IVA of the municipality *j* in relation to the average IVA of its *m-1* neighbors, in a given set of *m* contiguous municipalities, allows the identification of industrial agglomerations in Brazil, without necessarily taking into account its political/administrative division.

The incidence of these agglomerations depends first on the statistical significance of the spatial autocorrelation test (set at 10%), as it may limit the number of agglomerations within the territory and exclude existing agglomerations that are not statistically significant. For this reason, we will name the existing significant agglomerations as "Spatial Industrial Agglomerations" (SIA), which will be more restricted than those industrial agglomerations identified in other studies in Brazil, such as that by Diniz & Crocco (1996).

The definition of SIAs in this study thus has a restricted meaning, since it incorporates only the municipalities with an industrial production which is statistically correlated to the average of their neighbors. The distribution of the municipalities pursuant to the IVA in the Spatial Analysis divides them into four types:

(a) Municipalities with high IVA and high positive correlation with neighbors (*High-High*);

(b) Municipalities with high IVA and high negative correlation with neighbors (*High-Low*);

(c) Municipalities with low IVA and high positive correlation with neighbors (*Low-Low*);

(d) Municipalities with low IVA and high negative correlation with neighbors (*Low-High*).

From the standpoint of SIA identification, type 1 (HH) is the relevant one, for it expresses the spatial correlation of two or more municipalities with a high industrial production, suggesting the existing of spatial spillovers and production effects, through complementarities and regional industrial integration.

Type 2 (HL) reveals, in turn, the existence of a localized industrial production in a single municipality, which may be integrated upstream and downstream with the local non-industrial production base, especially in the area of agriculture and specialized services, which presupposes a region with a dense urban network. This agglomeration may also be an "industrial island" with a subsistence area surrounding it, like an urban/industrial enclave. The first case shall be called a Localized Industrial Agglomeration (LIA) and the second an Industrial Enclave (IE).

As to type 3 (*LL*), it is mainly relevant in the identification of the areas and regions excluded from industrial activity, which would be an indication of the effects of the geographic restrictions to the industrial spatial spillover. In other words, there is also a significant spatial correlation among municipalities where no minimum scale of industrial activity is found. This type may also indicate, yet marginally, the existence of municipalities with some but not statistically significant industrial production. This is because the correlation among neighbor non-industrial municipalities (LL) prevailed in the significance test over the correlation between the high value of the reference municipality and the low average value of its neighbors (HL). In this case, this municipality was defined as an Industrial Enclave (IE) after reaching a minimum level of industrial production.

And finally, type 4 (*LH*) may reveal two distinct phenomena. The first refers to the geographical limits of the industrial agglomerations, indicating the restrictive and excluding nature of the reproduction of industrial activity in the space. The second reveals a phenomenon similar to type 2 (HL), i.e., the existence of localized industrial production in a single municipality, which does not reach the expected level of significance (H) but, on the other hand, lends significance to the downstream IVA neighbor (L). In this case, it will be classified as an Industrial Enclave (IE) and, possibly, as a Localized Industrial Agglomeration (LIA) if neighbor non-industrial municipalities have a high per capita income, close to the level of the industrial municipality. [4]

Figure 2 shows the industrial concentration of companies per municipality, with a higher occurrence of SIAS in the South and Southeast regions (High-High). Generally, Low-High classification applies to areas surrounding HH agglomerations, but also in some isolate points. A High-Low classification denotes industrial enclaves or localized industrial agglomerations.

As shown in Table 2, there are only 15 SIAs, in a restricted group of 254 out of 5,507 Brazilian municipalities, accounting for 75% of the industrial production of the companies operating in the country. In addition, more than 90% of the production in these agglomerations is from type A and B companies, which suggests the existence of barriers preventing C type companies entering such spatial agglomerations. The spatial distribution of SIAs is notably concentrated in Brazil, particularly in clearly delimited industrial corridors across the South and Southeast regions (Figure 2). The Northeast Region has SIAs that are confined within metropolitan areas of major state capitals and no SIA was identified in the North Region, despite the significant contribution of Manaus Free-Trade Zone to the national industrial production. In turn, the absence of SIAs in the Central region reveals that intense agribusiness expansion over the last two decades has not been sufficient to build industrial density needed to produce spillover and industrial effects over the space.

In addition to the criteria already defined for the identification of local agglomerations (LIAs) and industrial enclaves (IEs), based on the Spatial Analysis' types 2 (*HL*), 3 (*LL*) and 4 (*LH*), we have

[4] See Lemos et al (2005-a and 2005-b) for more details on the classification of agglomerations and enclaves.

defined some additional methodological procedures necessary for the identification and subsequent classification of the localized industrial activities.

The first refers to the minimum scale of industrial agglomeration, since the potential of spatial effects of spillover and production complementarity only occurs after a certain critical level of production. The reference value was set at R$ 100 million of industrial value-added, which equates to the average industrial production value of 2,253 municipalities where industrial companies are located.

