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Spatial patterns of mobility of skilled workers in Brazilian regions

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Abstract
The mobility of skilled workers represents an important local knowledge spillovers due to its capacity to increase the creation and diffusion of new knowledge in regions. In this way, the aim of this paper is to present the patterns of spatial mobility of skilled workers in Brazilian regions. Based on the microdata from the Annual Report on Social Information for the period 2009-2014, we map the mobility of skilled workers among microregions throughout the country, contributing to the debate on the patterns of mobility of skilled workers, which have important effects on regional development. The results show that the São Paulo Metropolitan Area, some state capitals, and medium-sized Brazilian cities were the regions that received more skilled workers, as well as diversified regions, and those with a higher share of high-tech activities. Additionally, skilled workers present higher mobility than nonqualified workers.
Keywords: mobility, knowledge spillovers; skilled workers.

Resumo
A mobilidade de trabalhadores qualificados representa uma das mais importantes formas de geração de transbordamentos locais de conhecimento, uma vez que trabalhadores qualificados possuem a capacidade de incrementar a geração e a difusão de novos conhecimentos nas regiões. Nessa linha, o objetivo deste artigo é apresentar os padrões de mobilidade espacial dos trabalhadores qualificados nas regiões brasileiras. A partir dos microdados da RAIS no período 2009-2014 foi possível mapear a mobilidade desses trabalhadores entre microrregiões em todo o país. Os resultados contribuem para o debate sobre os padrões de movimentação de trabalhadores qualificados, com efeitos importantes sobre o desenvolvimento regional. Os resultados apontam que a Região Metropolitana de São Paulo, algumas capitais de estados e cidades médias brasileiras foram as regiões que mais receberam trabalhadores qualificados, com destaque para regiões que são mais diversificadas e possuem maior número de atividades tecnológicas. Adicionalmente, observou-se que os trabalhadores qualificados se movem percentualmente mais do que os totais.
Palavras-chave: mobilidade; transbordamento local de conhecimento; trabalhadores qualificados.

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1 Introduction

Local knowledge spillovers and their effects on the development of regions have been widely explored in the literature on regional economics and innovation. Since Marshall's (1920) seminal work, local knowledge spillovers have been identified as one of the main drivers of regional development (Marshall, 1920), as they largely explain the formation of clusters of firms and the concentration of innovative activities (Feldman & Audretsch, 1999; Grossman & Helpman, 1991). However, the literature has paid less attention to the mechanisms by which knowledge flows are diffused among regions (Breschi, Lawson, Lissoni, Morrison, & Salter, 2020; Breschi & Lenzi, 2010).

One of the mechanisms of knowledge transfer between regions is the mobility of skilled workers (Boschma; Eriksson & Lindgren, 2014; Breschi & Lenzi, 2010; Gagliardi, 2015; Lenzi, 2013). In recent years, scholars have shown the important role of skilled workers and their mobility patterns as active actors in the dissemination of new knowledge, with positive effects on the development of regions and on firms' innovation (Agrawal, Cockburn & Mchale, 2006; Almeida & Mchale, 2006; Almeida & Mchale, 2006; Almeida & Mchale, 2006). Kogut, 1999; Breschi & Lenzi, 2010). The mobility of skilled workers is one of the factors that affects knowledge sharing, as it is a way of increasing the intensity and concentration of knowledge flows (Breschi & Lissoni, 2001; Faggian, Rajbhandari & Dotzel, 2001; Faggian, Rajbhandari & Dotzel, 2017; Fratesi, 2014; Lenzi, 2013). The mobility of skilled workers enables knowledge to circulate at the regional level (Boschma *et al*., 2014), as knowledge is embedded in the capabilities and skills of individuals, and through mobility, the tacit and idiosyncratic attributes of knowledge become transferable (Breschi & Lenzi, 2010; Fratesi, 2014).

Based in this debate, the aim of this paper is to present the patterns of spatial mobility of skilled workers in the Brazilian regions. The mobility of workers is a little explored subject in the Brazilian debate since few studies have addressed the determinants of mobility and its relationship with innovation (Costa, Garcia, Roselino & Cruz, 2023; Gonçalves, Ribeiro & Freguglia, 2016; Mendes, Gonçalves & Freguglia, 2017). Therefore, there is a gap in the debate regarding the identification of the main mobility patterns of skilled workers in Brazil. Thus, the main contribution of this paper is to present a mapping of the mobility of skilled workers across Brazilian regions, which allows identifying patterns of mobility of these workers and the regions that received more skilled workers in the analyzed period. The identification of these standards can help to understand the main impact on regional development in Brazil, given the ability of skilled workers to create and disseminate new knowledge in regions. In addition, we can also move forward in the understanding of the ways in which local spillovers of knowledge manifest themselves, since skilled workers tend to be employed in activities that generate greater dynamism for the regions.

To perform this mapping, we develop new measures of worker mobility among different Brazilian microregions throughout the country between 2009 and 2014. These measures were constructed by using microdata at the individual level of Brazilian formal workers, available in the Identified Annual Report of Social Information (RAIS ID). The mobility pattern is presented for 3 groups of workers in selected economic activities: total workers; workers with higher education; and workers employed in technical and scientific occupations (STEM occupations). Two of these measures have been considered skilled workers.

