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Geographical proximity and technological intensity in manufacturing: evidence from the periphery of the São Paulo-Brasília axis at the beginning of the 21st century

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GEOGRAPHICAL PROXIMITY AND TECHNOLOGICAL INTENSITY IN MANUFACTURING:

EVIDENCE FROM THE PERIPHERY OF THE SÃO PAULO-BRASÍLIA AXIS AT THE
BEGINNING OF THE 21ST CENTURY

PROXIMIDADE GEOGRÁFICA E INTENSIDADE TECNOLÓGICA NA INDÚSTRIA:

EVIDÊNCIAS DA PERIFERIA DO EIXO SÃO PAULO-BRASÍLIA NO INÍCIO DO SÉCULO XXI

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ABSTRACT: This article analyzes manufacturing dynamics along the periphery of the São Paulo-Brasília axis from a perspective that studies the extent to which technological intensity has been influenced by being distant from the core. The aim is to investigate geographical proximity as a limiting factor in the ongoing process of manufacturing deconcentration in Brazil. To measure this phenomenon, the São Paulo-Brasília axis was divided into three peripheral regions: nearby, middle and distant. Subsequently, data related to the industrial workforce, the level of average real salaries, and qualifications of the workforce were used to analyze each of the subdivisions during 2002, 2008, 2014. Results demonstrate that even within a context of investments in transport infrastructure and new possibilities created by advances in communication technologies, the heterogeneities of manufacturing became more intense. The regions geographically closer to the Metropolitan Region of São Paulo demonstrate a higher technological qualification of its industrial structure, while those furthest away are primarily composed of labor-intensive natural resource industries.

KEYWORDS: geographical proximity; industrial deconcentration; technological intensity of the manufacturing industry.

RESUMO: O artigo analisa a dinâmica industrial na periferia do eixo São Paulo-Brasília por uma perspectiva que estuda a influência da distância do centro na intensidade tecnológica. O objetivo é investigar a proximidade geográfica como um fator limitante na desconcentração industrial em curso no Brasil. Para captar esse fenômeno, divide-se esse eixo em três partes: periferia próxima, média e distante. Em seguida, foram utilizados dados de emprego industrial, nível dos salários médios reais e qualificação da mão de obra para analisar cada uma dessas subdivisões nos anos de 2002, 2008 e 2014. Constata-se que, mesmo em um contexto de investimentos em infraestrutura de transportes e com novas possibilidades criadas pelo avanço nas tecnologias de comunicação, as heterogeneidades na indústria se aprofundam. Partes geograficamente próximas à Região Metropolitana de São Paulo continuam tendo maior qualificação tecnológica da estrutura industrial enquanto as mais distantes continuam pautadas, essencialmente, por plantas intensivas em mão de obra e em recursos naturais.

PALAVRAS-CHAVE: proximidade geográfica; desconcentração industrial; intensidade tecnológica da indústria.

Contribution of each author: A. theoretical and conceptual basis and problematization; B. research data and statistical analysis; C. producing figures and tables; D. photographs; E. preparation and drafting of manuscript; F. selection of references.

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INTRODUCTION

One of the paradoxes that has been under discussion with regard to the globalization process is that instead of reducing the importance of geographical proximity, the development of new communication technologies and a logistics infrastructure for transport, has in fact acted to the contrary and has actually intensified it (SONN; STORPER, 2008; STORPER, 1997; 2013). This is due to the fact that, although information and goods may circulate on a global level, certain central factors linked to innovation, such as tacit knowledge, are still dependent on local relations (AUDRETSCH; FELDMAN, 1996; STORPER, 1997).

Based on this premise, our aim has been to investigate geographical proximity as a limiting factor within the ongoing industrial deconcentration in Brazil, focusing on the variation of employment in manufacturing due to technological intensity. The concept of core-periphery (PREBISCH, 2000), applied to the region of influence in the Metropolitan Region of São Paulo (hereafter MRSP) (FURTADO, 1986), is used to analyze the manner in which an increase in physical distance from the core affects the industrial dynamics of the periphery within the context of Brazilian manufacturing deconcentration (AZZONI, 1986; DINIZ, 1991; CANO, 2008; SABOIA, 2013).

Therefore, we have studied the peripheral regions of the São Paulo-Brasília axis. Various urban centers are located along this route, which are essential for the Brazilian manufacturing industry, such as Jundiaí, Campinas, Sumaré, Hortolândia and Ribeirão Preto, in the state of São Paulo (SP); Uberaba and Uberlândia, in the state of Minas Gerais (MG); and Catalão, in the state of Goiás (GO). These urban areas are connected by a multimodal transport system that includes: the Anhanguera and BR-050 highways; the Central Atlantic Railway (FCA); and the São Paulo-Brasília Pipeline (OSBRA).

The idea is that even with investments in transportation and the possibilities created by new communication techniques, there is a division within the types of manufacturing that have grown throughout the periphery of this axis. Regions that are geographically closer to the MRSP present a certain diversification of manufacturing structure, while those that are more distant are essentially labor-intensive natural resources industries. It is our intention to seek an explanation for this phenomenon.

The starting point for our analysis is Furtado's (1986) proposal to divide the interior of the state of São Paulo into three peripheral regions: nearby, middle, and distant. We have therefore applied this same methodology to the São Paulo-Brasília axis. We will then discuss data from the Brazilian Annual Report on Social Information (RAIS) related to the distribution of manufacturing employment, the level of schooling, the average real salary and the locational quotient (QL) in each of these subdivisions. The sections presented are on the microregional level, according to the Regional Division of Brazil as proposed by the Brazilian Institute of Geography and Statistics (IBGE). The data analysis period covers the years 2002, 2008 and 2014.