The second refers to the differentiation between LIA and IE. The basic difference lies between a region with a dense urban network, integrated upstream and downstream with the local non-industrial production base, mainly agriculture and services, and an industry-based locality with a surrounding area of subsistence.

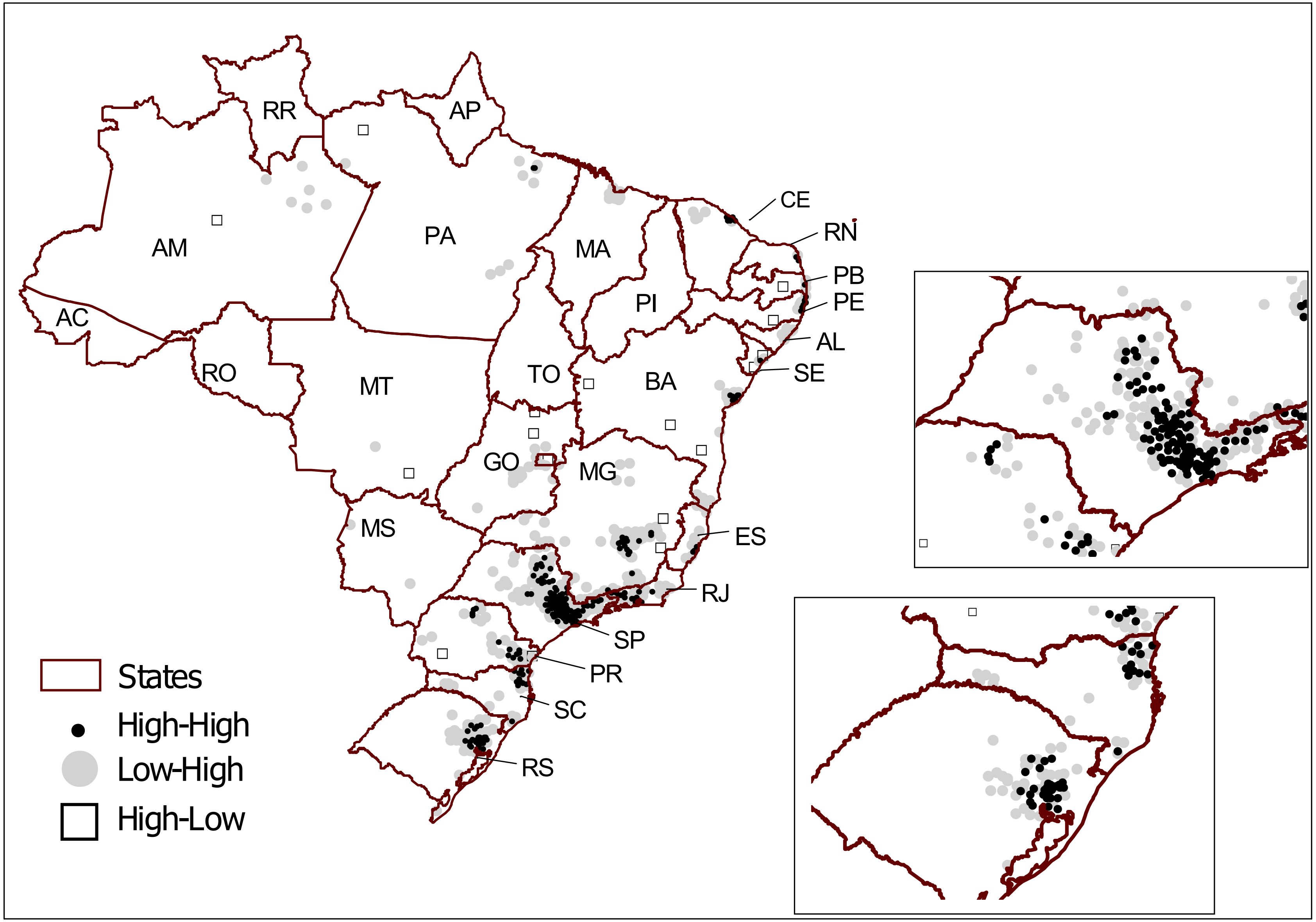
Table 2

Table 2: Industrial Clustering, Brazil (2000)

REGION	Number		Value-Added	
	AIE	Cities	Value (R$ millions)	Share (1)
South	5	66	30.649	0,13
Ceter-South	0	0	0	0,00
Northeast	4	25	13.080	0,06
North	0	0	0	0,00
Sao Paulo (SP)	1	120	97.799	0,42
Southeast	5	43	34.757	0,15
Brazil	15	254	176.285	0,75

(1) % Total Share in Brazil.

Figure 2: Spatial Concentration – Industrial Value-Added (Brazil, 2000)



Two criteria were used to clearly differentiate municipalities with localized industrial activity: the average per capita income level of their neighbors and the ratio (the standard deviation divided by the average value) by which per capita income varies between the reference municipality and its neighbors' average. Industrial localities whose neighbors have an average per capita income higher than the national average and a variance coefficient (CV) below 0.5 were classified as Local Industrial Agglomerations (LIAs). And those having neighbors with an average per capita income below the national average and a CV of 0.5 or over were classified as Industrial Enclaves (IEs). An additional criterion differentiated a Concentrated Income Enclave (IE-CI), with the industrial municipality having a high per capita income and its neighbors a low per capita income, from a Low Income Enclave (IE-LI), where both the industrial municipality and its neighbors have a low per capita income.