The main results show, first, that the mobility flows of workers toward metropolitan regions stand out, with a strong emphasis on the São Paulo Metropolitan Area (SPMA). Second, there is a pattern of mobility of skilled workers, beyond the SPMA, to some capitals and

medium-sized cities in the interior of the main states, especially São Paulo and Rio de Janeiro. Both patterns point to the mobility of workers to clustered and diversified regions, such as state capitals, or with specialization in some technological area. In these regions, the exchange of knowledge among actors is a relevant positive local externality, with important effects on innovation-based regional development. Finally, we find that there is a strong movement of skilled workers in comparison to the total workforce, which shows the greater possibilities of circulation and sharing of knowledge, intensifying the benefits of local spillovers through the mobility of skilled workers.

The article is structured in 5 sections, including this introduction. The next section discusses some brief conceptual remarks on the importance of the mobility of skilled workers for regional development. Section 3 presents methodological aspects, such as the assembly of the database and the method of constructing the mobility measures. Section 4 shows the main results of the mapping of worker mobility in Brazil, and section 5 discusses the main findings and the implications for the debate.

2 Mobility of skilled workers and regional development

The literature has studied for some decades the role of local knowledge spillovers and local external economies as one of the drivers for promoting regional development (Crescenzi, Rodríguez-Pose & Storper, 2007; Feldman & Audretsch, 1999). Local knowledge spillovers are related to the availability of knowledge in a region and its possibilities for generating externalities. The importance of knowledge is highlighted, as it is a specific asset inherent to people and the basis on which productive activities are developed. Knowledge is an output from the actions of individuals, and it is not fully reducible to a formal set of principles. Knowledge is partially tacit, which reveals the importance of the personal and social context in which it is shared (Garcia, 2021; Gertler, 2007).

Recognizing that scientific and technological knowledge is largely tacit, empirical studies have identified that knowledge spillovers are strongly mediated by geographical factors. Face-to-face contacts and frequent interactions are mechanisms by which knowledge is shared among agents. Several studies recognize the role of skilled workers and their mobility patterns as mechanisms for disseminating knowledge, with positive effects on regional development (Breschi & Lenzi, 2010; Miguelez, 2019). As knowledge is embedded in people, the mobility of skilled workers impacts the possibilities and opportunities of sharing knowledge.

Among scholars, there are several efforts to understand the flows of knowledge and the mobility of workers. As knowledge is embedded in the abilities of individuals to decode it (Fratesi, 2014), the diffusion of knowledge is related to the mobility of skilled individuals who create (social and professional) contacts and relationships (networks) with other actors (Breschi & Lenzi, 2010; Miguelez, 2019). Social relations are developed primarily at the local level. However, as they become well established, they persist, even as people relocate to other regions or greater distances (Breschi & Lenzi, 2010, Pinate, Faggian, di Berardino & Castaldi, 2022). The prior location of workers not only allows for the formation of social relations among actors but is also able to shape and direct the subsequent geographical distribution of knowledge spillovers. Knowledge flows are considered a regional phenomenon (Almeida & Kogut, 1999), so they are shaped differently according to the region. In industrial clusters, the concentration of several agents can generate external economies, which benefit all clustered actors (Suzigan, Furtado, Garcia, & Sampaio, 2004). The creation of networks is among these externalities, since

it allow actors to get to know each other, facilitating the employment of certain individuals and access to information about the others knowledge.

On the other hand, in large and diversified cities, the existence of knowledge spillovers takes on a distinct character, more associated with the generation and diffusion of more diversified and complex knowledge (Jacobs, 1969), in line with the notion of buzz cities (Asheim, Coenen & Vang, 2007; Storper & Venables, 2004). Buzz cities are usually defined as highly urbanized cities with high productive and social diversity. The diversification of economic activities, concentration and apparent disorganization allow actors to incorporate new skills that make them better able to interact and cooperate with their peers, in addition to promoting the exchange of more complex ideas and knowledge (Asheim et al., 2007). Large cities are characterized by having highly trained and productive professionals, which encourages interaction among them in specialized networks, even in different sectors. Face-to-face contact is one of the main mechanisms of knowledge circulation among actors, which results in competitive advantages for local producers and reinforces the process of agglomeration and knowledge transfer in these regions (Rodríguez-Pose & Crescenzi, 2008). In these cities, agglomeration forces are dependent not only on the classical economies of agglomerations (advantages of location and labor) but also on institutional factors related to buzz, equivalent to different types of cognitive, organizational, social, and institutional proximity (Rodríguez- Pose & Crescenzi, 2008). Face-to-face contact is an important element in understanding the concentration of these urban agglomerations (Rodríguez-Pose; Crescenzi, 2008).

The mobility of workers can bring several benefits, representing a powerful source of new knowledge for local producers. When professionals come from other regional firms, skilled workers can bring new knowledge to the region. These professionals represent an important way of internalizing new knowledge in the region, as they are in contact with external sources of innovation. New knowledge is often important to avoid regions from locking in certain technological and organizational trajectories (Hassink, 2010).

It is important to recognize the importance of worker mobility for regional development (Fratesi, 2014; Saxenian, 1999, 2005). Previous studies have identified a positive relationship between the presence of people from other regions and the innovation levels of individual firms (Faggian et al. 2017), with positive effects on the competitiveness of local firms and economic growth of the regions, in addition to other long-term benefits (Maré, Fabling & Stillman, 2014). The movement of workers changes the composition of the local workforce by bringing different types of knowledge that were not available in the region, increasing the diversity of local interactions. Workers entering a region bring with them tacit knowledge, which is only accessible locally, in addition to connections with people and networks from different locations (Maré et al., 2014). The interactions are not only carried out within the firms, and the regional benefits are diverse, especially for small and medium enterprises, since the local workforce tends to be an important source of new knowledge and ideas. The movement of skilled workers is one of the main mechanisms for the diffusion of tacit knowledge, as the influx of skilled workers tends to enrich the local knowledge base. There are direct effects associated with hiring workers in the labor market and indirect effects related to the existence of externalities and through the networks of relationships that connect individuals, groups, firms, and industries with different knowledge bases (Gagliardi, 2015).