The article contains five sections, in addition to the introduction. First, we present a theoretical discussion regarding the relationship between the concept of core-periphery and manufacturing deconcentration, analyzing the reasons why geographical proximity remains important. Second, we present a contextualization for

the São Paulo-Brasília axis. Third, we describe the methodology used to conduct the study. Fourth, we provide an analysis of the results, which are then followed by the final considerations.

INDUSTRIAL DECONCENTRATION WITHIN A CORE-PERIPHERY CONTEXT: THE PERSISTENCE OF GEOGRAPHICAL PROXIMITY TOWARDS THE CENTER

The concept of core-periphery refers back to studies from the late 1940s elaborated by the United Nations Economic Commission for Latin America (ECLAC). Although it has been conceived in the international economic system as a critique of the theory of comparative advantage (PREBISCH, 2000; FURTADO, 2007), the idea goes beyond this debate, demonstrating on the one hand, a concern for the particularities that mark the model of peripheral development and, on the other, that the world economy functions as a coordinated, albeit unequally organized, system (EGLER, 1994).

Even if some developments of the core-periphery relationship are linked to the deteriorating terms of trade and latent inflation (RODRIGUEZ, 2009), for the proposed analysis, the first step was to delimit the concept to the slow, uneven diffusion of technical progress. As Rodriguez (2009, 81) states, “core areas are identified with economies where capitalist production techniques first penetrate, whereas the periphery is made up of economies where production initially remains outmoded, from a technological and organizational viewpoint.” This situation displays the structural heterogeneity between the modern and outmoded sides in Latin American economies (PINTO, 2000).

The key idea, however, is that this heterogeneity is not only linked to the core in relation to the periphery, but it is actually present within the periphery itself. These areas are characterized by a dual movement: on the one hand, they are excluded from the modernization process, being dependent on the exploitation of natural resources and/or an unqualified workforce; while on the other, because of lower production costs, they eventually become attractive to dynamic activities with the devalorization of the center (FURTADO, 1986). Thus, two types of “peripheralization” may be distinguished. The first would be characterized as that specializing in natural resources or labor. In this case, “technical progress is not diffused in a homogeneous manner, but is only absorbed into certain activities, especially those related to exports, while the remaining productive structure stands unchanged” (PORCILE; YAMILA; CATELA, 2012, p.2). The second is defined by the mobility of capital, a movement through which the periphery manages to compete with the core to attract industries with a greater level of technological intensity (FURTADO, 1986). In this case, the diffusion of technical progress is more widespread among industrial sectors. Indeed, what distinguishes the first and the second peripheries is a qualitative process related to the type of manufacturing industry that each manages to attract.

Applying the core-periphery model to Brazil reopens the rupture provoked by the Crisis of 1929, which caused the internal market to become the motor of the

national economy (FURTADO, 2007) and the city of São Paulo – which, from the beginning of the 20th century, had emerged as an important urban-industrial nucleus (CANO, 2007) – the economic center¹. Development policies and the Brazilian process of import substitution² reinforced this position and laid the foundations for the expansion of a future metropolis, comprising the capital city of São Paulo and its surrounding cities, such as Guarulhos, Santo André, São Bernardo do Campo and São Caetano (SAMPAIO, 2009). From 1930 until 1970, Brazil witnessed a phase of industrial concentration in these urban regions, which has been widely discussed in the literature (CANO, 2007; DINIZ, 1991; NEGRI, 1996; PACHECO, 1998).

However, for the process under analysis, the present article focuses on the deconcentration period that followed after 1970 (PACHECO, 1998; CANO, 2008), specifically at the beginning of the 21st century. Within this context, the two types of peripheralization become components of the industrial spatial organization. The urbanization process and the population growth increased the demand for food, stimulating the market for food processing industries especially in the interior of the country (NEGRI, 1996), which thereby favored the first periphery. The emergence of diseconomies of agglomeration in São Paulo, with for example the high price of land, increased labor costs, congestion and environmental problems (NEGRI, 1996), created the motivation for the manufacturing industry to seek new locations, favoring the second periphery.

The distinction between these two types of periphery is defined territorially by the physical distance to the core. Although he did not use the terms, Azzoni (1986) identified this phenomenon by indicating that the areas around São Paulo had a different level of attraction and influence. For the author, an “agglomerative field” limited the spread of manufacturing and favored the agglomeration within a radius of around 150km to the capital city of São Paulo (AZZONI, 1986). This process was seen as a “concentrated deconcentration” or, an “extension of the territories of industrial concentration” (SAMPAIO, 2009, p.174).

Sampaio (2009), using the concepts of Milton Santos, distinguished two interdependent movements in the course of deconcentration: a horizontal arrangement, governed by spatial forms that are grouped in a continuous manner, and a vertical arrangement, defined by points that are integrated, although in a discontinuous manner. In order to consider these dynamics in the core-periphery relationship, horizontality is associated with expansion around the core, and verticality with the integration established with more distant peripheries.

During the initial deconcentration phase of the 1970s and 1980s, the importance of being geographically close to the core could be explained by the limitations imposed by the transport infrastructure and the difficulties involved in exchanging information. It should be remembered that the transport system, which will be further discussed in the case of the São Paulo-Brasília axis, was still being created, thereby increasing the costs of moving to more distant parts of the capital. The same assertion may also be made for the information infrastructure, since data-processing and telecommunications services required high investments. Moreover, moving far from the metropolis of São Paulo signified moving away from the country's main consumer market, which could therefore affect the competitiveness of the manufacturing industry. It also signified moving away from the main training center of skilled labor, thereby causing difficulties in acquiring new knowledge and exchanging information.