The consolidated results are shown in Table 3. For the entire national territory, 23 municipalities were identified as local industrial agglomerations, accounting for 9% of the industrial product of industrial organizations in Brazil. The distribution of municipalities based on the type of local industrial agglomeration includes 5 LIAs, 8 IE-LIs and 10 IE-CIs.

Table 3: Local Industrial Agglomerations (LIAs) and Industrial Enclaves (IEs)

	Cities	Value-Added	
		Value (R$ millions)	Share (1)
Local Industrial Agglomerations	5	7.064	0,03
Industrial Enclaves – Low Income	8	3.070	0,01
Industrial Enclaves – Concentrated Income	10	11.242	0,05
Total	23	21.377	0,09

(1) % Total Share in Brazil.

Table 4: Local Industrial Agglomerations (LIAs) and Industrial Enclaves (IEs) - Spatial Distribution

City	Value-Added			
	Value (1)	Share (2)	A (3)	B (3)
Local Industrial Agglomerations (LIAs)				
Chapecó (SC)	486	0,07	0,51	0,47
Cuiabá (MT)	220	0,03	0,00	0,80
Juiz de Fora (MG)	697	0,10	0,39	0,51
Macaé (RJ)	5.043	0,71	0,00	0,99
Uberlândia (MG)	619	0,09	0,49	0,39
LIA Total	7.064	1,00	0,12	0,85
Industrial Enclaves – Low Income (IE-LI)				
Belém (PA)	343	0,11	0,01	0,79
Coari (AM)	270	0,09	0,00	1,00
Dourados (MS)	180	0,06	0,00	0,97
Niquelândia-Minaçu (GO)	271	0,09	0,00	1,00
Mucuri (BA)	600	0,20	0,00	1,00
Oriximiná (PA)	277	0,09	0,00	1,00
Marabá-Parauapebas (PA)	1.018	0,33	0,00	0,99
Pelotas (RS)	110	0,04	0,16	0,53
IE-LI Total	3.070	1,00	0,01	0,95
Industrial Enclaves – Concentrated Income (IE-CI)				
Aracaju (SE)	495	0,04	0,00	0,90
Barreiras (BA)	116	0,01	0,03	0,87
Brasília (DF)	558	0,05	0,04	0,69
Goiânia (GO)	525	0,05	0,53	0,22
Gov. Valadares (MG)	111	0,01	0,01	0,66
Maceió (AL)	413	0,04	0,04	0,77
Manaus (AM)	7.691	0,68	0,38	0,60
Montes Claros (MG)	416	0,04	0,13	0,80
São Luís (MA)	614	0,05	0,02	0,89
Sobral (CE)	304	0,03	0,00	0,98
IE-CI Total	11.242	1,00	0,30	0,64

(1) R$ millions

(2) Group share.

(3) City share.

In short, tables 2 and 3 show that 84% of the industrial value-added is concentrated in some type of industrial cluster, 75% is in spatial agglomerations (SIAs), 3% in local agglomerations (LIAs), and 6% in enclaves (IEs). The remaining 16% is geographically dispersed.

Table 4 lists the industrial agglomerations and enclaves identified. Of five local industrial agglomerations, the only large-sized one is Macaé (RJ), which has also built industrial density because of the high IVA of type A companies. Macaé is the hub of Petrobrás' oil extraction operations in Rio de

Janeiro. Its major drawback is the lack of integration with surrounding areas because of difficulties in different sectors hindering production complementarity at a regional level.

Cuiabá (MT) is the only state capital classified as an LIA, with a relatively low industrial product level related to agribusiness industries. The strong agricultural base in the surrounding areas is an indication of potential dynamism and production complementarity between manufacture and agriculture. Other LIAs include municipalities that also have a strong agribusiness base: Chapecó (SC) and Uberlândia (MG) which, as well as a dynamic agribusiness industry in their surrounding areas, are home to type A companies that account for approximately 50% of each agglomeration's industrial product.

A more complex case is Juiz de Fora's LIA in the State of Minas Gerais. Besides having a relatively small industrial base and showing the prevalence of type B companies, it has achieved no production specialization, which is an obstacle to drawing on potentials found in nearby areas.

The ten concentrated income enclaves (EI-CI) are most significant, since they account for 5% of Brazil's industrial product. However, they make up a heterogeneous set of agglomerations, including the Federal District and five state capitals: Aracaju, Goiânia, Maceió, Manaus and São Luís. Manaus industrial agglomeration stands out as it has a product similar to that of major metropolitan agglomerations, such as Curitiba and Salvador, and is home to companies of an importance comparable to those found in agglomerations in the South region and in the State of São Paulo.

