

Industrial location and sectoral linkages: the case of the Brazilian automotive industry

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ABSTRACT

The aim of this article is to analyse the spatial distribution of the automotive industry in Brazil in terms of its various economic categories between 1995 and 2011, and to shed light on its sectoral linkages through inter-regional input-output matrices. By calculating the coefficient of localization (QL_{ij}) for that period, it was found that the third wave of investments, which began in the second half of the 1990s, actually caused a slight spatial deconcentration of this sector in the national economy. The coefficient of geographic association (CA_{jk}) calculated for different years revealed a slight reduction, while maintaining a high level of concentration, which suggests that vehicle production is closely integrated with other economic activities. This integration was corroborated particularly in terms of input purchases (backward linkages) in all of the analysed regions.

KEYWORDS

Industrial location, automotive industry, investments, industrial production, industrial statistics, Brazil

JEL CLASSIFICATION

R11, R12, R30

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I

Introduction

The main activity of the automotive sector is vehicle assembly, which constitutes a global oligopoly formed by a few large internationalized firms organized in various productive clusters in different countries. To understand the behaviour of this market, it is essential to take account of the large economies of scale and agglomeration, among other entry barriers, that operate in the process of producing an automobile.

According to Costa and Henkin (2011, p. 4), assembly enterprises generally use various manufacturing plants, sometimes specialized by vehicle type and manufacturing platform, which allows for variations in the models they produce. Ferraz, Kupfer and Haguenaer (1996) and Casotti and Goldenstein (2008) find that this sector is in a permanent process of consolidation that frequently involves newly created firms, mergers, joint ventures and commercial partnerships of the most varied type, which generally reaffirm the sector's oligopolized market structure.

Aside from this global oligopoly's great importance for the economy, the firms that participate in the sector have been pioneers in developing new technologies and new factory management models, as noted in Casotti and Goldenstein (2008, p. 149). In technological terms, the automotive sector includes the firms that are most active in technological activities among a group of multinationals encompassing 45 sectors in the Brazilian economy.¹

In different countries, automobile production and employment in the sector are generally organized in productive clusters in just a few regions. According to Sturgeon, Biesebroeck and Gereffi (2008, p. 9), in some cases these clusters specialize in specific aspects, such as vehicle design, final assembly, or the manufacture of parts with common characteristics such as the electronic content or labour intensity.

The same authors explain that, in the context of the complex economic geography of the automotive industry, global integration has generated very profound relations between buyers and sellers, particularly in the case of assembly firms and their main suppliers. This process means that production tends to be organized regionally, or nationally for the mass production of specific vehicle

models at sites close to the assembly plants, so as to increase the logistical advantages of delivery time, economies of scale, and labour cost saving.

Within this general framework, Brazil has a large domestic market (both actual and potential), a complete industrial park, a solid engineering base related to the automotive industry, and a network of distributors with widespread presence across the country. The aforementioned characteristics can be clearly seen when the geographical distribution of vehicle production in Brazil and the market share of the main assembly firms are analyzed.

Given this complex economic geography, the present study sets out to analyse the spatial distribution of the automotive industry in Brazil between 1995 and 2011, based on its various economic categories, and also to reveal its sectoral linkages by analysing the Hirschman-Rasmussen linkage indices and production multipliers, based on data from the industry's inter-regional input-output matrix for 2004 (the latest available public matrix).

Among the location and specialization measures existing in the bibliography, two are most widely used: the coefficient of localization (QL_{ij}) and the coefficient of geographic association (CA_{ik}). The QL_{ij} coefficient was used to determine the location of manufacturing industry in Brazil between 1994 and 2009 (Rezende, Campolina and Paixão, 2013) and the geographical distribution of creative and cultural industries in Spain, Italy and the United Kingdom (Basset, Griffiths and Smith, 2002; García, Fernández and Zobio, 2003; Lazzeretti, Boix and Capone, 2008). Albuquerque and others (2002) used the CA_{ik} coefficient to analyse the linkage between science and technology indicators and urban installations across a wide range of Brazilian municipalities.

To fulfil the proposed objective, the study is divided as follows. Following this brief Introduction, section II presents a number of preliminary considerations on the automotive industry that to some extent help to explain the spatial distribution of the firms (mainly assembly firms). Section III makes a regional analysis of the automotive industry in Brazil, to evaluate its sectoral linkages. Section IV reveals the geographical distribution of the automotive industry in Brazil by analysing the coefficients of localization and coefficients of geographic association; and, lastly, section V offers some final thoughts.

¹ Albuquerque (2000) performs this analysis on the basis of an indicator of the relative internalization of technological activities.

II

The automotive industry: some preliminary considerations

The market structure of the automotive industry constitutes an international oligopoly subject to major entry barriers, with differentiated but concentrated oligopolies also operating in each country. There is a division of labour within the automobile product value chain, with decision centres and research and development (R&D) located in the headquarter countries, while manufacturing is internationally dispersed Costa and Henkin (2011, p. 4).

In that context, the industrial plants are situated close to the main consumer markets (an essentially “Weberian” element)²—owing to freight costs and tariff barriers (elements highlighted by Lösch),³ the various policies to support the sector, lower production costs, and the other advantages related to location—. In addition, Costa and Henkin (2011) explain what share of production is sent to the markets and regions in which the plants are located, thereby configuring regional platforms.

In its current phase, the automotive industry market displays a high level of competition owing to the saturation and greater maturity of certain markets. This is leading large firms to pursue new growth and profit opportunities in emerging countries such as Brazil (Senhoras, 2005).

Given these characteristics, the main strategies adopted by those firms include the pursuit of product differentiation, partnerships, alliances, and, above all, the internationalization of their activities.

The automotive industry displays a number of key characteristics, such as economies of scale and agglomeration, and the level of technological intensity needed to produce a vehicle. This means that a large volume of initial capital is needed for a firm to enter the market, which in turn implies substantial entry barriers.

² In the context of location theory, the fundamental question that Weber (1929) seeks to answer is where the location of a productive unit will occur in spatial terms, taking account of the economic conditions of production and distribution. For this purpose, the author constructed a model based on the verifiable empirical finding that raw materials are not distributed homogeneously in spatial terms. Hence, firms seek to locate in the geographical place that optimizes transport costs.

³ Lösch (1954) assumed increasing returns as essential for forming the economic space and developed a model based on monopolistic competition, like Kaldor. Lösch argues that increments in the economies of scale lead to an increase in the firm’s global supply in the economic space, by expanding the market area.

Marshall (1985) stresses the positive effects of agglomeration by studying the industrial district located close to large cities, where various types of externality naturally arise, classified in three main categories: (i) internal economies of scale, relating to the reduction of average costs as production levels increase; within the firm (ii) localization economies to the firms and internal to the sector, related to the benefits generated by the clustering of suppliers, subcontractors and partners, owing to productive specialization; and (iii) spatial economies, external to both the firms and the sector, caused by the expansion of social capital in the region.

The spatial arrangement of economic activities, or industrial concentration, is an outcome of two types of opposing forces: agglomeration and dispersion. Generally, the former tend to be caused by the three “Marshallian” externalities noted above. The dispersion forces (also referred to as congestion effects) consist of lack of labour mobility, transport costs, and environmental externalities, among other factors.