¹ In general, the core-periphery relationship is applied on an international scale, as originally conceived. Applying it to the national scale, however, follows the evolution of this concept, as seen in Becker (1972). In the case of this article, the influence is from the work of Furtado (1986).

² Further work on the ideological cycle of developmentalism in Brazil was produced by Bielschowsky (1988). For the industrialization process through import substitution in Brazil, Tavares (1973) is suggested.

The point we intend to discuss is that in the 1990s and by the beginning of the 21st century many of the barriers posed by transport and communications infrastructure had been overcome. However, the burden of geographic proximity to the economic core persisted.

Studies have indicated that a reduction in transport costs has limited effects on the spreading of manufacture, since the exchange relationships between distant economies are accompanied by an increase in trade costs³. This is due to the fact that long-distance relationships increase the need for feedback, which thus generates new costs⁴ (STORPER, 2013). From this perspective, while the decreasing costs of commodity detachment constitute a force that stimulates the disintegration of activities within the space, the additional costs that arise from trade relationships act in the opposite direction, strengthening reintegration and the advantage of maintaining commercial ties at a local level (SCOTT, 2006). Hence, being geographically closer to the consumer market remains economically more profitable.

New technologies within the information systems have guided the transmission, processing and storage of information towards a world level with decreasing costs (LASTRES *et al.*, 1999). However, it is essential to remember that information is not the same as economically useful knowledge for the production process (SONN; STORPER, 2008). This type of knowledge has a high tacit dimension, which obstructs its long distance transmission with the use of communication technologies. In this case, face-to-face contact – where verbal and physical language is present – is essential among workers and researchers⁵ (STORPER; VENABLES, 2004). Manufacturing continues to depend on closer ties with educational institutions, which provide skilled workers, especially when engaged in projects for technological development. In this case, because the Science & Technology (S & T) structure in the state of São Paulo remains concentrated over the “wide-ranging environment” of the capital (SUZIGAN *et al.*, 2005), it is therefore essential to be close to this environment.

It may be affirmed that the possibilities of integration promoted by the globalization process do not negate geographical proximity and that the two types of peripheralization continue to be defined by distance from the core. The study on the São Paulo-Brasília axis is presented as a manner of testing this hypothesis.

THE FORMATION AND CONFIGURATION OF THE SÃO PAULO-BRASÍLIA AXIS: EVOLUTION OF THE TRANSPORTATION AND COMMUNICATIONS SYSTEMS

The formation of the axis that today establishes communication between São Paulo and Brasília has historical origins in the colonial period, more precisely, between the end of the seventeenth century and the beginning of the eighteenth century, when the search for gold in the interior of Brazil intensified. With this, a number of routes out of São Paulo towards the countryside were marked out. Among them, the Anhanguera Route – also known as the Estrada Real or Picada de Goiás – which led in the direction of the current region of Franca, crossing the River Grande towards surrounding areas of the what today is Uberaba and Araguari, then moving

³ Trade costs are understood as all the other costs involved in the transfer of merchandise to its final user, except transportation costs (STORPER, 2013).

⁴ Taking the example of the machine industry, based on the work of Gertler (2004), Storper (2013) demonstrates that the transfer of equipment from one place to another includes, in addition to product displacement, costs associated with personalization, installation and training of the workforce.

⁵ It is not a question of alleging that no complex knowledge may be transmitted over long distances (STORPER, 2000), but that in this situation proximity between the actors is central.

beyond the Paranaíba River, to the current municipality of Catalão, and later to the Arraial de Vila Boa (BRANDÃO, 1989).

This route was to gain greater relevance in the late nineteenth century with the growth of coffee production in São Paulo and the formation of mercantile links, such as internal food marketing. The essence of this process lies in the very functioning of the coffee economy. At first, it was possible for farms to produce food crops (beans, corn and rice) intercropped with coffee. Nevertheless, insofar as this production moved into the west, the coffee trees began to be planted closer to each other, limiting food production. Within this context, new farms that specialized in food crops were encouraged (MARTINS, 1986). It is important to highlight that this occurred at the same time that the extensive population growth and the increased urbanization, which São Paulo experienced with European immigration, increased the demand for food. As a result, regions such as the Minas Gerais Triangle and the southern parts of the state of Goiás emerged as potential suppliers of meat and cereals to the emerging São Paulo economy that had formed from coffee.

Gradually, the Anhanguera Route was to be served by the railway. São Paulo and the Minas Gerais Triangle were in charge of the Mogiana Railway Company, which initially started out from Campinas, moving towards Mogi Mirim. In 1883, the line was extended to Ribeirão Preto and five years later, had reached Franca. The line entered the state of Minas Gerais in 1889, with a connection to Uberaba and in 1896, it arrived in Araguari (CMEF, 2016). During the first decade of the twentieth century, together with the Goiás Railway Company, construction began on the line that connected Goiás to Mogiana. By 1913 the lines had extended to Catalão, from where they proceeded through to Annapolis, which was completed in 1935 (CASTILLO, 2012).

A new phase for the axis occurred just after 1930, when road transport became the object of policies to promote national integration (SILVEIRA, 2003). In this context, in 1939, construction work began on the section of the Anhanguera Highway, which was initially responsible for connecting São Paulo to Jundiaí. By 1947, 44 kilometers of the São Paulo-Jundiaí axis had been completely paved and in that same year, work on the “stretch of land between Jundiaí and Campinas was intensified, and completed in 1948” (CANNABRAVA FILHO, 2004, p. 110). It was merely a question of time before it arrived in Ribeirão Preto, which at that time was already a prosperous industrial nucleus in the interior of São Paulo (NEGRI, 1996). The first intervention towards this direction was undertaken in 1953 with the construction of an unpaved road (MESQUITA, 2011).