The remaining four agglomerations are located in medium-sized cities, some in areas of subsistence farming, having little chance of promoting regional production integration, such as Montes Claros (MG), Governador Valadares (MG) and Sobral (CE). Barreiras (BA), which is the hub of a region experiencing expansion of modern agribusiness, has good chance of achieving agro-industrial integration with surrounding areas.

The set of low-income industrial enclaves (IE-LI) is also heterogeneous, but with the difference that it holds a small share in the industrial product, of only 1%. Type B companies comprise it predominantly, with the exception of Dourados Enclave which, in turn, ranks lowest in industrial product among the eight enclaves identified. Worth noting is the relatively minor role of Belém agglomeration and the outstanding participation of two mineral extraction agglomerates in Niquelândia (GO) and Marabá (PA), where Carajás Mineral Complex is situated.

In the next section, spatial econometric models will be estimated in order to capture the relationship between the industrial agglomerations and the basic characteristics of the economic space, characterized by certain indicators.

4. SPATIAL STRUCTURES OF REGIONAL INDUSTRIAL AGGLOMERATIONS

4.1. SPATIAL ECONOMETRIC MODELS

The industrial variables in table 5 were constructed through the municipality-based aggregation of data of local industrial units. A statistical model of imputation was developed to classify the companies which are in two different data bases: PIA (Industrial Research by Sampling) and PINTEC (Technological Innovation - Industrial Research), both IBGE industrial data bases. The classification of the local units pursuant to innovation criteria defined by PINTEC followed the classification given to the company: firms which innovate, differentiate products, are price markers, and export (type A), firms that specialize in standardized products, are price takers, and that export (type B), firms which do not differentiate products, are price takers, have lower productivity and do not export (type C). The location quotients (QLA, QLB and QLC) for each of these categories were calculated based on the IVA for each type. A municipality's sector-based industrial structure is captured by variables that indicate sector shares in the total IVA of that municipality. So BI denotes the participation of the intermediate goods industry in the local IVA, BCD is the indicator for capital goods and durable consumer goods, BCND for non-durable consumer goods and EXTRA for the extraction industry.[5]

The socio-economic variables listed in Table 5 are defined for each of the 5,507 Brazilian municipalities, based on information available from different sources. Selected variables capture some aspects of Brazil's economic space structure, such as upper schooling levels (E25), serving to measure educational qualifications across the municipality's labor force; population (POP), a measure of the scale of the local economy and/or market; percentage of the local population provided with sewage connection to the sanitary system (ESGT), a measure of urban infrastructure availability; and the classification of the municipality compared to certain metropolitan areas (NRM)[6]. Transportation cost variables are determined by applying a linear programming procedure to calculate the lowest cost incurred to travel from the center of a given municipality to the city of São Paulo and to the nearest state capital (CTRPSP and CTRPCAP, respectively).[7]

[5] The sum of these four variables for a given municipality is equal to 1, so that only three of them should be used in the regressions (the one excluded is reflected in the constant).

[6] The modeling effort covered 5179 non-metropolitan and 328 metropolitan municipalities, distributed among 13 metropolitan areas: Belém, Teresina, Fortaleza, Maceió, Natal, Recife, Salvador, São Luís, Goiânia, Brasília, Vitória, Belo Horizonte, Rio de Janeiro, São Paulo, Campinas, Santos, Curitiba, Florianópolis and Porto Alegre.

[7] Highway transportation costs are estimated as a function of the distance and cost of the paving type of federal and state highways (see Castro *et al.,* 1999).

Table 5: Variables

Variable/Description		Source
IVA	Industrial Value-Added (R$ millions)	PIA 2000
EXP	Industrial Exports (R$ millions)	SECEX
IMP	Industrial Imports (R$ millions)	SECEX
BI	Intermediate share in total IVA	PIA 2000
BCD	Capital and durable goods share in total IVA	PIA 2000
BCND	Non-durable consumption share in total IVA	PIA 2000
EXTRA	Mining share in total industrial activity	PIA 2000
QLA	Location Quotient, type A manufacture [a]	PIA - PINTEC (2000)
QLB	Location Quotient, type B manufacture [b]	PIA - PINTEC (2000)
QLC	Location Quotient, type C manufacture [c]	PIA - PINTEC (2000)
ESGT	Sewage Connection to the sanitary system (% houses)	Atlas do Desenvolvimento Humano
E25	Upper Schooling (share of population above 25 years-old with 12 or more years of education)	Atlas do Desenvolvimento Humano
POP	Population	SIM BRASIL
CTRPSP	Transport cost to the city of Sao Paulo	IPEADATA
CTRPCAP	Transport cost to state capital	IPEADATA
NRM	Non-Metropolitan *Dummy*	IBGE

[a] Type A: firms which innovate, differentiate products and export.
[b] Type B: firms that specialize in standardized products and that export.
[c] Type C: firms which do not differentiate products, have lower productivity and do not export.

The spatial econometric models allow distinguish two types of spatial correlation, which result in multiplier effects both locally and globally. Global effects are recorded using SAR (spatial autoregressive) models and local effects using SMA (spatial moving average) models.