The externality-generating mechanism, related to increasing returns, is based on the market’s interaction forces, according to Freitas (2012), related to the firm’s transactions with its suppliers (backward linkages) and its transactions with consumers (forward linkages). Marshall’s approach thus focuses on the effect of market mechanisms and accords a pecuniary nature to the externalities, as determinants of the spatial agglomeration and dispersion of industry.

Camargo (2006, p. 115) argues that, in a developing country, the location of firms in the automotive industry depends on situational factors relating to the economies and diseconomies of agglomeration, such as the characteristics of the labour market, the cost of urban land, and the conditions of urban infrastructure and service provision—as manifested in the road structure, the existence of schools and universities, or in logistics, among other characteristics—. In the case of Brazil in particular, fiscal and tax factors also exert a significant influence on the situational structure and the implementation of new production units.

According to Camargo (2006, pp. 116-117), assembly firms generally created an institutional governance structure making it possible to reproduce specialization

economies for a more intensive exploitation of their assets. Nonetheless, location requirements were later eased substantially, which enabled those firms and their supplier networks to set up in places that were further from the main consumer markets.

The interaction between forward and backward linkages described by Hirschman (1961) enables a series of increasing returns to scale, external to the firm but internal to the local cluster, which include lower transaction costs. Camargo (2006) argues that the possibility of creating economies of specialization reduced the importance of economies of urbanization⁴ and enabled the assembly firms to avoid diseconomies of agglomeration. They therefore set up in smaller and more distant urban centres, although usually they had to remain in the suburban radius of the metropolitan centre with the higher-level “central place” function.

The automotive industry is also an excellent candidate for generating large multiplier effects in the productive structure, owing to its intersectoral relations with various segments, mainly backward linkages in the productive chain. Ribeiro and others (2010), and Ribeiro, Montenegro and Pereira (2013), for example, claim that in Bahia and Minas Gerais this sector displayed backward linkages that were above average for their respective states.

Based on the study by Freitas (2012, p. 15), the bibliography on agglomeration economies relates the

growth of industrial activity to firm-level productivity increases, arising from external economies of scale or local externalities, depending on the region’s productive structure. This author argues that these agglomeration economies can be divided into static and dynamic economies, depending on the context. In a static context, these economies relate to productivity increases caused by the current industrial environment; whereas in a dynamic context they consist of past interactions between agents that affect current productivity.

Combining the macro-location and micro-location factors of the assembly firm and its suppliers, Camargo (2006, p. 118) explains that:

“(…) The location decision of a local supplier network depends initially on a macro-location decision, related to the assembly firm’s competitive strategy. The micro-location decision is linked to agglomeration and dis-agglomeration factors, which affect the process of network formation and organization, and influence the concentration of first-tier supplier firms; while the location of the other firms from the subsequent levels in the network hierarchy will depend on the type and nature of their product, its ease of transportability, and the location factors determined by the specifics of the place in which the network is established.”

Given the importance of productive linkages in creating externalities and forming clusters, section III makes a regional analysis of the automotive industry in Brazil, through indicators constructed from the inter-regional input-output matrices, estimated by Joaquim Guilhoto for 2004,⁵ following the procedures described in Guilhoto and Sesso Filho (2005) and Guilhoto and others (2010).

⁵ There are no more recent inter-regional matrices available for Brazil.

⁴ According to Freitas (2012), urbanization can be seen to play a prominent role by the fact that it receives a large proportion of public investments and displays the advantages of agglomeration economies. Given the increase in urban costs in the main production hubs, as a result of their modernization, geographical concentration in the Brazilian economy has been unwinding since the mid-1980s, in a process that has been intensifying in recent years, including in the automotive industry.

III

Sectoral linkages of the automotive industry in Brazil

According to Miller and Blair (2009), it is preferable to use inter-regional input-output models rather than models specified for a single region. This is because the latter do not capture the inter-relations between spatial units; in other words, the region in question is isolated

or disconnected from the rest of the country in which it is inserted. Moreover, according to those authors, the basic structure of an inter-regional input-output model for two regions can be represented as follows. Assume a model with two regions L and M:

$$Z = \begin{bmatrix} Z^{LL} & \dots & Z^{LM} \\ \dots & \dots & \dots \\ Z^{ML} & \dots & Z^{MM} \end{bmatrix} \quad (1)$$

where Z^{LM} are the inter-regional flows (for example, exports from region L), and Z^{LL} represents the intra-regional flows (for example trade within region L). After some algebraic manipulation, the solution to this model can be expressed in the form of equation (2):

$$x = (I - A)^{-1} f \quad (2)$$

where x and f are the vectors of production and final demand, respectively; A represents the matrix of technical coefficients a_{ij} , defined as the quantity of products used by sector i as intermediate inputs to produce one monetary unit of output in sector j , for $i, j = 1, \dots, n$; and $(I - A)^{-1}$ is the inverse Leontief matrix.

With the aim of verifying the structure of regional linkages in the automotive industry in Brazil, the following data are presented for 2004: (i) the destination of sales for the components of intermediate and final demand; and (ii) the origin of purchases.

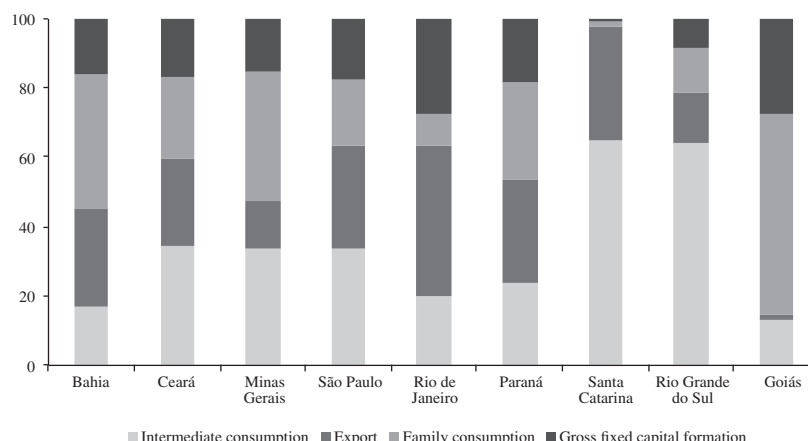
Figure 1 displays the destination of total automobiles sales in 2004, in terms of the output of the nine main Brazilian states. The destination of production varies considerably between states. Intermediate consumption is the largest proportion in Santa Catarina and in Rio Grande do Sul, but the smallest percentage in Bahia and Goiás. Rio de Janeiro and Santa Catarina were the main export platforms in 2004, in relative terms, with shares of 44% and 32.5% of their total sales, respectively. In contrast, the majority (58.1%) of vehicle production in Goiás was destined for family consumption.

In the selected states, an average of 66.1% of motor vehicle production was absorbed by final demand; so, a small forward linkage effect is likely to be produced in the productive chain for this sector, as shown below.

Figure 2 displays the origin of automotive industry purchases, which display a more homogeneous pattern between the states, unlike the destination of sales. The import component, for example, is smallest in all of the states analysed (10.9% on average). In 2004, Rio de Janeiro and São Paulo were the states with the largest proportion of imported inputs, at 17% and 15.5% respectively.