With the inauguration of Brasília and simultaneously of plans related to the expansion of road transportation across the country, investments in highways were stepped up in this part of the country. By 1959 the Ribeirão Preto stretch had been completely paved and in 1961, the route was completed towards Igarapava, near the frontier with Minas Gerais.

Since then, further integration of the Minas Gerais Triangle and Brasília into the São Paulo road system has aroused the interest of the ruling classes in São Paulo and Minas Gerais. The same, however, may not be said in relation to Goiás⁶. At the time, there was competition within the São Paulo-Brasília axis for the BR-050 and the BR-153 – a route that passed through Goiânia and São José do Rio Preto, strategically positioned to the west of the Triangle, without cutting through its main munic-

6 As Guimarães points out (1990, 124), “the Goiás Government not only tried to boycott the BR-116 highway [BR-050], but also sought to divert the funds from it to a Goiania-Crystalline link (the BR-040 Junction)”. Those behind the construction of the route for the BR-050 were politicians and entrepreneurs from São Paulo.

ipalities of Uberaba and Uberlândia. This second route “during the construction of Brasília and until the early 1960s” maintained the exclusivity of road transportation between the federal capital and São Paulo (GUIMARÃES, 1990, p. 123).

The completion of the axis highway with the BR-050, although conflictual, would be achieved in later decades. By 1961, the route between Uberaba and Araguari was in operation, although it had not been paved. The asphalted link was only completed in 1968 and the route to Brasília via Catalão and Cristalina in 1974 (GUIMARÃES, 1990). At that moment, the construction of the main integration route between the port of Santos, São Paulo and Brasília was completed.

During the 1990s and at the beginning of the 21st century, the São Paulo-Brasília axis received new investments for the transportation system, improving the logistics and linkage systems along its route. The Anhangüera and BR-050 highways were widened to the city of Araguari. The railroad, now controlled by the FCA, interconnected branches in Brasília and Goiânia, and was an important export corridor for agricultural products from the Midwest and the Minas Gerais Triangle. At the same time, the urban areas along this axis benefited from a new communications system consisting of fiber optic cables that followed the entire length of the Anhangüera and BR-050 highways, thereby speeding up the transmission of information. In 1996, the Osbra was inaugurated, with a total extension of 964 kilometers, facilitating the flow of fuels from the Paulínia Refinery (Replan). In addition, although it followed a different route after Uberaba, moving into the Southwest of Goiás, it is also important to mention the Logum Logistics project for the construction of an alcohol pipeline linking São Paulo, Minas Gerais and Goiás also got underway. In 2013, the first phase was completed, which established the 207-kilometer connection between Replan and Ribeirão Preto.

SUBDIVISIONS OF THE SÃO PAULO-BRASÍLIA AXIS: ELEMENTS FOR THE STUDY OF INDUSTRIAL ACTIVITY

The process of industrial deconcentration is usually studied on two levels: national – with an emphasis on reducing the participation of São Paulo and the gains of other federative units (DINIZ, 2000; CANO, 2008); and internal to the state of São Paulo – focusing on the growth of the interior and reducing the percentage of the MRSP (LENCIONI, 1994; SAMPAIO, 2009).

However, some aspects of the industrial scenario suggest the need for a third approach – which in some way may be seen as an outcome of the second – where two conditions need to be included:

- I. An extension of the periphery interlinked with the MRSP into other federative units, such as the Minas Gerais Triangle and the Southeast of Goiás;
- II. A way of identifying the structural heterogeneity that exists in the periphery, which at the same time comprises a number of very dynamic and some less dynamic regions.

In the first point, it should be emphasized that the integration promoted by the São Paulo-Brasília axis represented an extension of the power of influence from the core into other federative units, such as Minas Gerais and Goiás. This system thus

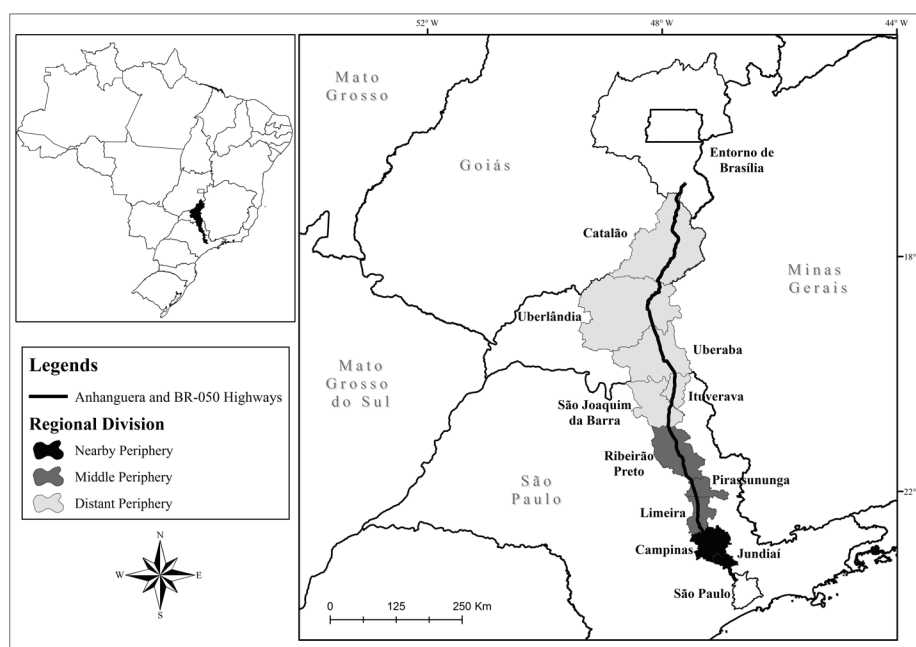
enabled the Minas Gerais Triangle and Southeast Goiás to be included as peripheries of São Paulo. In relation to the second point, it should be stressed that within the Brazilian territorial formation, there are social, regional and productive heterogeneities (BRANDÃO, 2007).