The two SAR models most commonly used in spatial econometrics are the spatial autoregressive error and the spatial lag models. Global spatial dependence in error terms is taken into account using spatial autoregressive error terms, as follows:

$$Y = X\beta + \varepsilon \quad (1)$$

$$\varepsilon = \lambda W\varepsilon + u \quad (2)$$

$$Y = X\beta + (I-\lambda W)^{-1} u \quad (3)$$

Where ε is the autocorrelated error term and *u* é is an i.i.d. error term. The spatial error model is suitable when the variables that are not included in the model but are present in the error terms are spatially autocorrelated. The spatial lag model is specified as follows:

$$Y = \rho Wy + X\beta + \varepsilon \quad (4)$$

Where W is the spatial weights matrix; X is the matrix of independent variables; β is the vector of coefficients of independent variables; ρ is the autoregressive spatial coefficient and ε is the error term. Adding Wy as an explanatory variable to model 4 means that the values of variable y in the locality i are related to the values of this variable in neighboring localities. This model's estimation method must take into account the endogenous nature of variable Wy (Anselin, 1999). Its reduced form gives a more precise interpretation of model 4:

$$Y = (I - \rho W)^{-1} X\beta + (I - \rho W)^{-1} \varepsilon \tag{5}$$

The expansion $(I - \rho W)^{-1}$ includes both the explanatory variables and the error terms. So the economic interpretation of the causality relationship $yj \rightarrow yi$ may be considered as being the result of a process involving global spatial correlation in the explanatory variables and error terms. This implies that shocks in a given locality will affect all other localities through a global multiplier effect, associated to both the explanatory variables and the ones that were not considered into it but are present in the error terms.

In addition to the two models specified above, another model was used when so required by the tests: SARSAR (or SARMA), which is a combination of the two previous models (error and spatial lag models).[8]

The models were estimated using *SpaceStat* 1.80 (Anselin, 2001). The methods available for estimating the spatial lag model are the maximum likelihood (ML) and instrumental variables - IV (2SLS, Robust and *Bootstrap*). IV-Robust and IV-Bootstrap estimates are alternatives to 2SLS in the case of nonnormality of residuals and heteroscedasticity. Both GMM estimation alternatives are robust for nonnormality of errors.

Once the analysis of residuals for all models had produced strong evidence of nonnormality, spatial error models were estimated using the 2-stage GM method, and spatial lag models using the VI-Robust method. In regard to the SARSAR/SARMA model, Kelejian & Prucha IV-Generalized procedure was used (1998).[9]

For this paper, the model estimation procedure comprised the following stages: (a) typical OLS estimations; (b) use of specification tests to detect spatial patterns in OLS residuals; (c) model re-estimation following more suitable specifications as shown by specification tests; (d) confirmatory test for the final specification.

[8] In practice, none of the specification tests based on MQO residuals is able to distinguish between an AR and a MA spatial error, since these are considered to be locally equivalent alternatives (Anselin, 1999).
[9] Jarque-Bera test results to be seen in all OLS-estimated equations.

4.2. Industrial Spatial Structures

The first estimated model (Table 6) identifies the explanatory variables that are relevant to major industrial agglomerations. These agglomerations are measured based on the IVA of each municipality. Significant variables in explaining such agglomerations were: QLA, QLC, POP, BI, BCD, BCND and CTSPM. In addition, the spatial lag model was found to be the most adequate in the specification tests.

The positive and significant value of the coefficient of the lagged dependent variable (W_IVA) is no reason to rule out the hypothesis of a global spatial autocorrelation in the explanatory variables and error terms[10]. This implies that changes (shocks) associated to both the variables that have been added and those that have not been added to the model will produce effects causing a municipality's features to spill over into its neighbors. These effects are most noticeable to the closest neighbors, becoming increasingly less noticeable as one moves away from their source.

It is no surprise that the resident population of the municipality (POP) and its surrounding area proves to be the most statistically significant variable in explaining the local industrial agglomeration level. This is a proxy variable of the urban scale that is usually found in literature. It confirms the significance of diversification or Jacobian external economies, stemming from the urban scale, in attracting and agglomerating industrial activities (Pred, 1966; Jacobs, 1969; Glaeser et al, 1992). Upper schooling (E25) and infrastructure (ESGT) variables were not significant, and the same is true for the dummy variable for non-metropolitan municipalities.

Sectoral variables BI, BCD and BDND capture the influence of the municipality's sectoral structure on industrial concentration as measured by the IVA. Results indicate that the municipalities with larger presence of companies producing capital and durable goods have a larger IVA, while municipalities with prevalence of manufacturers of non-durable consumer goods have a smaller IVA. This relationship was somehow expected: major value-added industrial agglomerations are comprised of world competitive companies that are capable of differentiating themselves technologically and involve directly or indirectly manufacturers of capital and durable goods (A type companies); these are "polarizing" companies. The opposite is usually true for non-durable consumer goods industries: companies are not very competitive and use established technologies. Such companies will not give rise to industrial agglomerations and, as a matter of fact, they tend to be located outside of these agglomerations.