FIGURE 1

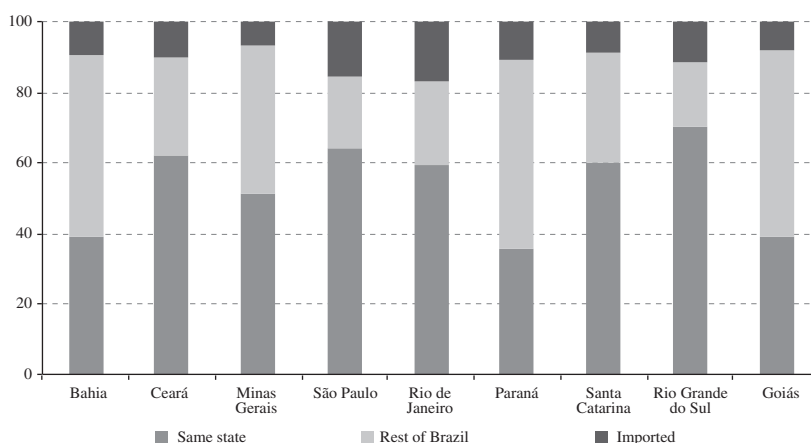
Brazil (selected states): destination of automotive industry sales, 2004
(Percentages)



Source: Prepared by the authors, on the basis of J.J.M. Guilhoto and U.A. Sesso Filho, “Estimação da matriz insumo-produto a partir de dados preliminares das contas nacionais”, *Economia Aplicada*, vol. 9, No. 2, 2005; J.J.M. Guilhoto and others, *Matriz de insumo-produto do Nordeste e Estados: metodologia e resultados*, Fortaleza, Banco do Nordeste, 2010.

FIGURE 2

Brazil (selected states): origin of automotive industry purchases, 2004
(Percentages)



Source: Prepared by the authors, on the basis of J.J.M. Guilhoto and U.A. Sesso Filho, “Estimação da matriz insumo-produto a partir de dados preliminares das contas nacionais”, *Economia Aplicada*, vol. 9, No. 2, 2005; J.J.M. Guilhoto and others, *Matriz de insumo-produto do Nordeste e Estados: metodologia e resultados*, Fortaleza, Banco do Nordeste, 2010.

The states in which production is most self-sufficient, in the sense of relying above all on inputs sourced from within their borders, were Rio Grande do Sul (70.3%), followed by São Paulo (63.8%) and Ceará (63.1%). Theoretically, this suggests that those states offered favourable conditions for the establishment of industries supplying raw materials for the automotive sector. In contrast, Paraná, Goiás and Bahia sourced over half of their total purchases from the rest of Brazil, with shares of 53.6%, 53.1% and 51.1%, respectively.

It is well known that upstream relations (input purchases) in the automotive industry mean a larger number of activities, which suggests a greater importance for backward linkages to the detriment of forward linkages. To test this hypothesis, the Hirschman-Rasmussen linkage indices⁶ were calculated (see table 1), which show whether the sectors’ purchase and sales ratios are above or below the economy-wide average.

The backward indices of the automotive industry displayed levels above 1 in all of the states analysed; whereas all of the forward regional indices were below 1. In other words, in 2004, this sector had backward linkages above the economy-wide average in each state and weak forward linkage effects. The forward linkages indicator in the São Paulo state industry was 0.87, which

underscores the importance of that state in the supply of motor vehicles.

Nonetheless, linkage relations must be internalized in the region in which the industrial unit is located. L. Haddad and others (2007) report, for example, that the Fiat plant in Minas Gerais in the 1970s relied on inputs from outside the state, obtained mainly from São Paulo. In the ensuing decade, however, the firm managed to attract its main suppliers to Minas Gerais in a process the authors refer to as the “minerization” of Fiat. Ribeiro and Britto (2013), note that the automotive industry established in Bahia (Ford) had not yet attained that result, since it depended on inputs located outside the state borders. This is a negative point, because that characteristic tends to cause job losses and income leakages.

To evaluate the degree of that internalization in each of the analysed states, table 2 presents the results of the production multiplier,⁷ broken down into intra-regional and inter-regional effects, as shown by this indicator’s leakage rate.

The largest total production multiplier is that of the automotive industry of Goiás at 2.61, which means that, to satisfy every additional monetary unit of demand in the sector, the economy as a whole must produce 2.61 units. However, this state also displays the largest

⁶ The formal derivation of those indices is beyond the scope of this article. Further information on the subject can be found in Ribeiro and others (2010), or in Ribeiro, Montenegro and Pereira (2013).

⁷ This indicator can be expressed formally as: $Mp_j = \sum_{i=1}^n b_{ij}$, where b_{ij} are the elements of the inverse Leontief matrix.

TABLE 1

Brazil (selected states): Hirschman-Rasmussen linkage indices of the automotive industry, 2004

Linkages	Bahia	Ceará	Minas Gerais	São Paulo	Rio de Janeiro	Paraná	Santa Catarina	Rio Grande do Sul	Goiás
Backward	1.32	1.28	1.32	1.21	1.18	1.29	1.20	1.24	1.34
Forward	0.61	0.63	0.68	0.87	0.66	0.66	0.70	0.76	0.54

Source: Prepared by the authors, on the basis of J.J.M. Guilhoto and U.A. Sesso Filho, "Estimação da matriz insumo-produto a partir de dados preliminares das contas nacionais", *Economia Aplicada*, vol. 9, No. 2, 2005; J.J.M. Guilhoto and others, *Matriz de insumo-produto do Nordeste e Estados: metodologia e resultados*, Fortaleza, Banco do Nordeste, 2010.

TABLE 2

Brazil (selected states): production multiplier of the automotive industry, 2004

Effects	Bahia	Ceará	Minas Gerais	São Paulo	Rio de Janeiro	Paraná	Santa Catarina	Rio Grande do Sul	Goiás
Intra-regional	1.48	1.69	1.66	1.83	1.65	1.41	1.65	1.87	1.45
Inter-regional	1.04	0.72	0.89	0.45	0.51	1.05	0.67	0.49	1.16
Total	2.52	2.41	2.54	2.28	2.17	2.46	2.32	2.36	2.61
Leakages (%)	41.3	30.0	34.9	19.7	23.8	42.6	28.9	20.8	44.4

Source: Prepared by the authors, on the basis of J.J.M. Guilhoto and U.A. Sesso Filho, "Estimação da matriz insumo-produto a partir de dados preliminares das contas nacionais", *Economia Aplicada*, vol. 9, No. 2, 2005; J.J.M. Guilhoto and others, *Matriz de insumo-produto do Nordeste e Estados: metodologia e resultados*, Fortaleza, Banco do Nordeste, 2010.

leakage effect, at 44%, such that 1.16 of those units are generated in the rest of Brazil (inter-regional effect) and only 1.45 are generated within the region. In contrast, São Paulo has the lowest production leakage rate: just 19.7%. This may be partly due to the consolidation of this industrial segment in the state, which is the headquarters of major assembly firms.

As would be expected, the result of the production multipliers shown in table 2 reflects the origin of the

sectors purchases (see figure 2). The states with the largest inter-regional multipliers (Goiás, Paraná and Bahia) and, consequently, those displaying the largest leakage effect, also rely most on inputs sourced from the rest of Brazil. This result shows that the automotive industry in those three states produces substantial inter-regional effects, which need to be taken into account in sector policies that aim to generate an impact at the national level.