To express the dimension of these phenomena, we applied Furtado's (1986) proposal to divide the São Paulo-Brasília axis into three subdivisions. First, the nearby periphery, characterized by horizontal arrangements towards the core, where there is a higher level of urbanization, educational and research institutes and a greater diversification of production. Second, the distant periphery, characterized by verticality, where there is a high dependence on the exploitation of natural resources or unskilled intensive labor. Thirdly, between these two other subdivisions, the middle periphery, characterized by vertical arrangements, but which constitutes the first area of horizontal advancement. This may be viewed as a transition area between the two previous classifications.

In order to conduct a study on the axis, we mainly used the microregions defined by the IBGE. This may be justified by extending the influence zone of the axis to localities that are situated beyond the municipalities cut through by their transport routes, but that are inserted into the same dynamics of industrial growth.

In order to select the microregions for the present work, we began from the line of the Anhanguera and BR-050 highways. This choice is justified by the importance of road transport in integrating the peripheral region of the São Paulo-Brasília axis. On completion of this task, this axis was divided into the following sections: nearby periphery: Jundiaí and Campinas; middle periphery: Limeira, Pirassununga and Ribeirão Preto; and distant periphery: São Joaquim da Barra and Ituverava in São Paulo, Uberaba and Uberlândia in Minas Gerais, and Catalão in Goiás. The final result is illustrated in Map 1.

Map 1: Microregions and subdivision of the São Paulo-Brasília Development Axis



Source: Produced with IBGE (2016) data.

For the empirical analysis, we selected the years 2002, 2008 and 2014, thereby providing us with a dimension that includes periods with high (2002-2008) and low (2008-2014) economic growth.

To study the disparity of deconcentration in the nearby, middle and distant peripheries, manufacturing industry was divided according to its technological intensity. To this end, we used the types of industrial groups from the Organization for Economic Co-operation and Development (OECD), inspired by Furtado and Carvalho (2005), and the translation proposal of the Brazilian National Classification of Economic Activities (known as CNAE) version 1.0 to 2.0 by Sampaio (2015). The groups analyzed were of high technological intensity (HTI); medium-high technological intensity (MHTI); medium-low technological intensity (MLTI); and low technological intensity (LTI).

The data used were obtained from RAIS. The following items were discussed: the number of actively engaged employees on December 31st of the stated years; the qualification of work; and average salaries. The specialization indicator used was the QL, calculated as follows:

$$QL = \frac{(\sum Eri / \sum Eai)}{(\sum Ert / \sum Eat)}$$

where *E* refers to the number of employees, *r* to the region under analysis, *i* to the industrial group in question, *a* to the value of the São Paulo-Brasília axis and *t* to the total. Values greater than 1 indicate a greater degree of specialization of the sector in the region, while numbers less than 1 demonstrate a lower degree of specialization.

INDUSTRIAL DECONCENTRATION ALONG THE PERIPHERY OF THE SÃO PAULO-BRASÍLIA AXIS IN TERMS OF TECHNOLOGICAL INTENSITY (2002, 2008 AND 2014)

In this section we present the results from the analysis related to the peripheries of the São Paulo-Brasília axis. Data is presented regarding the number of jobs; the locational quotient; and finally, on the base salaries and qualifications of the workforce.

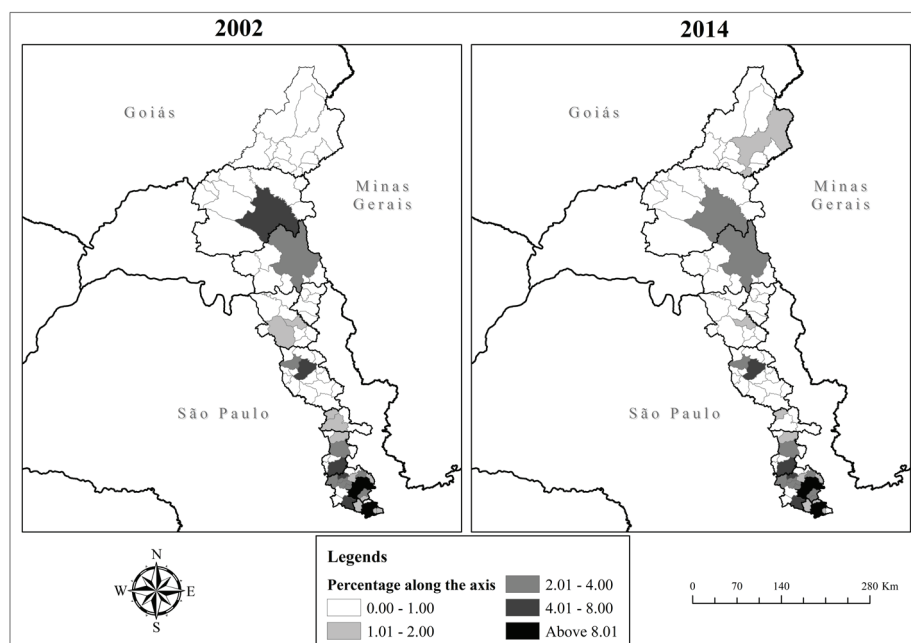
NUMBER OF JOBS IN THE MANUFACTURING INDUSTRY

The total number of jobs in manufacturing along the periphery of the São Paulo-Brasília axis increased from 341.75 thousand in 2002 to 506.16 thousand in 2008 and to 548.75 thousand in 2014, which generated an average growth rate of 4% per annum.