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[10] The spatial weight matrix used in this study is a contiguity matrix for the 5,507 municipalities, built using *ArcView* 3.2, pursuant to *Queen* criteria. A matrix was built for the distances between the seats of the various municipalities, but it was not possible to use it with the models because of the computer's storage capacity and the file's size (1.2GB).

The cost of transportation to state capitals was not significant in explaining municipal IVA. This seemingly low ability to polarize industrial activity does not mean that such regional centers have no influence on how their economic spaces are organized, but it does mean that being close to a state capital is not enough to play a determinant role in this process when compared to other factors.

As to the cost of transportation to Brazil's largest economic center (CTRPSP), São Paulo, this factor proved to have a strong influence on the scale of industrial activity. The closer one gets to São Paulo city, the smaller the transportation cost and the higher the industrial concentration will be; in other words, the higher the income generated by the industrial sector will be. As regards the organization of the industrial space, this relationship indicates that the area surrounding the São Paulo metropolitan area tends to be most preferred by industrial companies; a classic result of traditional gravitational models applied to regional economics (Isard, 1956; Fujita et al, 1999)[11].

Of the location quotients (QL), the only one that did not prove to be a determinant of spatial concentrations was the one for type B companies (despite being positive – an expected sign – the location quotient for type B companies is not statistically significant). At the outset, this result may seem counterintuitive. Type B companies are large size businesses, usually competitive and selling to foreign markets. However, these type B companies were expected to have more influence on the scale of activity locally. As to type A companies, results were what had been expected. These companies have positive and statistically significant location quotients. In general, type A companies are at least as large as type B companies, but they are even more competitive and capable of adding value to industrial activity, which can be partly explained by their technological capabilities.

[11] This concentration of industrial activity around the city of de São Paulo was identified in a previous article and named São Paulo's Prime Industrial Agglomeration.

Table 6: Industrial Agglomerations (IVA , lag model)

Independent Variables	OLS	SAR
W_VTI		0.11 ***
Constant	31.25 *	-11.06 NS
QLA	10.05 ***	9.19 ***
QLB	10.07 NS	10.37 NS
QLC	-17.48 **	-15.38 **
E25	-1.27 NS	2.15 NS
POP	1.58 ***	1.57 ***
ESGT	0.27 NS	0.25 NS
NRM	-35.73 ***	5.34 NS
BI	34.89 **	26.62 *
BCD	218.16 ***	182.19 ***
BCND	-27.21 *	-25.64 *
CTRPSP	-13.63 ***	-11.99 ***
CTRPCAP	7.59 NS	7.57 NS
R^2aj. / R^2buse	0.60	0.60
Jarque-Bera	45013097.7 ***	
Koenker-Basset	138.89 ***	
White	1414.96 ***	
Specification Tests		
Moran	71.7 ***	
LM (erro)	49.51 ***	
LM robusto (erro)	1.97 NS	
LM (lag)	135.26 ***	
LM robusto (lag)	87.72 ***	

*significant, 10%; **significant, 5%; ***significant, 1%

The composition of industrial agglomerations in terms of location quotient deserves more detailed comments, particularly the fact that the prevalence of type B companies (QLB) is not significant in explaining the emergence of industrial agglomerations. Firstly, the scale advantages that these companies may achieve are predominantly internal rather than external to the companies. Producers of intermediate inputs, in particular, do not really need to be present in urban areas and may be sited relatively isolated from large urban agglomerations, as is the case of integrated steel works. What they need is to be located near a nodal point of inter-regional exchanges to minimize transportation costs.

Secondly, studies of spatial autocorrelation have shown that there is a correlation between type A and type B companies. The agglomeration of type A companies seems to attract type B companies, but the opposite is not true. It is known that type B companies benefit from external savings resulting from downward linkages between type B suppliers and type A users of industrial inputs. On the other hand, the fact that the prevalence of type B companies is not a significant variable corroborates the evidence that the agglomeration of type B companies is not a factor attracting type A companies. And this will lead to a one-way rather than two-way relationship.

With respect to type C companies, the location quotient appears to be significant, but negatively correlated to the municipal IVA. Type C companies are small size business that are spatially scattered and are not exporters. Hence these companies should be expected to have a limited influence on the scale of municipal IVA. In fact, this is what has been observed: higher municipal IVA figures are associated to a smaller concentration of type C companies (negative QLC coefficient).

Such "exclusion" of type C companies from large industrial agglomerations may be related to the difficulties experienced by type C companies in sharing economic spaces with leading industrial companies (type A companies and, secondarily, type B companies). The high costs associated with urban agglomerations can only be supported by those companies that do add more value to their products (through product and/or process innovation) and this is not, by definition, the case of type C companies. However, in order to remain active, such companies tend to be located in smaller, more scattered industrial centers where costs are lower than in urban areas. To have access to major markets, these companies (or their customers) must bear the costs of transportation. Exceptionally, type C companies are found present in major agglomerations, occupying interstices of the metropolitan space and offering products of low unit price and high transportation cost, including some standardized food products.[12]

4.3. International Insertion – Export and Import

International trade of major industrial agglomerations is highlighted in Tables 7 and 8. To analyze this aspect, we considered the total exports and imports of each municipality as a synthetic measure of competitiveness of the industrial agglomerations.