IV Geographical distribution of the automotive industry in Brazil: an analysis by coefficients of localization and coefficients of geographic association

Most of the firms that belong to the National Association of Motor Vehicle Manufacturers (ANFAVEA) of Brazil keep their main productive activities in the south east and south regions, except for the Ford and Mitsubishi factories, which are installed in the north-

east and centre-west, respectively. An analysis of the geographical distribution of the main productive unit shows the characteristics of spatial clustering based on the effects of the agglomeration economies mentioned in section II.

Prior to the 1990s, the automotive industry was stagnated. The recovery plan for the industry was set out in measures adopted in 1992 and 1993, under the auspices of the Sectoral Chamber of the Automotive Industry, in which the government, workers and the private sector signed an automotive agreement setting various targets for the sector.

According to Santos and Burity (2003), as a result of the new automotive regime, the situation of stagnation eased and a variety of investment plans were announced. The regime aimed to encourage a resumption of investments in the sector and to enhance competitiveness to increase exports. The new regime was created in 1995⁸ and was reformulated in 1997 to encompass the less developed states. It included tax incentives to set up firms in the country along with differentiated incentives for firms that decided to establish units in less developed regions. These policies resulted in several factories being set up in other states in the third wave of investments in the sector, starting in the mid-1990s.

Marx and Mello (2008) point out that the automotive industry has been the subject of many studies and the target of various public policies. This reflects its strong and direct influence on gross domestic product (GDP), and its indirect effects, given, primarily, its capacity to generate backward linkages in the productive chain: glass,

rubber, iron and steel, aluminium, oil, petrochemicals, chemicals, alcohol and biodiesel, capital goods and others, in addition to forward linkages in various segments of the service sector: commerce, insurance, repair workshops, technical assistance and specialized technical services (engineering and design, among others) as described in section III of this article.

Broadly speaking, Marx and Mello (2008) stress that the sector is formed by firms that assemble automobiles, trucks and bus chassis, along with suppliers of spare parts and components, and a set of heterogeneous segments. Thus, the automotive industry might not be viable without well-established spare parts and component suppliers.

As explained in Salerno and others (2008) and also in Marx and Mello (2008), the automotive industry extends beyond the economic activity division of motor vehicle manufacturing and assembly, to encompass activities involving the supply of basic inputs ranging from glass and rubber through to specialized services. Table 3 identifies the categories of the National Classification of Economic Activities (CNAE) used in this study.

According to Simões (2005, p. 7), there is a set of descriptive and highly exploratory measures that can be used for an initial approach to a large mass of data, which are generally used in diagnostics for industrial decentralization policies and, mainly, to characterize the regional patterns of the spatial distribution of economic activity.

These descriptive measures can be divided into localization and specialization measures. The former, of a sectoral nature, reflect the pattern of location of the

⁸ According to Rodríguez-Pose and Arbix (1999), 16 large assembly enterprises, 150 autopart firms, and 29 firms from other productive sectors have affiliated to the new automotive regime since 1996.

TABLE 3

Brazil: description of activities related to the automotive industry according to the National Classification of Economic Activities (CNAE) 1.0

Category	Description of activity
25	Manufacture of rubber and plastic articles
27	Basic metallurgy
26	Manufacture of nonmetallic mineral products
29	Manufacture of machinery and equipment
28	Manufacture of metal products, except machinery and equipment
31	Manufacture of electrical machinery, apparatus and equipment
34 ^a	Manufacture and assembly of motor vehicles, trailers and chassis
35	Manufacture of other transport equipment
50	Trade and repair of motor vehicles and motorcycles; and retail trade in fuels
71	Rental of vehicles, machinery and equipment without drivers or operators, and personal and domestic appliances

Source: Brazilian Geographical and Statistical Institute (IBGE), *Pesquisa Industrial Anual*, 2010 [online] <http://www.ibge.gov.br>.

Nota: The main automotive industry category is 34 (with the corresponding three-digit activity classes). In fact, except for category 34, the other categories do not include economic activities that are exclusive to the automotive industry; and, in some cases, they have closer links with other economic sectors, in addition to their links with the automotive sector, ranging from the supply of basic inputs to higher value-added intermediate goods.

^a In CNAE 2.0 this corresponds to Category 29.

activities between the regions (Haddad, 1989) and seek to describe spatial concentration or dispersion patterns. The specialization measures, in contrast, focus on the analysis of each region's productive structure, with the aim of describing the degree of regional specialization and its diversification in different periods.

According to the literature, the two most widely used location and specialization measures are the coefficient of localization (QL_{ij}) and the coefficient of geographic association (CA_{ik}).

The location coefficient (QL_{ij})⁹ indicates a state's relative specialization compared to the concentration level of all producer states selected as representative. An

indicator above 1 means that the sector's relative share in the state is above its average relative share across all states; and when it is below 1, there is no productive specialization in the state in question. Authors such as Combes (2000); Fochezatto (2010), and Freitas (2012) even consider that that indicator can be taken as a representative variable for identifying Marshall-Arrow-Romer (MAR) type externalities.

More specifically, QL values between 0 and 0.49 indicate weak location; values between 0.50 and 0.99 show medium localization; and values greater than 1 indicate strong location.

Tables 4 to 9 show that the industry's location pattern changed substantially as a result of the investments made in the 1990s, which caused the economic activities of this industrial sector to emerge as from 2000 in states other than São Paulo (QL of 2.14) and Minas Gerais (QL of 1.10), such as Paraná (QL of 0.47, which indicates a still low level of localization) and Rio Grande do Sul (QL of 0.93, i.e. a location considered medium).

In 1995, there was weak productive localization in the states of Ceará, Bahia, Paraná and Goiás. The high QL reported for Santa Catarina may be partly due to its motor vehicle industry centred on truck manufacture.

⁹ The formula for the coefficient of localization is as follows:

$$QL_{ij} = \frac{E_{ij}}{\sum_j E_{ij}} \bigg/ \frac{\sum_i E_{ij}}{\sum_i \sum_j E_{ij}}$$

where: E_{ij} = Jobs in sector i in state j .
 $\sum_i E_{ij}$ = Jobs in all sectors in state j .
 $\sum_j E_{ij}$ = Jobs in sector i in all states.

TABLE 4

Brazil (selected states): coefficient of localization by categories of the National Classification of Economic Activities (CNAE) 1.0 of activities related to the automotive industry, 1995

CNAE 1.0 category	Location coefficient									
	Ceará	Bahia	Minas Gerais	Rio de Janeiro	São Paulo	Paraná	Santa Catarina	Rio Grande do Sul	Goiás	Total
Manufacture of rubber and plastic articles	0.51	0.49	0.43	0.76	1.75	0.71	1.66	1.29	0.35	1.17
Basic metallurgy	0.20	0.43	2.74	1.02	1.19	0.29	1.29	0.68	0.28	1.16
Manufacture of machinery and equipment	0.16	0.08	0.39	0.44	1.84	1.09	2.25	1.77	0.08	1.22
Manufacture of electrical machinery, apparatus and equipment	0.36	0.12	0.86	0.39	1.91	0.61	1.71	0.98	0.12	1.18
Manufacture and assembly of motor vehicles	0.05	0.03	1.10	0.17	2.24	0.47	0.68	0.93	0.12	1.23
Manufacture of other transport equipment	0.32	0.13	0.26	3.11	1.28	0.45	0.36	0.20	0.34	1.09
Trade and repair of motor vehicles and motorcycles; and retail trade in fuels	0.72	0.93	1.14	0.82	1.00	1.34	1.23	1.12	1.46	1.04
Rental of vehicles, machinery and equipment	0.70	1.41	1.34	1.74	0.96	0.80	0.42	0.54	1.00	1.06
Total (activities)	0.39	0.45	1.09	0.71	1.54	0.84	1.38	1.11	0.57	1.15

Source: Prepared by the authors, on the basis of Ministry of Labour and Employment, *Relação Anual de Informações Sociais*, Brasília, 2006.