The mobility of workers is an important way for the transfer of external knowledge, which can renew and increase the local knowledge base (Almeida & Kogut, 1999). The benefits of the mobility of skilled workers is intensified if there are mechanisms that facilitate the

circulation of this knowledge among actors, such as the formation of knowledge networks (Breschi & Lissoni, 2009; Miguelez, 2019) and forms of cognitive proximity agents (Capello & Caragliu, 2018; Santos, Garcia, Araujo, Mascarini & Costa, 2020). Workers who move bring their knowledge with them, and the benefits of this displacement occur when this information is effectively shared, either through formal agreements (Breschi & Lissoni, 2001) or through their networks or informal contacts (Araújo & Garcia, 2013; Dahl & Pedersen, 2004).

3 Methodology

3.1. Database

The mapping of worker mobility was performed using data from the identified version of the Annual Report of Social Information (RAIS ID). The RAIS ID provides individual-level information, which allows us to track all formally registered workers in any economic activity in Brazil. In addition to information related to their occupation, education, location, and classification of activity in which the worker is employed over time. The wide scope of this database guarantees several advantages. On the other hand, there are disadvantages related to the possible problems related to its filling, such as omissions and problems of aggregation between headquarters and branches. However, given the scope of the analysis performed in this research, these problems do not affect the main findings of the mapping.

We present an empirical and descriptive analysis related to the interregional mobility of workers in Brazil between 2009 and 2014. The mobility of workers was mapped with 3 different approaches:

a) Total workers.
b) Workers with Higher Education: workers who had completed higher education, in 2014, including master's and doctoral degrees.
c) Workers in Technical and Scientific Occupations (STEM): workers who, in 2014, were registered in selected occupations. Occupations include researchers, engineers, R&D directors, managers, and scientific professionals. These were selected because they are potentially involved in science and technology activities (ARAÚJO; CAVALCANTE; ALVEZ, 2009). These occupations can be classified as STEM occupations (science, technology, engineering, and math occupations).

For each approach, mobility was mapped according to the economic activities (CNAE) to which the worker moved: Manufacturing, Extractive and Agriculture. These activities are important for regional productive and technological development, as they have a greater number of qualified professionals compared to other activities, such as personal services. In addition, activities that demand specific knowledge may be more related to the possible transfer of knowledge. The queries were performed using free database management software called pgAdmin III.

3.2. Mobility indicators

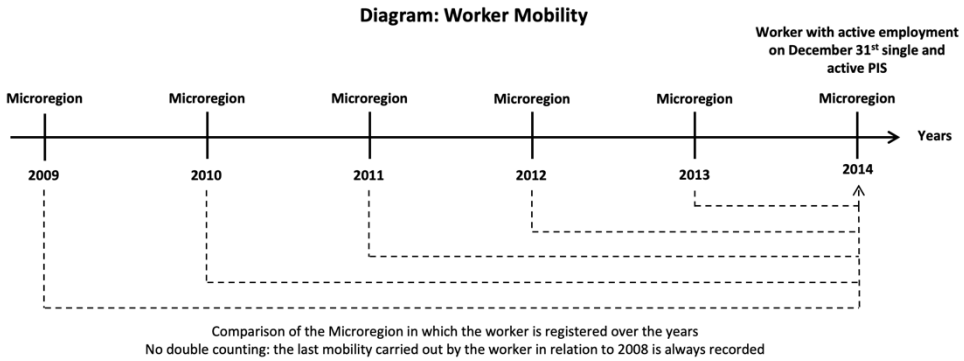
To assemble the mobility measures based on the RAIS ID, we use two data sources: an identifier (ID) for each worker's employment relationship (using the Programa de Integração Social do Trabalhador – PIS) and the possibility of obtaining information on the change of employment record. workplace in a period. To assess whether a worker has changed their place

of work, it is necessary to know where they were employed at some point, information available in the active contract on December 31st.

The idea of the mobility measure is to compare a worker's location through their identifier number and their status as an active worker on December 31st, 2014, and their active contract on December 31st for the other years. Figure 1 presents the scheme of assembling the mobility measure. We use microregions as the geographical unit of analysis of the interregional movement of workers. Microregions are widely used in studies of local spillovers of knowledge since knowledge rarely respects the geographical limits of municipalities.

Figure 1

Scheme of construction of the measure of worker mobility



Source: Own elaboration

First, we compare the microregion where the worker's contract with a single and active identifier was registered on December 31st, 2014, and the worker's contract with a single and active identifier on December 31st, 2013. If the location of the employment relationship was different between the two years of employment, we considered that there was mobility. Next, the same queries were performed for the other years, but a new condition was added: if between 2013 and 2014 there was mobility related to a particular worker with a single and active identifier, they are not included in the mobility calculation in the other years, i.e., this worker does not appear in the mobility from 2012 to 2014, 2011 to 2008, and so on. This condition avoids errors related to the counting of intermediate movements of the worker; if the worker has moved to another microregion in several years, it is possible to know when the change of place of employment in relation to 2014 occurred. The next step was to count mobility, aggregating them by microregion, called inflow, which was accounted for when a worker entered a microregion.