Between 2002 and 2008, the total number of employees in the nearby periphery of the São Paulo-Brasília axis fell from 59.0% to 57.6%, and remained within this range, with 57.7%, in 2014. The middle periphery increased from 25.2% to 26.6% between 2002 and 2008, to 26.9% in 2014. The distant periphery remained at 15.8% between 2002 and 2008, and dropped to 15.4% in 2014.

The industrial growth is detailed in Map 2, based on the participation of each municipality in the total number of industrial jobs along the São Paulo-Brasília axis in 2002 and 2014.

Map 2: The São Paulo-Brasília Axis: Participation of the municipalities in the total number of jobs (in %)

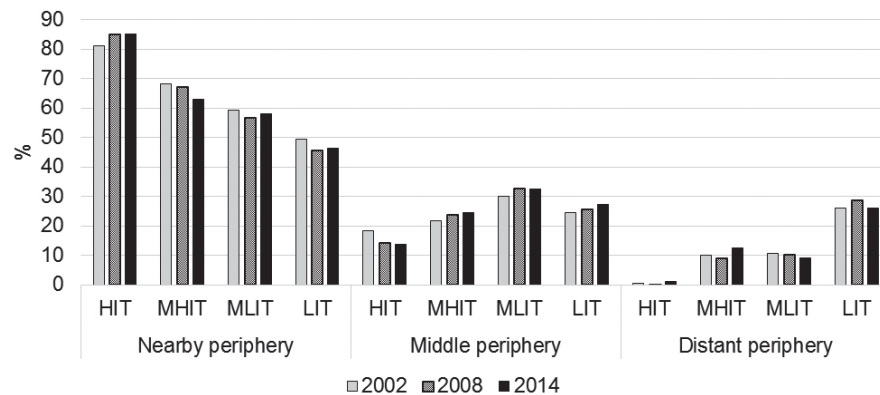


Source: Produced with microdata from RAIS (2002 and 2014).

The formation of an urban-industrial agglomeration may be observed in the microregions of the nearby periphery. This fact is evident in the microregion of Campinas, where the 2.91 pp decrease in participation in the São Paulo-Brasília axis by the main municipality between 2002 and 2014 is to some extent offset by the growth of the continuous municipalities of Hortolândia (0.90 pp), Sumaré (0.69 pp), Vinhedo (0.63 pp) and Indaiatuba (0.60 pp). Although to a lower degree, a similar event may be observed in the middle periphery, in the microregion of Ribeirão Preto where the homonymous municipality reduced by 0.07 pp, although Sertãozinho and Cravinhos increased by 0.52 pp and 0.36 pp, respectively. On the other hand, in the distant periphery, the main municipalities of the microregions absorbed almost the entire manufacturing of the microregion. Thus, decreases such as in Uberlândia (-1.31 pp) and Uberaba (-0.58 pp), are not compensated for in the local sphere. In the distant periphery, the reason the decrease was not greater was because Catalão emerged as an industrial nucleus. This municipality grew by 0.65 pp induced by the construction of a Mitsubishi plant and through recent investments in industries producing agricultural inputs and equipment.

However, the distinction between the manufacturing industry dynamics of the peripheries of the São Paulo-Brasília axis is not only quantitative but also qualitative. This statement is evidenced in the location of the HTI, MHTI, MLTI and LIT groups in their different parts, as expressed in Graph 1.

Graph 1: Employees in the manufacturing industry along the entire São Paulo-Brasília Axis (in %, actively engaged on 31/12)



Source: Produced with microdata from RAIS (2002, 2008 and 2014).

The nearby periphery, which in 2002 registered 81.2% of the total employment of the HTI group along the São Paulo-Brasília axis, increased its share to 85.1% in 2008 and 85.2% in 2014. On the other hand, there was a decrease in this group in the middle periphery and a small increase in the distant periphery, but in this latter it still constitutes something residual.

The deconcentration along the axis was more effective in the MHTI and LTI groups, in that the nearby periphery presented losses of 5.3 pp and 3.1 pp respectively between 2002 and 2014. In the MHTI group, both the middle and the distant peripheries presented positive growth rates during the period. In the LTI group however, the deconcentration movement was essentially driven by the middle periphery. While the HTI activities in the distant periphery presented greater competitiveness, they presented a reduction just after the international crisis of 2008, and a deceleration of the country's economic growth after 2010, resulting in decreased relative values (-2.5 pp) along the axis and absolute values (4.2 thousand of the employment links) between 2008 and 2014.

LOCATIONAL QUOTIENT AND TECHNOLOGICAL DISPARITIES IN THE MANUFACTURING INDUSTRY

A second factor that reinforces the evidence regarding the limits of industrial deconcentration and the increase of regional heterogeneity in the peripheries of the São Paulo-Brasília axis is the degree of specialization regarding technological intensity, measured on the basis of LQ. This data is presented in Table 1.

Initially, a degree of specialization may be observed in the HTI group of the nearby periphery. This result is basically due to the dynamism of two activities: the pharmaceutical industry, with companies such as Rhodia, Medley (Campinas) and EMS (Hortolândia); and the electronics industry, with the presence of global players such as Dell, ZTE (Hortolândia), Ericsson (Indaiatuba), HP, Foxconn, Siemens (Jundiaí) and Samsung (Campinas).