Table 5 shows the *QL* calculations for 2000, which reflect the emergence of new specialized hubs in this industrial segment, apart from São Paulo and Minas Gerais, located in the states of Paraná¹⁰ and Rio Grande do Sul.¹¹

Between 1989 and 2003, the automotive industry underwent a first productive restructuring and, from

2004 to 2010 there was a second stage in which Brazil consolidated its position as a consumer centre and regional platform for the production and distribution of vehicles, according to Costa and Henkin (2011, p. 12). These authors also note that the new firms in the sector started to invest in the installation of national production. The “traditional” assembly firms were following a similar path, by setting up new productive units in the country and modernizing existing ones, with the aim of maintaining their positions in the market, which were now threatened by the new assembly enterprises. That process meant that the *QL* of Rio Grande do Sul in 2000 (*QL* of 1.19) even exceeded the productive specialization of Minas Gerais (*QL* of 1.12).

In CNI/ECLAC (2001) the authors note a trend towards intensifying spatial diversification of investments in the industries since 1996. The tax benefits offered by the states, the proximity of the consumer market, and the cost of labour were the key determinants of this process (see table 6).

In that context, as shown by the pattern of factory installations reported in table 4, the effects of agglomeration economies and public sector tax benefits had a major influence on the industrial location of the assembly plants outside the traditional zone consisting of the states of São Paulo and Minas Gerais, in the period analysed.

Moreover, as highlighted in Rodríguez-Pose and Arbix (1999, p. 64), wage differences in the interior of Brazil, together with education improvements across the country in recent years, have led the assembly enterprises

¹⁰ According to Rodríguez-Pose and Arbix (1999, p. 66), in March 1996, the state government, together with the municipality of São José dos Pinhais and the Economic Development Fund, signed a protocol with Renault. The conditions of the agreement specified that Renault would build a plant in São José dos Pinhais by early 1999, and put up 60% of the total capital of the project. The French multinational would also create 1,500 direct jobs and would pay a penalty of R\$ 50.5 million if the plant was closed down within 20 years. The state of Paraná and the municipality of São José dos Pinhais would grant 2.5 million m² in land and provide the infrastructure and necessary logistics, including rail and road accesses, as well as an exclusive area for the firm in the port of Paranaguá. Energy would be supplied as a 25% discount on the market price. The state would own 40% of the capital invested (with a maximum of US\$ 300 million). The official loans to Renault would be linked to the firm's production levels; they would not be inflation indexed; and repayments would begin 10 years after the start of operations. Renault would also be exempt from local taxes for 10 years, as would all suppliers that set up operations in the same zone, which, incidentally, is an environmental protection area.

¹¹ Rodríguez-Pose and Arbix (1999, p. 67) view the conditions of the agreement between General Motors and the state government of Rio Grande do Sul as extremely generous to the assembly enterprise. The protocol signed envisaged US\$ 310 million in official loans to finance land purchase at an interest rate of 6% per year, payable as from 2002. Tax exemption would last 15 years, and the state would supply infrastructure and water, electricity, natural gas and telecommunication services at subsidized rates. In addition, it would construct a private port and a maritime access channel, and also guarantee public transport to the factory.

TABLE 5

Brazil (selected states): coefficient of localization by categories of the National Classification of Economic Activities (CNAE) 1.0 of activities related to the automotive industry, 2000

CNAE 1.0 category	Location coefficient									
	Ceará	Bahia	Minas Gerais	Rio de Janeiro	São Paulo	Paraná	Santa Catarina	Rio Grande do Sul	Goiás	Total
Manufacture of rubber and plastic articles	0.48	0.48	0.53	0.66	1.68	0.90	1.97	1.53	0.43	1.18
Basic metallurgy	0.18	0.42	2.74	0.96	1.11	0.33	1.67	0.71	0.39	1.15
Manufacture of machinery and equipment	0.31	0.12	0.48	0.41	1.81	1.17	2.13	1.90	0.21	1.22
Manufacture of electrical machinery, apparatus and equipment	0.40	0.15	0.87	0.35	1.89	0.96	1.76	1.03	0.20	1.19
Manufacture and assembly of motor vehicles	0.14	0.09	1.12	0.21	2.06	1.23	0.71	1.19	0.19	1.24
Manufacture of other transport equipment	0.25	0.25	0.51	1.04	1.85	0.39	0.49	0.26	0.44	1.04
Trade and repair of motor vehicles and motorcycles; and retail trade in fuels	0.74	0.94	1.14	0.80	0.95	1.22	1.24	1.02	1.39	1.01
Rental of vehicles, machinery and equipment	1.16	1.66	1.33	1.57	0.91	0.88	0.48	0.51	0.83	1.04
Total (activities)	0.48	0.54	1.09	0.65	1.43	1.04	1.44	1.18	0.70	1.12

Source: Prepared by the authors, on the basis of Ministry of Labour and Employment, *Relação Anual de Informações Sociais*, Brasília, 2006.

TABLE 6

Brazil (selected states): factors that encouraged the installation of plants in other places, 1998-2002
(Percentages)

Main factors	1998-1999			2000-2002		
	In another state	Within the state	Total	In another state	Within the state	Total
Labour cost	40.9	38.9	44.2	39	47.4	86
Labour skills	9.1	27.8	20.9	7.3	15.8	23.3
Federal tax benefits	13.6	5.6	14	22	2.6	23.3
State tax benefits	54.5	22.2	41.9	56.1	23.7	83.7
Municipal benefits	18.2	22.2	23.3	34.1	50	83.7
Active labour union in the region of origin	–	16.7	9.3	2.4	7.9	14
Spatial saturation in the region of origin	27.3	27.8	25.6	12.2	31.6	39.5
Proximity to raw materials and natural resources	13.6	27.8	20.9	29.3	21.1	51.2
Proximity to the consumer market	50	27.8	41.9	56.1	26.3	86
Better infrastructure	13.6	33.3	25.6	4.9	31.6	34.9

Source: National Confederation of Industry (CNI)/Economic Commission for Latin America and the Caribbean (ECLAC), *Investimentos na Indústria Brasileira 1998-2002*, Brasília, 2001.

to seek regions with lower labour costs. In that regard, workers in the state of São Paulo, in particular the metropolitan region of that state, are at a disadvantage relative to those of the rest of the country in terms of hourly labour cost.

According to Rodríguez-Pose and Arbix (1999, p. 69), once manufacturers have chosen Brazil as the suitable place for their investments, the states that compete with each other to attract the assembly firms actually finance a large proportion of the facilities and even the functioning of the new factories. Following the implementation of the special automotive regime, several assembly firms that had previously announced investments in areas close to São Paulo changed the location of their plants to the north east, north and centre-west regions.