4 Mapping of worker mobility

4.1. Mobility of workers in Brazil

This section shows worker mobility in Brazil between 2009 and 2014. Table 1 presents the mobility data for each period analyzed for the selected economic activities.

Table 1
Mobility of workers in Brazil

Time	Total		Higher Education		Technical and Scientific Occupations	
	Inflow	Outflow	Inflow	Outflow	Inflow	Outflow
2009-2014	210,673	206,258	27,045	27,729	3,625	3,437
2010-2014	261,355	259,873	36,562	37,266	5,507	5,468
2011-2014	313,093	314,685	43,495	43,282	10,059	10,377
2012-2014	372,441	366,819	58,472	57,957	7,994	8,183
2013-2014	312,115	320,711	39,278	39,617	8,016	8,255
Total	1,469,677	1,468,346	204,852	205,851	35,201	35,720

* In the mobility of workers in the selected CNAEs, the equivalence between inflow and outflow does not exist, since, by changing the microregion of registration, workers can be admitted to other economic activities not analyzed.
Source: Own elaboration

Table 2 shows the worker mobility and the share of new entrants in the local workforce. It also presents the share of workers who moved over the years in each category of workers. For the mapping, it was observed throughout the study that both the inflow and outflow of workers occur repeatedly in the same microregions, evidencing a significant movement of workers in these regions. Thus, the mapping presents information related to the inflow of workers in the regions.

Table 2
Mobility of workers and the local workforce (2009-2014)

Workers	Mobility (a)	% Local workforce	Workers (b)	% (a/b)
Total	1,469,677	15.4	9,518,357	15.4
Higher Education	204,852	2.2	858,229	23.9
Technical and Scientific Occupations	35.201	0.4	137,300	25.6

Source: Own elaboration

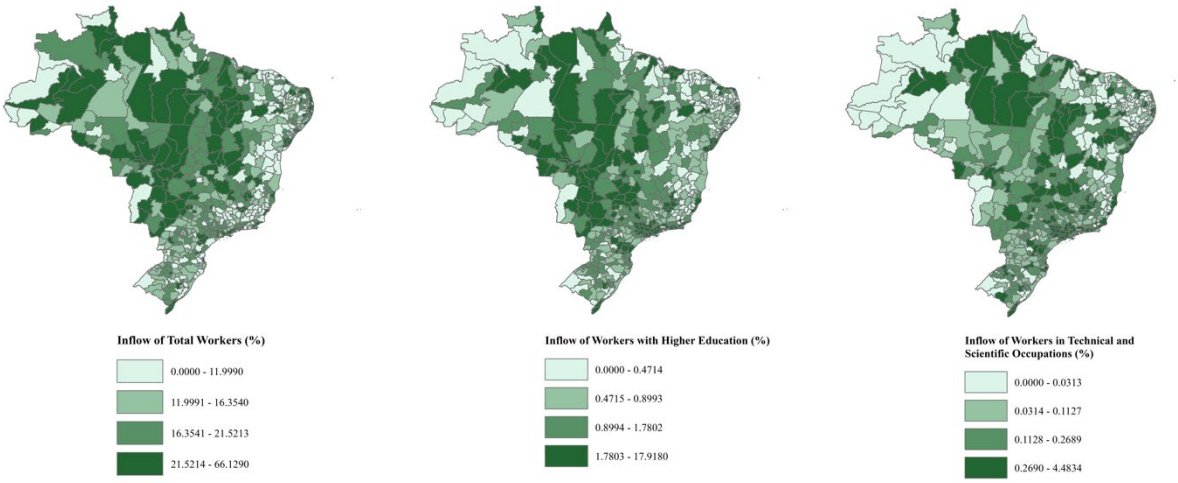
The mobility of workers with higher education and in technical and scientific occupations represents a small share of the local workforce in comparison to total workers in the same category. However, the share of high-skilled mobility is higher than the total, which means that skilled workers tend to move more than the total (percentages are around 25%).

4.2. Mobility of workers by region

The mapping of the interregional mobility of workers was performed using a measure of regional movement of workers, calculated by the ratio between the inflow of workers in the microregion by workers in the selected CNAEs. Map 1 presents an overview of mobility for each of the worker selections, as total workers, workers with higher education and workers in technical and scientific occupations. The maps are presented using the quartiles as delimitation of the classes that compose the color separation of the maps. The maps show that, in general, the mobility of workers is dispersed across regions. However, the movement of skilled workers is regionally more unequal, as we can see a concentration in the São Paulo Metropolitan Area and in other state capitals' regions. This concentration is even more evident in the map of technical and scientific occupations.

Map 1

Mapping of worker mobility: inflow by selected workers



Source: Own elaboration

To analyze the pattern of interregional mobility of skilled workers in Brazilian regions, we performed a selection of the most important regions using two complementary criteria. The first is the ratio between the mobility of workers in each of the cutouts and the total workers in the selected activities in the regions. The rationale for using this cut-out is that total mobility may not represent a more relevant indicator of the measure of worker movement in the region. The second criterion was the average number of workers in each region, which allows the selection of regions with higher volumes of workers. The rationale for this approach is that regions with larger workforces are more capable of generating agglomeration externalities. Therefore, the mobility of workers may be a driver of the knowledge spillover in these locations. The mobility tables by region only present those that had, in 2014, a number of workers above the average for the period, i.e., 17,058 workers (active on December 31st, with a single ID).