Table 1: Location quotient (LQ) of the periphery along the São Paulo-Brasília Axis

Technological Intensity	Nearby Periphery			Middle Periphery			Distant Periphery		
	2002	2008	2014	2002	2008	2014	2002	2008	2014
HTI	1.38	1.48	1.48	0.73	0.54	0.51	0.03	0.04	0.08
MHTI	1.16	1.17	1.09	0.86	0.90	0.91	0.64	0.57	0.82
MLTI	1.01	0.99	1.01	1.19	1.24	1.21	0.67	0.65	0.60
LTI	0.84	0.79	0.80	0.97	0.97	1.02	1.64	1.82	1.70

Source: Produced with microdata from RAIS (2002, 2008 and 2014).

Among the reasons that explain the growth of these types of manufacturing is the fact that the nearby periphery fosters the generation of beneficial, tacit knowledge for the production process. At this point, we highlight the role of Campinas, where there is an “extremely favorable environment for research, which began to form with the presence of several agricultural research centers and the implementation of the State University of Campinas (UNICAMP), in 1962” (DINIZ, GONÇALVES, 2005, p.160). In addition to the university system, also present are the Institutes of Science and Technology (known as ICTs) – such as the Center for Research and Development in Telecommunications (CPqD), the National Center for Research in Energy and Materials (CNPEM) and the Eldorado Research Institute (BALDONI, 2015) – and the technical training courses for the industrial workforce (SUZIGAN *et al.*, 2005). In addition, the nearby periphery has a higher possibility of obtaining skilled labor and technological knowledge, thereby facilitating the creation of partnerships and new technologies (GARCIA *et al.*, 2014).

With regard to the nearby periphery, it is also important to highlight the MHTI group, which, although demonstrating a fall in the LQ, remained above 1.0. In this case, it is the automobile industry that stands out, with the Honda (Sumaré) and Toyota (Indaiatuba) plants, which resulted from a set of investments during the second half of the 1990s and the 2000s; together with automotive parts industries, such as Pirelli and Bosch, both in Campinas.

The table also demonstrates a high degree of specialization in the LTI sector in the distant periphery, for which the municipality of Uberlândia is largely responsible, where there are plants from Cargill, ADM Agrícola and ABC Agro, related to soybean processing, and BRF (formerly Sadia), for meat processing. Also noteworthy is the role of Uberaba, São Joaquim da Barra and Ituverava in the distant periphery as important locations of sugarcane mills associated with the production of sugar.

The agro-industrial growth in the distant periphery may be divided into two phases. The first is linked to the grain and meat industries, which continued their shift from the agricultural frontier to the Cerrado regions after modernization in the 1970s and 1980s. This process made it attractive for the food industries to migrate to the region, because they could increase the economies of scale with the proximity of production that was established in Central Brazil, especially of soybean (CASTRO; FONSECA, 1995). At the time, because there were few regional centers that until then had formed in the Midwest, Uberlândia became the center for resources in that region and began to attract agro-industries (MESQUITA, 2011). The second phase, linked to the sugarcane agro-industry, occurred during the first decade of the 2000s, when there were more intense signs of depletion on the frontier of the more traditional zones of São Paulo (FIGUEIRA; PEDROSA; BELIK, 2013). This mo-

ment coincides with the growth of the ethanol and sugar market, which favored the displacement of mills to the distant periphery.

The middle periphery finds itself in an intermediate position in relation to the nearby and distant peripheries. In this subdivision, the role of the Ribeirão Preto microregion should be highlighted. This region has an industrial structure historically related either to the processing of sugarcane or the production of industrial inputs for the sugarcane mills. However, currently there has been a diversification in the industrial structure with the growth of the medical and hospital equipment sector. According to Suzigan et al. (2005, p.10), the only microregion outside the broad axis “that has been formed with the Metropolitan Region of São Paulo, and which is among the ten largest microregions in terms of participating in the employment of technological occupations is that of Ribeirão Preto”. Part of this process has also been to valorize the scientific research developed through the University of São Paulo (USP) and the Foundation of the Advanced Institute Center for Health (Fipase), thereby bringing a local scientific base for manufacturing, hitherto centered on agriculture.

Although only slightly representative and with little interference in the LQ, one phenomenon that should be highlighted in the middle periphery is related to the growth of certain sectors of the HTI and MHTI groups in the microregion of Limeira. This result is due, respectively, to the machinery and equipment sector (Newton and LC Máquinas) and components for motor vehicles (TRW Automotive and Fumagalli), in the municipality of Limeira, and organic chemistry in Iracemápolis⁷. Limeira has been also recognized for the manufacture of semi-precious stones and ceramics. However, there are initial signs of an expansion of horizontal arrangements from the nearby periphery towards the middle periphery.

⁷ In 2016 the Mercedes-Benz industrial plant was inaugurated in this municipality.

AVERAGE REAL SALARIES AND QUALIFICATION OF THE WORKFORCE

Lastly, it is important to discuss factors related to the level of salaries and the qualification of the workforce. These data help to analyze the previously-collected information and emphasize that the heterogeneity of the São Paulo-Brasília axis is a phenomenon that is both economic and social. Table 2 presents this relationship at the level of mean salaries.

Table 2: Average real salaries in the manufacturing industry in the periphery along the São Paulo-Brasília Axis (in R\$)*

Technological Intensity	Nearby Periphery			Middle Periphery			Distant Periphery		
	2002	2008	2014	2002	2008	2014	2002	2008	2014
HTI	2.716	3.306	3.517	1.445	1.568	1.978	701	881	1.317
MHTI	3.430	3.426	4.012	1.684	2.195	2.573	1.390	1.699	1.967
MLTI	2.146	2.497	2.869	1.740	1.511	1.853	988	1.296	1.319
LTI	1.948	2.041	2.506	1.678	1.926	2.170	1.248	1.500	1.655
Total Ind. Transf.	2.556	2.806	3.215	1.666	1.818	2.159	1.146	1.419	1.599

Source: Produced with microdata from RAIS (2002, 2008 and 2014).