In relation to the automotive sector in particular, Latini (2007) and Santos and Burity (2003) state that the main incentive measures in the sector between 1989 and 1993 were the creation of the Sectoral Chamber of the Automotive Industry in 1992, the automotive agreements of 1992 and 1993 and Decree 799/1993, which offered incentives for the manufacture of vehicles with low-capacity engines.

Santos and Burity (2003) report that a total of 21 instruments were approved between 1990 and 1998 (including administrative regulations, decrees and provisional measures) relating to the reduction of tax rates: the Sales Tax on Merchandise and Services (ICMS), and the Industrial Products Tax (IPI) at the time of the Sectoral Chamber, along with emergency agreements

and the automotive regime. The 1990s also saw reductions in import duties and in the nationalization indices required for the industry, which dropped from 85% to 60%.

This new location pattern assumed by the automotive industry remained unchanged in the first decade of the twenty-first century. Tables 7 to 9 show that the main specialized hubs of this industrial sector continue to be the states of São Paulo, Minas Gerais, Paraná and Rio Grande do Sul.

This result can be associated with the input-output indices calculated in the previous section. The automotive industry in those states displayed above average backward linkage indicators. Moreover, most of the raw materials of this segment were produced in the respective states, so one would expect the sector to have a high *QL*, both in relation to the vehicle assembly sector itself and in relation to activities that supply inputs. In fact, there is a correlation between states with the highest level of input self-sufficiency and those that reported the highest *QL*, namely Rio Grande do Sul (70.3%) and São Paulo (63.8%).

As noted above, the backward linkage index of the automotive industry in Bahia is above average. Nonetheless, over half of this sector's inputs come from outside the state, which is shown both in the input-output analysis and by the *QL* results (see table 7), which indicate a low concentration of upstream industries. Thus, to increase the competitiveness of this segment, initially mechanisms should be created to attract industries that

TABLE 7

Brazil (selected states): coefficient of localization of activities related to the automotive industry by categories of the National Classification of Economic Activities (CNAE) 1.0, 2006

CNAE 1.0 category	Location coefficient									
	Ceará	Bahia	Minas Gerais	Rio de Janeiro	São Paulo	Paraná	Santa Catarina	Rio Grande do Sul	Goiás	Total
Manufacture of rubber and plastic articles	0.52	0.65	0.61	0.56	1.62	1.01	1.97	1.46	0.49	1.17
Basic metallurgy	0.38	0.33	2.73	0.86	1.14	0.40	1.63	0.85	0.23	1.16
Manufacture of machinery and equipment	0.30	0.31	0.66	0.49	1.73	1.09	2.10	1.90	0.23	1.22
Manufacture of electrical machinery, apparatus and equipment	0.33	0.33	1.16	0.29	1.81	1.09	1.89	0.98	0.15	1.20
Manufacture and assembly of motor vehicles	0.15	0.41	1.01	0.27	2.04	1.30	0.64	1.51	0.24	1.26
Manufacture of other transport equipment	0.34	0.11	0.30	2.99	1.30	0.28	0.75	0.58	0.14	1.04
Trade and repair of motor vehicles	0.77	0.90	1.10	0.75	0.96	1.24	1.30	1.02	1.24	1.00
Rental of vehicles, machinery and equipment	0.99	1.35	1.24	1.44	1.03	0.73	0.62	0.50	0.67	1.02
Total (activities)	0.52	0.62	1.08	0.69	1.40	1.06	1.45	1.23	0.64	1.12

Source: Prepared by the authors, on the basis of Ministry of Labour and Employment, *Relação Anual de Informações Sociais*, Brasília, 2006.

TABLE 8

Brazil (selected states): coefficient of localization of activities related to the automotive industry by categories of the National Classification of Economic Activities (CNAE) 1.0, 2009

CNAE 1.0 category	Location coefficient									
	Ceará	Bahia	Minas Gerais	Rio de Janeiro	São Paulo	Paraná	Santa Catarina	Rio Grande do Sul	Goiás	Total
Manufacture of rubber and plastic articles	0.43	0.67	0.64	0.60	1.62	1.04	1.96	1.41	0.49	1.17
Basic metallurgy	0.50	0.39	2.65	0.95	1.12	0.44	1.62	0.91	0.23	1.16
Manufacture of machinery and equipment	0.24	0.37	0.60	0.56	1.67	1.14	2.14	2.12	0.31	1.22
Manufacture of electrical machinery, apparatus and equipment	0.35	0.32	1.20	0.21	1.71	1.37	2.16	0.96	0.11	1.19
Manufacture and assembly of motor vehicles	0.15	0.36	1.20	0.30	1.97	1.29	0.69	1.59	0.35	1.27
Manufacture of other transport equipment	0.41	0.09	0.16	2.94	1.15	0.42	0.89	0.47	0.14	0.96
Trade and repair of motor vehicles	0.76	0.94	1.09	0.72	0.93	1.24	1.31	1.06	1.27	0.99
Rental of vehicles, machinery and equipment	0.96	1.21	1.38	1.25	1.02	0.76	0.55	0.52	0.78	1.01
Total (activities)	0.51	0.65	1.08	0.71	1.34	1.10	1.46	1.28	0.69	1.11

Source: Prepared by the authors, on the basis of Ministry of Labour and Employment, *Relação Anual de Informações Sociais*, Brasília, 2006.

TABLE 9

Brazil (selected states): coefficient of localization of activities related to the automotive industry by categories of the National Classification of Economic Activities (CNAE) 1.0, 2011

CNAE 1.0 category	Location coefficient									
	Ceará	Bahia	Minas Gerais	Rio de Janeiro	São Paulo	Paraná	Santa Catarina	Rio Grande do Sul	Goiás	Total
Manufacture of rubber and plastic articles	0.41	0.73	0.66	0.64	1.59	1.08	1.96	1.46	0.48	1.17
Basic metallurgy	0.45	0.37	2.61	1.00	1.11	0.57	1.87	0.86	0.22	1.17
Manufacture of machinery and equipment	0.25	0.31	0.68	0.54	1.62	1.20	2.15	2.15	0.38	1.21
Manufacture of electrical machinery, apparatus and equipment	0.36	0.37	1.02	0.23	1.67	1.61	2.43	1.00	0.17	1.20
Manufacture and assembly of motor vehicles	0.17	0.31	1.34	0.34	1.88	1.36	0.60	1.73	0.41	1.26
Manufacture of other transport equipment	0.46	0.23	0.22	2.82	1.11	0.26	1.19	0.72	0.15	0.98
Trade and repair of motor vehicles	0.81	0.96	1.08	0.69	0.93	1.24	1.30	1.08	1.29	0.99
Rental of vehicles, machinery and equipment	0.88	1.16	1.31	1.77	0.90	0.77	0.54	0.53	0.69	1.01
Total (activities)	0.52	0.65	1.10	0.73	1.31	1.15	1.48	1.32	0.72	1.11

Source: Prepared by the authors, on the basis of Ministry of Labour and Employment, *Relação Anual de Informações Sociais*, Brasília, 2006.

supply inputs to the same zone. This would trigger an increase in the concentration of industries supplying raw materials for the Bahia automotive sector, which would tend to be reflected in a higher *QL*. The result for Ceará is more worrying, however, for although this state's automotive sector has above-average backward linkages (1.28) and the third highest self-sufficiency index (63.1%) of the states analysed, that relatively high self-sufficiency is apparently insufficient for the state to increase its competitiveness. The most important development to occur between 2006 and 2000 is the reduction of the *QL* of São Paulo and the large increase in that of Minas Gerais. According to Rodríguez-Pose and Arbix (1999, pp. 66-67), Mercedes-Benz announced the continuation of a US\$ 400 million investment involving the creation of 1,500 direct jobs to set up a new plant in Juiz da Fora. The German assembly enterprise would receive official loans amounting to US\$ 100 million and exemption from state and municipal taxes for 10 years, together with a land site of 2.8 million m², infrastructure and urbanization of the banks of the Paraíba river, construction of access roads, car parks, testing tracks,

development of sanitation infrastructure, a rail terminal and small-scale improvements, such as schools for workers children. The assembly firm also received guarantees from the state concerning the establishment of a more rigid environmental regulation, so as to make it difficult for other firms to develop activities considered prejudicial for vehicle production in the surroundings of the plant.