Table 3 shows the regions that had the highest inflows of total workers in the analyzed period.

Table 3
Percentage of inflow of workers by microregion

State	Microregion	Inflow (a)	Workers in selected activities 2014 (b)	%(a/b)	% Total inflow in Brazil
PE	Suape	12,600	28,046	44.9	0.9
RS	Litoral Lagunar	6,383	18,671	34.2	0.4
SP	Osasco	30,744	96,314	31.9	2.1
RJ	Macaé	12,531	39,915	31.4	0.9
PA	Tomé Açu	5,896	19,052	30.9	0.4
MS	Três Lagoas	6,902	23,006	30.0	0.5
SP	Itapecerica da Serra	16,781	57,711	29.1	1.1
SC	Itajaí	10,034	40,281	24.9	0.7
PE	Mata Setentrional Pernambucana	8,930	36,012	24.8	0.6
MG	Paracatu	4,813	20,135	23.9	0.3
MT	Alto Teles Pires	6,468	27,376	23.6	0.4
AL	Maceió	7,015	30,297	23.2	0.5
GO	Entorno de Brasília	5,226	22,635	23.1	0.4
SP	Jundiaí	18,067	79,467	22.7	1.2
SP	Guarulhos	25,384	111,766	22.7	1.7
MT	Rondonópolis	4,291	19,617	21.9	0.3
SP	Mogi das Cruzes	16,860	77,179	21.8	1.1
MS	Iguatemi	4,407	20,343	21.7	0.3
MG	Uberaba	5,786	27,099	21.4	0.4
MG	Itabira	5,270	24,684	21.3	0.4
PE	Mata Meridional Pernambucana	5,318	24,927	21.3	0.4
RS	Montenegro	6,903	32,526	21.2	0.5
SP	São Joaquim da Barra	6,144	29,567	20.8	0.4
SP	Santos	4,834	23,394	20.7	0.3
SP	Botucatu	4,534	22,023	20.6	0.3
RN	Mossoró	3,592	17,542	20.5	0.2
SP	Bragança Paulista	10,184	49,918	20.4	0.7
SP	Tatuí	7,130	35,723	20.0	0.5
SP	Araraquara	13,497	67,720	19.9	0.9
SP	Itapetininga	3,394	17,109	19.8	0.2
30 main microregion		279,918	1,140,055	24.6	19.0
Other microregion		1,189,759	8,378,302	14.2	81.0
Total		1,469,677	9,518,357	15.4	100.0

Source: Own elaboration

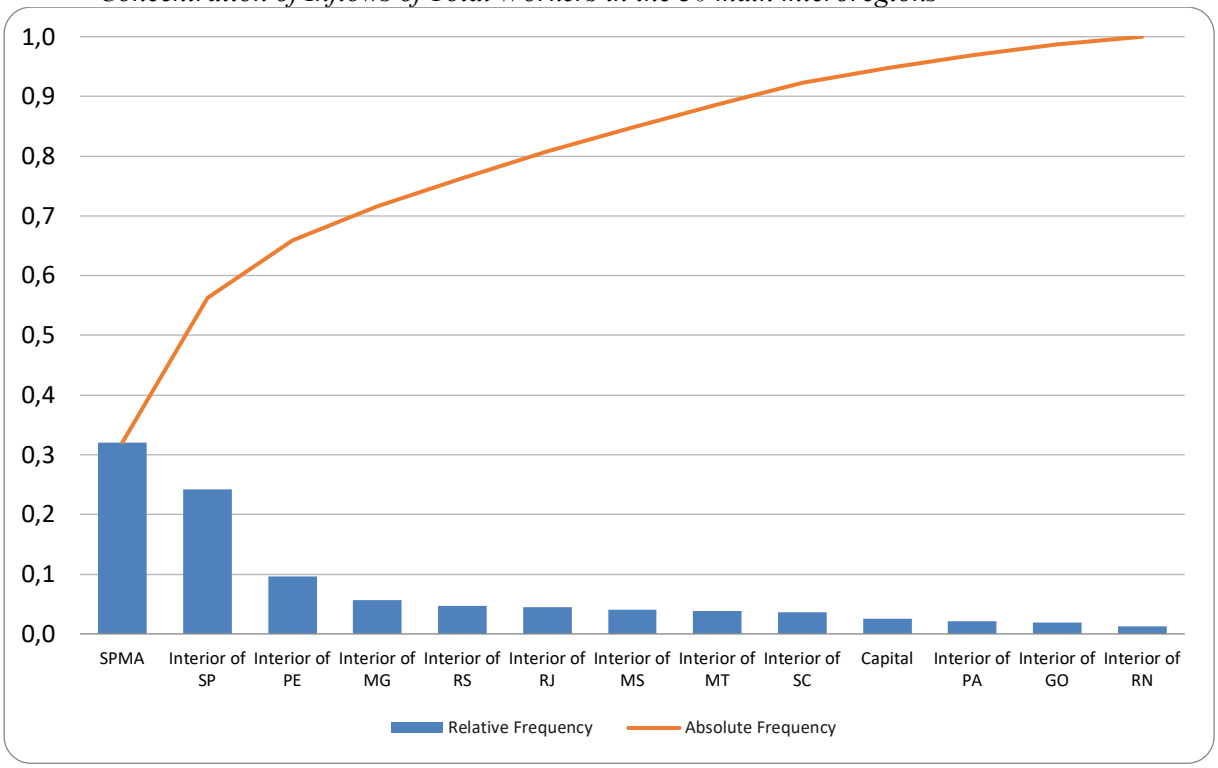
The data show that the share of new entrants in the local workforce varies between 44.9% and 19.8%. The largest percentage inflow of workers is in the region of Suape (PE), with 44.9%, followed by Litoral Lagunar (RS), 34.2%; Osasco (SP), 31.9%; and the regions of Macaé (RJ), Tomé Açu (PA) and Três Lagoas (MS). We can also highlight the importance of regions in the State of São Paulo, although some from other states also stand out. The only state capital is Maceió (AL). Overall, there is a heterogeneous movement of workers regarding regions that receive workers.