* Deflator: General Price Index-Internal Availability (IGP-DI); Base period: December 2014. The cents were omitted.

It should be highlighted that although there has been a growth in the total value⁸ of salaries throughout the selected periods along the entire axis, a distinction

⁸ There were few groups and periods in which a reduction was observed in the real average wage. In the nearby periphery, in MAIT there was a reduction of R\$4.00 between 2002 and 2008; in the middle periphery, in MAIT there was a reduction of approximately 13% between 2002 and 2008; and finally, it should be noted that there were no reductions in the distant periphery.

persists at all levels among the nearby, middle and distant peripheries. It is important to note the manner in which the average salary decreases as the distance to the center increases.

Salaries in the nearby periphery are the highest in all the industrial groups, but the difference is greater in the HTI and MHTI groups. Even when compared with the middle periphery there is a very expressive difference. In this case, taking the year 2014 as the base, the salary of the nearby periphery was 43.8% higher in the HTI group and 35.9% higher in the MHTI group.

In relation to the distant periphery, lower salaries collaborate to demonstrate that industrial growth is not only related to activities that are intensive in natural resources, but is also due to the search for lower labor costs. This may be an explanatory factor for the HTI, MLTI and MHTI groups. It should be noted that, compared to the nearby periphery, in 2014, salaries in the distant periphery in the LTI group were 34.0% lower; in the MLTI group, the difference was 54.0%; and in the MHTI group, 51.0%.

Educational level is an important variable in determining the level of average real salaries and the capacity to generate innovations. This possibility is more present in the strata of the population with an educational level above or equal to a higher educational degree. A first appreciation of these data is presented in Table 3, which indicates the percentage of workers with and without higher education in each of the divisions along the São Paulo-Brasília Axis.

Table 3: Educational level of employment in the manufacturing industry in the periphery of the São Paulo-Brasília by subdivision (in % along the entire axis)

Periphery of the SP-Brasília Axis	No higher education		Higher education and above	
	2002	2014	2002	2014
Nearby Periphery	57,91	55,83	74,10	70,63
Middle Periphery	25,77	28,09	17,46	18,72
Distant Periphery	16,32	16,08	8,44	10,64
Total	100,00	100,00	100,00	100,00

Source: Produced with microdata from RAIS (2002 and 2014).

Initially, it may be observed that there is a concentration of workers with higher education and above in the nearby periphery. Despite a reduction of 3.47 pp, registered between 2002 and 2014, this subdivision of the São Paulo-Brasília axis nonetheless registered 70.6% of employees within this category. However, the middle and distant peripheries together registered 29.4%.

This reinforces the notion that there are many more skilled workers in the nearby periphery. Higher levels of education are essential for the need to dominate all scientific and technological aspects directly related to the processes of innovation and increasing industrial productivity, for which the nearby periphery is revealed as being a differential representative along the axis.

FINAL CONSIDERATIONS

The present article has demonstrated that improvements in the transportation infrastructure and communications system, which make the São Paulo-Brasília axis a privileged area in terms of communications and logistics, have been accompanied by an increase in manufacturing heterogeneity. A clear distinction persists between different types of peripheralization as defined by the physical distance from the economic center.

The nearby periphery reproduces the peripheral type capable of competing with the center for attracting more dynamic industries, since it offers certain advantages, such as lower trade costs and a favorable environment for research and workforce qualifications. In this system, the generation and use of tacit knowledge in the manufacturing industry process is more expressive and face-to-face contacts are more frequent. Salaries are at their highest in this subdivision, where the largest portion of workers with higher education is also located.

The distant periphery reproduces the idea of dependence on natural resources and/or labor intensive activities, with industries that seek lower labor costs. The most expressive activities in this region are those of HTI. There is only one case outside this group, which is the automotive industry in Catalão (GO). In this subdivision, wages are lower than in the nearby and middle peripheries in all industrial groups. This is also the area of the axis with the fewest workers to have attained higher educational qualifications.

The middle periphery constitutes a region that has developed based on resource intensive industries. However, unlike the distant periphery, this subdivision is undergoing a process to obtain greater industrial diversification, such as in the microregion of Ribeirão Preto and Limeira. Thus, certain elements have been created that cause the middle periphery to approach the second type of peripheralization, although, in essence, this subdivision of the axis continues to be associated with the LTI and MLTI groups.

Instead of creating a system capable of reducing the disparities of manufacturing, as observed in the São Paulo-Brasília axis, based on LQ data, specialization was accentuated in the nearby periphery in the sectors of greater technological intensity, while the distant periphery has conceived the same process in the lower intensity group. In the middle periphery, the highest degree of specialization is in the MLTI group.

Thus, the idea is that manufacturing deconcentration has remained limited, since the HTI and MHTI groups have maintained spatial arrangements defined by the horizontalities, which chiefly privileges the nearby periphery. On the other hand, the activities of the MLTI and LTI groups demonstrate a greater potential for growth through vertical arrangements, which are the main engines of the manufacturing industry, both in the middle and in the distant periphery.

The results support the concept that current localization patterns of manufacturing extend way beyond transport costs or information flows, depending on local characteristics such as university-business partnerships, scientific research, face-to-face contacts and the local training of a skilled workforce. A favorable environment for this system was created in the contiguous areas to the core and little has changed with the advance of globalization and greater articulation between places.

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