In Brazil, imports and exports diverge in terms of technological content, sectoral structure and competitiveness. The same tends to apply to how industrial space is organized (Haddad & Azzoni, 1999). The estimated model in Table 7 looks into some of these features. In this case, the dependent variable is the total industrial export per municipality.

[12] Lemos et al (2005-b) present a more detailed studies on the determinants of the location of firms A, B and C and their spatial interactions. Lemos et al (2005-c) presents another and similar study that stresses the locational differences between domestic and foreigner firms.

Table 7: Exports (Model: IV 2SLSs)

Independent variables	OLS	SAR
W_EXP		0.04 *
Constant	-2.38 NS	-5.72 NS
QLA	1.27 NS	1.16 NS
QLB	0.98 NS	0.89 NS
QLC	-5.74 *	-5.61 *
E25	1.64 ***	1.55 **
POP	0.24 ***	0.24 ***
ESGT	-0.02 NS	-0.02 NS
NRM	-0.57 NS	2.41 NS
BCD	62.61 ***	59.79 ***
BI	6.41 NS	5.88 NS
BCND	2.27 NS	2.34 NS
CTSPM	0.00 NS	-0.67 NS
CTCAPM	0.00 NS	0.04 NS
R_POS1	793.21 ***	791.53 ***
R_NEG1	-340.50 ***	-336.29 ***
R^2aj. / R^2buse	0.49	0.49
Jarque-Bera	2499383055 ***	
Koenker-Basset	166.96 ***	
Specification Tests		
Moran	1.63 ***	
LM (erro)	2.28 NS	0.11 NS
LM robusto (erro)	0.09 NS	
LM (lag)	3.45 **	
LM robusto (lag)	1.25 NS	

*significant, 10%; **significant, 5%; ***significant, 1%

The specification tests have shown that the spatial lag model is the most appropriate[13]. As anticipated, the location quotient variable (QL) indicates that industrial exports are negatively correlated with type C agglomerations. By definition, type C are not exporting companies and therefore their presence is small in environments where exports are higher. From the viewpoint of industrial and regional policies, this is an important aspect, since large municipality-based concentrations of type C companies do not share the same economic spaces with agglomerations of exporting companies into which all type A and most type B companies fit. Such spatial "segregation" limits the spillover effects, captured by the statistically significant spatial lag variable, which could help in the competitive catching-up of type C companies.

[13] Variables R_POS1 and R_NEG1 are dummies built from OLS residuals, intended to capture outliers that might affect model estimations.

Table 8: Imports (SAR error model – GM estimation)

Independent variables	OLS		SARMA	
W_IMP			0.15	***
Constant	18.43	NS	-6.24	NS
QLA	3.68	***	3.36	***
QLB	-1.52	NS	-1.11	NS
QLC	-12.05	***	-10.97	***
E25	0.08	NS	-0.29	NS
POP	0.48	***	0.48	***
ESGT	0.06	NS	0.05	NS
NRM	-22.04	**	1.93	NS
BCD	147.80	NS	133.86	***
BI	21.16	***	17.59	***
EXTRA	16.20	NS	16.85	NS
CTSPM	-2.14	NS	-1.48	NS
CTCAPM	-0.51	NS	-0.68	NS
Lambda			-0.04	***
R^2aj. / R^2buse	0.30		0.31	
jarque-Bera	359717227	***		
Koenker-Basset	57.05	***		
Specification Tests				
Moran	3.83	***		
LM (erro)	13.74	***		
LM robusto (erro)	4.31	**		
LM (lag)	47.00	***		
LM robusto (lag)	37.56	***		

*significant, 10%; **significant, 5%; ***significant, 1%

The results also show that municipal exporting areas are explained by the size of their municipalities (a positive coefficient for the population variable) and also by the qualification of their labor force (a positive coefficient for E25). Another significant variable for the volume of municipal exports is the concentration of capital and durable consumer goods sectors. On the other hand, given Brazil's trend toward exporting industrial commodities, the intermediate goods sector was expected to make a positive and significant contribution. However, a substantial portion of these sectors is geared to the domestic market and intensive in natural resources, particularly the chemical, metal and non-metal industries, which could explain the lack of statistical significance.

The specification tests have shown that the SARSAR (or SARMA) model is the most appropriate for industrial exports and have strongly indicated the non-inclusion of spatially autocorrelated variables in the import model, such as tradable commodities in which Brazil is not self-sufficient (e.g. oil). Importing areas are those with high concentration of type A and low concentration of type C companies, which seem to have a very low proclivity to import. As expected, the scale of the local market, measured based on its population, has a positive effect on industrial imports. With respect to the mix of the production structure, imports are higher where a concentration exists of durable consumer and capital goods (BCD) sectors. Concentrations of intermediate goods (BI) sectors have also a positive impact on imports, but to a smaller degree.