Regarding the share of inflows of workers in each region in the total of inflows, our results show a small average percentage in the regions, which means that no specific region received a large absolute inflow of workers. The highest share is of the region of Osasco (SP), located in the São Paulo Metropolitan Area (SPMA), with 2.1% of the total inflow in the region.

The top 30 regions present a share of 19% of the total worker inflow. Graph 1 shows the concentration of total worker inflow in these regions by category (Interior of the state, São Paulo Metropolitan Area, or Capitals). This categorization allows us to understand the mobility pattern in the regions for each category. The analysis of the mobility pattern of total workers highlights regions of São Paulo State, both in the Metropolitan Area and in the interior, as the regions that received more workers. Next, our results show other states' regions. Table 4 shows the regions with the greatest inflows of workers with higher education degrees.

Graph 1

Concentration of Inflows of Total Workers in the 30 main microregions



Source: Own elaboration

Table 4
Percentage inflow of workers with higher education by microregion

State	Microregion	Inflow (a)	Workers in selected activities 2014 (b)	% (a/b)	Workers in selected activities 2014 with Higher Education (c)	% (a/c)	% Total Inflow in Brazil
RJ	Macaé	4,236	39,915	10.6	15,491	27.3	2.1
SP	Osasco	7,997	96,314	8.3	16,254	49.2	3.9
SP	Santos	1,646	23,394	7.0	5,331	30.9	0.8
SP	Itapecerica da Serra	3,668	57,711	6.4	7,433	49.3	1.8
SP	Jundiaí	4,039	79,467	5.1	11,976	33.7	2.0
SP	Guarulhos	5,529	111,766	4.9	14,245	38.8	2.7
PE	Mata Setentrional Pernambucana	1,700	36,012	4.7	2,598	65.4	0.8
PE	Suape	1,265	28,046	4.5	2,282	55.4	0.6
SP	Campinas	10,453	247,935	4.2	36,607	28.6	5.1
RS	Litoral Lagunar	744	18,671	4.0	1,442	51.6	0.4
SP	São Paulo	27,352	696,245	3.9	124,626	21.9	13.4
SP	Sorocaba	5,456	140,069	3.9	19,178	28.4	2.7
SP	Piracicaba	2,568	67,033	3.8	7,315	35.1	1.3
SP	São José dos Campos	3,938	103,588	3.8	23,107	17.0	1.9
RJ	Rio de Janeiro	10,074	273,743	3.7	50,865	19.8	4.9
SP	Bragança Paulista	1,709	49,918	3.4	4,454	38.4	0.8
SP	Amparo	659	20,395	3.2	1,629	40.5	0.3
MG	Belo Horizonte	7,626	239,582	3.2	42,656	17.9	3.7
ES	Vitória	1,716	55,431	3.1	7,168	23.9	0.8
SP	Tatuí	1,093	35,723	3.1	2,891	37.8	0.5
GO	Meia Ponte	812	28,342	2.9	2,718	29.9	0.4
MG	Itabira	696	24,684	2.8	2,364	29.4	0.3
SP	Guaratinguetá	621	22,245	2.8	2,663	23.3	0.3
MS	Campo Grande	843	30,205	2.8	4,957	17.0	0.4
SP	Mogi das Cruzes	2,111	77,179	2.7	7,436	28.4	1.0
MT	Rondonópolis	536	19,617	2.7	2,039	26.3	0.3
SC	Itajaí	1,095	40,281	2.7	2,701	40.5	0.5
RJ	Vale do Paraíba Fluminense	1,129	42,039	2.7	5,516	20.5	0.6
MS	Três Lagoas	593	23,006	2.6	1,357	43.7	0.3
SP	Rio Claro	839	32,789	2.6	3,050	27.5	0.4
30 main microregion		112,743	2,761,345	4.1	432,349	26.1	55.0
Other microregion		92.109	6,757,012	1.4	425,880	21.6	45.0
Total		204.852	9,518,357	2.2	858,229	23.9	100.0

Source: Own elaboration

When analyzing the inflow of workers with higher education, the first measure of skilled workers is the share of the movement of workers in the total local workforce. This indicator varies from 10.6% to 2.6%, and it is lower than the mobility of total workers. The highest share of new entrants with higher education in the workforce is 10.6% in Macaé (RJ), followed by regions adjacent to São Paulo. Outside the SPMA, two regions of Pernambuco (Suape and Mata Setentrional) stand out. It is also noteworthy that regions of the SPMA and the interior of the state of São Paulo, such as Santos, Campinas, Jundiaí and Sorocaba, in addition to those composed of states capitals in the Brazilian Southeast Region, such as São Paulo (3.9%), Rio de Janeiro (3.7%), Belo Horizonte (3.2%) and Vitória (3.1%).