During the period, the coefficient of localization of the sum of all of the activities grew in the states of Paraná and Rio Grande do Sul to the detriment of Minas Gerais and São Paulo. This means that, in addition to having become less concentrated, the automotive industry became less heterogeneous between the four main producer states in 2011.

Despite this slight deconcentration in the most recent period, the relative importance of the automotive industry can be discerned in the spatial distribution of employment corresponding to the manufacture and assembly of motor vehicles, trailers and chassis by class of economic activity (see table 10). São Paulo accounts for nearly 56% of all of the related classes of economic activity.

TABLE 10

Brazil (selected states): distribution of formal labour in the manufacture and assembly of motor vehicles, trailers and chassis, 2011
(Percentages)

Class of economic activity	Ceará	Bahia	Minas Gerais	Rio de Janeiro	São Paulo	Paraná	Santa Catarina	Rio Grande do Sul	Goiás	Total
Manufacture of automobiles, vans and utility vehicles	0.51	3.80	17.09	4.69	54.81	10.42	0.03	4.18	4.46	100
Manufacture of trucks and buses	0.00	0.00	0.00	3.64	73.29	13.98	0.00	9.09	0.00	100
Manufacture of cabins, chassis and trailers for trucks	1.64	1.56	4.43	5.73	30.10	14.64	11.06	29.36	1.48	100
Manufacture of chassis for buses	0.09	0.00	0.13	12.00	18.50	7.69	8.53	53.05	0.00	100
Manufacture of cabins, chassis and trailers for other vehicles	3.06	1.38	35.93	3.22	26.50	10.30	2.73	8.29	8.59	100
Manufacture of parts and accessories for the engine system	0.00	0.93	10.93	1.21	66.19	11.77	6.36	2.27	0.34	100
Manufacture of parts and accessories for the drive and transmission systems	0.00	0.02	3.20	0.12	76.53	0.19	0.05	19.88	0.00	100
Manufacture of parts and accessories for the braking system	3.50	0.35	8.57	2.36	54.16	1.45	4.47	25.14	0.00	100
Manufacture of parts and accessories for the steering and suspension system	1.27	0.03	13.72	6.95	59.56	8.39	2.63	7.23	0.21	100
Manufacture of other parts and accessories for motor vehicles not elsewhere specified	0.10	1.30	19.85	1.40	60.84	7.05	1.41	7.95	0.10	100
Repair or restoration of motor vehicle engines	4.37	4.29	19.37	7.84	34.29	9.70	8.51	6.58	5.06	100
Total	0.53	1.57	14.50	3.30	56.04	8.84	2.75	11.21	1.25	100

Source: Prepared by the authors, on the basis of Ministry of Labour and Employment, *Relação Anual de Informações Sociais*, Brasília, 2006.

Geographic association of the distribution of the automotive industry in Brazil in relation to vehicle manufacture and assembly

The coefficient of geographic association (CA_{ik})¹² shows the geographical association between two sectors (denoted i and k), by comparing the percentage distributions of labour between the producer states. It takes values ranging from 0—which means that sector i is distributed between the states in the same way as sector k (so the location patterns of the two sectors are deemed to be geographically associated)—to close to 1, which indicates no association.

Specifically, values between 0 and 0.35 are taken as indicating significant association, values between 0.36 and 0.68 medium association, and values of 0.69 and above weak association.

¹² The formula for the coefficient of geographical association is:

$$CA_{ik} = \frac{\sum_j \left(\left(\frac{E_{ij}}{\sum_i E_{ij}} \right) - \left(\frac{E_{kj}}{\sum_i E_{ij}} \right) \right)^2}{2}$$

where: E_{ij} = Jobs in sector i in state j .

$\sum_i E_{ij}$ = Jobs in all sectors in state j .

The analysis of table 11 shows that sectors related to motor vehicle manufacture and assembly display significant association, which declines slightly over time but still remains at a high level. Those showing the highest association include the manufacture of electrical machinery, apparatus and materials, the manufacture of machinery and equipment, and the manufacture of rubber and plastic articles, which indicates that the national motor vehicle industry has a highly integrated productive process, such that the location patterns of these sectors are geographically associated. As can be seen in tables 7 to 9, the increase in the QL of motor vehicle manufacture in the states was accompanied by a large proportion of the identified activities, thereby demonstrating this industry's tremendous attraction capacity, which, once again, may also be related to above-average Hirschman-Rasmussen linkage indices.

According to the joint results, obtained from the calculation of localization and specialization measures, the third wave of investments that began in the second half of the 1990s actually produced a slight spatial deconcentration of the national automotive industry, through its expansion from the traditional hubs of São Paulo and Minas Gerais, as can also be seen in table 12 in terms of industry value added (IVA).

TABLE 11

Brazil: coefficients of geographic association in the manufacture and assembly of motor vehicles in relation to complementary sectors, 1995-2011

CNAE 1.0 category	1995	2000	2006	2009	2011
Manufacture of rubber and plastic articles	0.20	0.17	0.14	0.13	0.14
Basic metallurgy	0.35	0.36	0.34	0.32	0.31
Manufacture of machinery and equipment	0.20	0.14	0.13	0.14	0.13
Manufacture of electrical machinery, apparatus and equipment	0.10	0.07	0.09	0.10	0.12
Manufacture and assembly of motor vehicles	-	-	-	-	-
Manufacture of other transport equipment	0.41	0.18	0.35	0.37	0.37
Trade and repair of motor vehicles	0.35	0.28	0.27	0.25	0.23
Rental of vehicles, machinery and equipment	0.40	0.37	0.32	0.29	0.32

Source: Prepared by the authors, on the basis of Ministry of Labour and Employment, *Relação Anual de Informações Sociais*, Brasília, 2006.