Before concluding this analysis, some remarks should be made. The estimated models point to strong spatial correlations that can be the result of spatial linkages related to a set of spatial spillover effects. For regional development policies, this model specification indicates the significance of centripetal forces present in industrial agglomerations and the difficulties that are faced by companies located far from consolidated industrial hubs. Such forces are probably more intense in the case of regional development policies that are focused on durable and capital goods industries, as these are positively related with the presence of diversified industrial agglomerations. Such difficulties would probably be less noticeable for non-durable consumer goods sectors.

Another noteworthy aspect is the absence in some cases of the effects measured by three indicators that reflect what are considered to be classic locational determinants, such as the extent of infrastructure (ESGT), the degree of upper schooling (E25) and the dummy NRM that captures non-metropolitan areas. The non-significance of these variables might be explained by the diversity of the industrial structure. To verify that such location determinants have no significance to industrial agglomerations, it would be advisable to separate these groups further into subgroups of companies, based either on their technological (A, B and C) or sectoral classification, and then make sure that they are really non-significant determinants.

5. Heterogeneous Spaces and Links of Industrial and Regional Policies

Based on the analysis of the industrial agglomerations as described above, one can illustrate potential conflicts and complementarities among the policies of industrial and regional development when implemented within very heterogeneous and fragmented economic spaces, as is the case in Brazil. Before dealing with these illustrations, it is necessary to summarize industry's spatial organization and highlight its main characteristics.

There are few spatial industrial agglomerations (SIAs) in the country, and their geographic distribution is limited to a few metropolitan areas and industrial hubs specialized in medium sized companies, concentrated in the South/Southeast. These SIAs concentrate 75% of the IVA , and practically all of the IVA of innovative, exporting and scale-intensive firms.

There are very few local industrial agglomerations (LIAs), and those that exist have little participation in the industrial product. This fact limits the positive effects they might have on production integration with non-industrial activities in their surroundings, especially agriculture, such as ripple effects downstream. The industrial enclaves (IE), on the other hand, are more numerous and have a more relevant participation in the industrial product (6%) – however, most of them have few material and financial resources to promote greater regional production integration, for the scope for the exploitation of the externalities of the geographic proximity is small.

Industrial concentrations have an excluding nature. Less competitive (type C) companies are "excluded" from more competitive economic spaces (prevalence of type A and B companies), which poses difficulties for local strategies aimed at catching up with regional levels, for more focused industrial demands, and for regional policies leading to the structuring of economic spaces of small urban density.

Due to the spatial fragmentation of industrial production, the lack of coordination among industrial and local development policies may create political and economic conflicts. Due to the spatial fragmentation of industrial production, the lack of coordination among industrial and local development policies may create political and economic conflicts. Both types of policies may have their efficiency mitigated and positive synergies be left untapped. For instance:

Industrial policies intrinsically place emphasis on increased production efficiency and competitiveness of companies, tending to focus on localities with greater positive externalities. A regional development policy would indicate in which localities these externalities would be present, that is to say, which SIAs would be most attractive for location of selected businesses (or industries).

On the other hand, if established SIAs experience strong diseconomies of agglomeration (depletion of natural resources, expensive land rent, transport and pollution costs), it would be wise to encourage investments in other agglomerations where such negative effects were not present. Again, articulating industrial and regional policies would be needed to minimize negative effects typical of an industrial mega-agglomeration. Which regions would be earmarked as potential investment recipients? These could include some of the industrial enclaves or even one of the local industrial agglomerations identified above.

A regional policy, in turn, must be aimed at a less unequal development within the country and prioritize regions deprived of the advantages of growing spatial returns, namely, peripheral regions. In order to develop such regions, regional development policies must create production and reproduction conditions locally in line with the objectives of the industrial policies.

In this respect, but in an opposite manner, the regional policy must select, from among the firms or industries given priority by the industrial policy, those that best suit regional particularities. As many have noticed, the location of firms (or even a group of firms) in some regions may spark strong negative reactions, including population displacement and environmental degradation, while failing to produce the spillover and ripple effects that are essential to sustainable regional development.

To what extent would it be possible to conciliate the objectives, instruments and social players involved in the public policies? The results of this study point to three lines of action which would correspond to the intersection points of industrial policy and regional policy for the Brazilian case. The first would be a policy of industrial promotion and metropolitan production integration of the lesser developed SIAs. The second line of action would be a policy of regional development of the potential SIAS, seeking to construct a regional production complementarity based on the successful so-called Local Production Arrangements (APLs). And finally, the third line of action would be the policy for local development of the areas surrounding the localized industrial agglomerations which are isolated within the country, the so-called Industrial Enclaves. The objectives would be to reduce the local territorial segmentation with the offering of an urban physical infrastructure, such as sanitation, transportation and housing.

These three lines of action would have to be implemented on the basis of the two main federal public policies for the production sector, namely the Industrial, Technological and Foreign Trade Policies and the National Policy for Regional Development. The competencies of the company and the territory would need to be integrated.

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