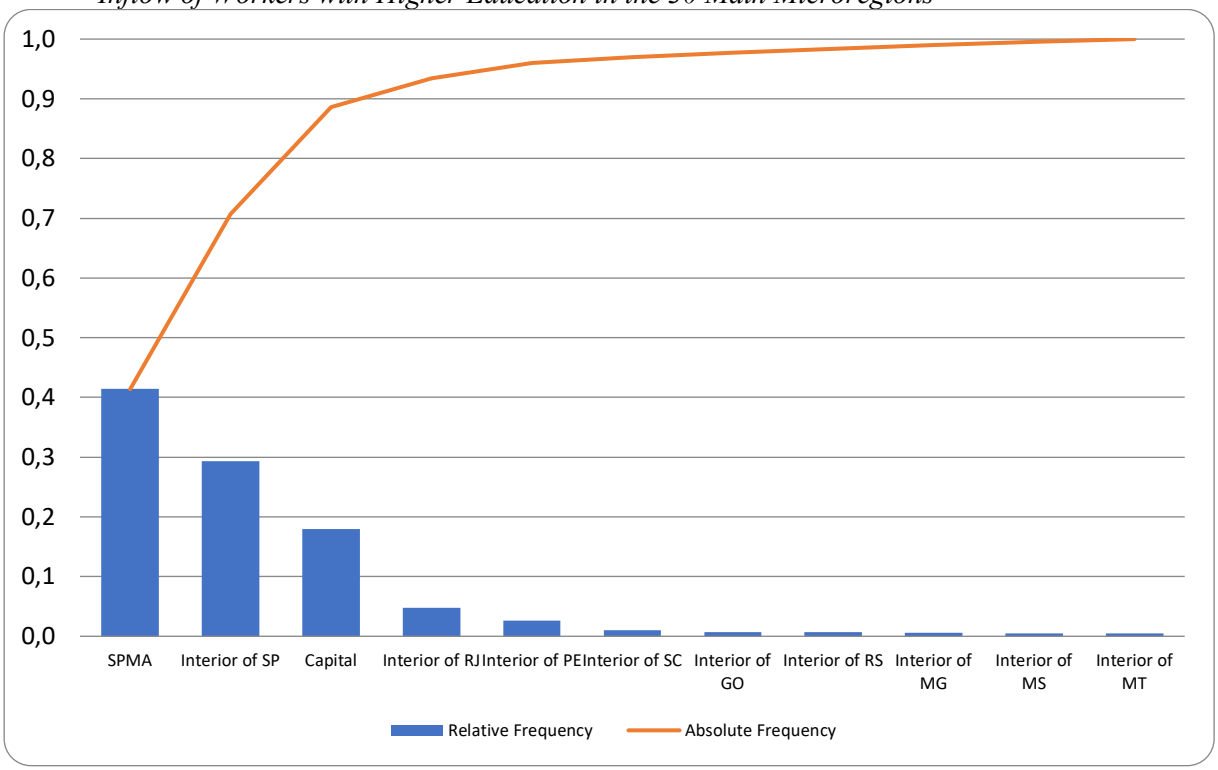
Regarding the share of inflow of workers with higher education degrees who moved to the regions in comparison to workers with higher education, our results show that the top 3

regions are Mata Setentrional Pernambucana (PE), with 65.4%; Suape (PE), with 55.4%; and Litoral Lagunar (RS), with 51.6%. This finding shows that the composition of the skilled labor force in these regions has significantly changed over the period analyzed.

Regarding the share of total inflow in the regions, the emphasis is on regions with higher absolute inflow, such as São Paulo, with a share of 13.4% of the total inflow, followed by regions in its Metropolitan Area. This concentration shows a relevant role of these regions in the high volume of skilled workers in the analyzed period.

Graph 2 shows the concentration of the 30 regions with the highest inflow of skilled workers. These regions are responsible for 55% of the mobility, with highlight to regions from the SPMA, the interior of the state of São Paulo and other state capitals.

Graph 2
Inflow of Workers with Higher Education in the 30 Main Microregions



Source: Own elaboration

Regarding STEM occupations, we find important differences. Among the 30 more important regions, the share of inflow of workers is much lower than in the others, varying from 3.6% to 0. 4% of the local workforce (Table 5).

Table 5
Percentage inflow of workers in technical and scientific occupations by microregion