TABLE 12

Brazil (selected states): industry value added (IVA) of the manufacture and assembly of motor vehicles, trailers and chassis, 1996-2010
(Percentages)

State	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007 ^a	2008	2009	2010
Brazil	7.87	8.4	7.96	6.1	6.95	6.55	7.07	7.48	7.73	7.77	8.03	9.29	9.81	10.1	10.1
Minas Gerais	12.5	13.93	11.07	9.27	11.2	10.37	9.09	9.42	8.93	9.51	11.47	13.4	13.6	13.4	11.87
Rio de Janeiro	0.98	1.13	3.91	2.85	2.93	3.49	3.61	3.4	4.15	4.71	4.27	4.61	5.13	4.33	5.05
São Paulo	11.83	12.14	11.49	8.22	9.45	8.77	9.65	10.6	11.1	10.98	11.16	12.9	13.4	14.3	15.06
Paraná	3.33	4.01	5.49	8.46	10.7	7.89	11.6	10.8	12.5	11.31	11.73	13.1	14.9	16.3	15.96
Rio Grande do Sul	5.45	6.4	5.12	4.93	5.98	7.59	6.98	8.21	7.77	7.93	8.42	9.74	10.3	11.8	12.04
Santa Catarina	3.88	4.24	3.96	4.22	4.62	4.62	3.44	3.53	3.81	4.53	4.59	4.55	5.26	3.47	3.71
Ceará	0.59	0.75	0.72	0.66	0.53	0.92	1.02	0.78	1.22	1.22	0.85	0.96	0.93	0.78	0.83
Bahia	0.08	0.09	0.04	0.04	0.03	0.04	4.13	5.79	5.6	6.31	6.19	6.39	9.27	10.3	9.71
Goiás	0.29	0.43	0.34	0.26	0.4	0.33	1.51	1.95	3.19	4.6	4.38	5.98	6.86	7.23	9.05

Source: Brazilian Geographical and Statistical Institute (IBGE), *Pesquisa Industrial Anual*, 2010 [online] <http://www.ibge.gov.br>.

^a As from 2007 the aggregation of the IVA is shown according to the National Classification of Economic Activities (CNAE) 2.0.

It should be noted that not all of the investments undertaken since the 1990s were significant in the sense of contributing to the spatial deconcentration of the industry, as was the case of those undertaken in Paraná and in Rio Grande do Sul. Investments targeting Rio de Janeiro, Bahia and Goiás did not produce the same statistical effect as recorded in the two states mentioned in the south region, although they did succeed in raising the respective coefficients of localization.

The main hypothesis on this discrepancy relates to the fact that the firms that moved to Rio de Janeiro, Bahia and Goiás, namely Ford, Peugeot/Citroën, Mitsubishi and Hyundai, are not the leading companies in the Brazilian market, nor those that grew most in the period, unlike those that chose to locate in Paraná and Rio Grande do Sul: Volkswagen, General Motors and Renault/Nissan.

Another secondary cause that can be adduced to explain the phenomenon is the heavy presence of urban networks in Paraná and Rio Grande do Sul, compared to Bahia and Goiás where their presence is less. Given that the urban network consists of the integrated and hierarchically-arranged system of cities, duly connected by adequate communication highways enabling expansion and integration of the investments, it is easy to see why states in the south region achieved better results than those of the centre-west and north-east regions. Although it is a relevant piece of information, it does not fully explain the case of Rio de Janeiro, which did not achieve significant integration effects despite having a highly developed urban network.

According to the Ministry of Development, Industry and Foreign Trade, the Brazilian automotive regime, in force from 2013 to 2017, defines new conditions

for authorizing assembly firms, as well as rules on the Industrial Products Tax (IPI) and transition rules for attracting investments in vehicle production in Brazil. Thus far, 43 groups have applied to participate in the program and 33 have been authorized.¹³ According to the expectations of the aforementioned ministry and ANFAVEA, investments in the sector will attain a level of R\$ 60 billion during the period.

ANFAVEA (2012b, p. 2) explains that the new regime sets goals of increasing the regional content measured by the volume of purchases of parts and productive inputs from Brazilian firms, investments in engineering and innovation, and an increase in the energy efficiency of the vehicles, with all of these factors being taken into account to obtain the reduction in IPI.

¹³ Producers: Nissan, Agrale, Caoa (Hyundai), Fiat, Ford, General Motors, Honda, International, Iveco, Man Mercedes-Benz, Mitsubishi (MMC), Peugeot, Citroën, Renault, Scania, Suzuki (SVB), Toyota, Volkswagen and Volvo. Importers: SsangYong/Changan (Districar), Rely (Venko), Chrysler, Porsche (Stuttgart Sportcar), Jaguar, Land Rover, Volvo, Bentley (British Cars Brasil) and Aston Martin (SNS). Investors: Chery, JAC Mitsubishi (MMC) and Nissan.

V

Conclusions

The third wave of investments that began in the second half of the 1990s actually achieved a slight spatial deconcentration as the national automobile industry spread beyond the traditional hubs of São Paulo and Minas Gerais, with positive repercussions on the industry value added (IVA) of the states analysed.

Not all of the investments made since the 1990s were significant in terms of spatially deconcentrating the automobile industry, as happened with those undertaken in Paraná and in Rio Grande do Sul. Investments targeting Rio de Janeiro, Bahia and Goiás did not produce the same statistical effect in terms of productive specialization as occurred in the two southern states mentioned, although they did succeed in raising the respective location coefficient and IVA indicator.

The main cause of this disparity is probably the fact that the firms that moved to Rio de Janeiro, Bahia and Goiás (Ford, Peugeot/Citroën, Mitsubishi and Hyundai) were neither leaders in the Brazilian market nor those that grew most during the period, unlike the

According to Maia Júnior (2012), construction projects are under way at Ford (Goiana, Pernambuco), Nissan (Resende, Rio de Janeiro), Chery (Jacareí, São Paulo), Toyota (Sorocaba, São Paulo) and Hyundai (Piracicaba, São Paulo). In addition, the following projects have also been announced: Effa Motors (Manaus, Amazonas), JAC Motors (Camaçari, Bahia), CN Auto (Linhares, Espírito Santo) and Suzuki (Itumbiara, Goiás).

These data show that São Paulo remains the state with the largest number of investments in the automotive sector, either under way or announced, which strengthens the concentrated nature of the sector, despite the productive relocation process that unfolded between 1995 and 2011, as described in this article.

This process corroborates the fact that the significant role played by economies of scale and agglomeration in vehicle production also has consequences for business location decisions. The two factors together tend to stimulate a sector that features a concentration of large firms, clustered in not very disperse geographic regions, as noted by Sturgeon, Biesebroeck and Gereffi (2008), among others.

firms that chose to set up in Paraná and Rio Grande do Sul (Volkswagen, General Motors and Renault/Nissan). Another explanation could be the heavier presence of urban networks in Paraná and Rio Grande do Sul, compared to Bahia and Goiás.

CNI/ECLAC (2001) shows that investments in the industries have been progressively diversifying since 1996. The tax benefits offered by the states, in conjunction with proximity to the consumer market (in international terms) and labour cost were the main determinants of this process.

In that context, the pattern of factory installations shows that the effects of agglomeration economies and tax benefits offered by the public sector had a major influence on the industrial location of the assembly firms in the period analysed, which expanded beyond the states of São Paulo and Minas Gerais. Those tax benefits to a large degree promoted territorial competition processes which, in conjunction with macro- and micro-location factors, were decisive for the establishment of the new assembly firms.

The installation of those new units must be accompanied by policies based on the internalization of the supply chain in the same region. This makes it possible to optimize what Hirschman (1961) called favourable or trickle-down effects. In addition, policymakers must also keep in mind the possible upstream effects of the

automotive industry, on both the regional and national scale. Moreover, the global competition process in the automotive sector tends to create global input chains, which means that incentives to internalize inputs (local suppliers) become largely ineffective and only benefit a few services and products of limited technological content.

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