State	Microregion	Inflow (a)	Workers in selected activities 2014 (b)	% (a/b)	Workers in selected activities 2014 in Technical and Scientific Occupations (c)	% (a/c)	% Total Inflow in Brazil
RJ	Macaé	1,443	39,915	3.6	3,995	36.1	4.1
SP	Santos	616	23,394	2.6	1,517	40.6	1.7
SP	São José dos Campos	1,238	103,588	1.2	7,105	17.4	3.5
SP	Osasco	1,084	96,314	1.1	2,451	44.2	3.1
RS	Litoral Lagunar	186	18,671	1.0	361	51.5	0.5
RJ	Rio de Janeiro	2,669	273,743	1.0	14,051	19.0	7.6
MG	Itabira	235	24,684	1.0	489	48.1	0.7
ES	Vitória	523	55,431	0.9	1,815	28.8	1.5
SP	Jundiaí	642	79,467	0.8	2,124	30.2	1.8
SP	Sorocaba	1,122	140,069	0.8	3,244	34.6	3.2
PE	Suape	208	28,046	0.7	405	51.4	0.6
SE	Aracaju	146	20,617	0.7	480	30.4	0.4
SP	Campinas	1,729	247,935	0.7	6,686	25.9	4.9
SP	Itapecerica da Serra	394	57,711	0.7	844	46.7	1.1
BA	Salvador	596	89,452	0.7	3,050	19.5	1.7
SP	Guarulhos	733	111,766	0.7	2,362	31.0	2.1
SP	Piracicaba	419	67,033	0.6	1,110	37.7	1.2
SP	Moji Mirim	269	45,753	0.6	717	37.5	0.8
SP	Bragança Paulista	293	49,918	0.6	827	35.4	0.8
SP	Guaratinguetá	127	22,245	0.6	486	26.1	0.4
SC	Itajaí	229	40,281	0.6	392	58.4	0.7
MG	Belo Horizonte	1,341	239,582	0.6	6,669	20.1	3.8
RJ	Vale do Paraíba Fluminense	235	42,039	0.6	1,363	17.2	0.7
PE	Mata Setentrional Pernambucana	194	36,012	0.5	270	71.9	0.6
RN	Mossoró	94	17,542	0.5	248	37.9	0.3
SP	São Paulo	3,629	696,245	0.5	18,855	19.2	10.3
PA	Tomé Açu	96	19,052	0.5	130	73.8	0.3
MG	Paracatu	100	20,135	0.5	221	45.2	0.3
SP	Mogi das Cruzes	365	77,179	0.5	1,144	31.9	1.0
ES	Linhares	131	29,442	0.4	321	40.8	0.4
30 main microregion		21,086	2,813,261	0.7	83,732	25.2	59.9
Other microregion		14,115	6,705,096	0.2	53,568	26.3	40.1
Total		35,201	9,518,357	0.4	137,300	25.6	100.0

Source: Own elaboration

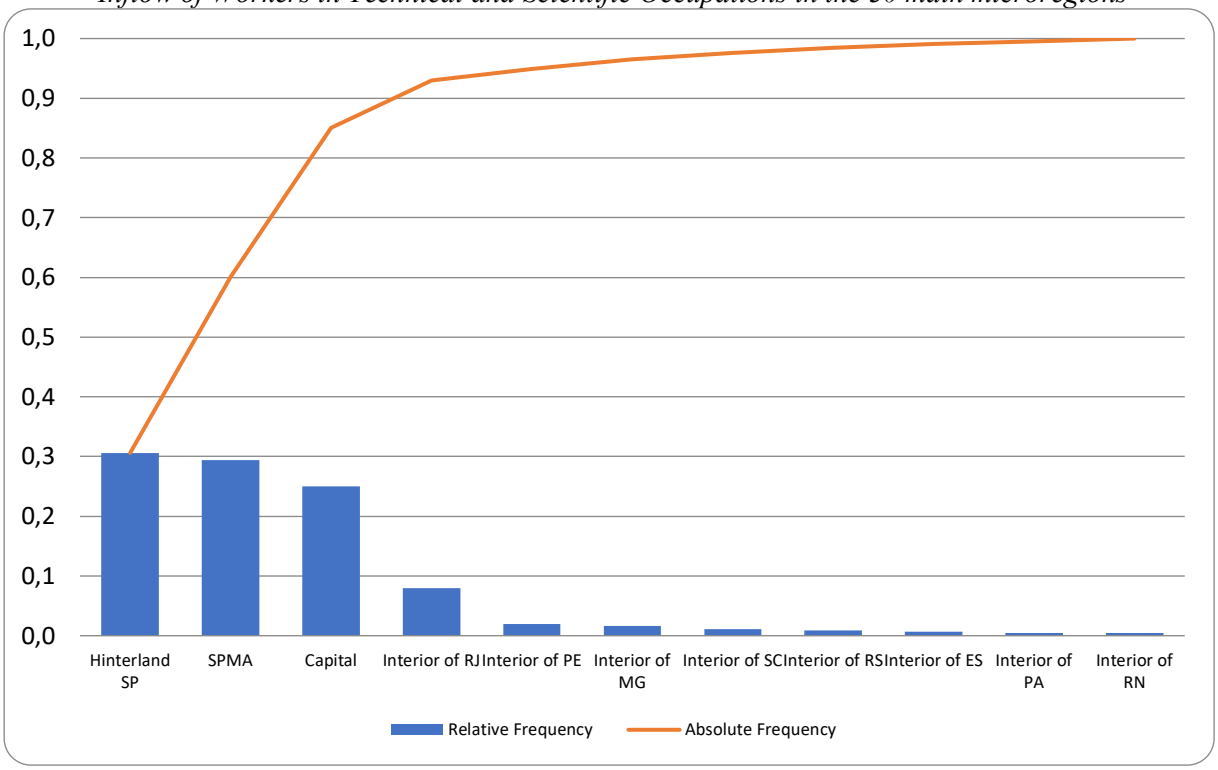
When analyzing the technical and scientific occupations, we observe that among the 30 main regions, the share of inflow of workers is much lower, with values from 3.6% to 0.43% of the composition of the local workforce.

The mobility measure shows the importance of the regions of Macaé (RJ), Santos (SP), São José dos Campos (SP), Osasco (SP) and Litoral Lagunar (RS). In the state of São Paulo, regions surrounding its Metropolitan Area, such as Campinas, Jundiaí, São José dos Campos and Sorocaba, are important regions in attracting skilled workers, since they are important economic and technological hubs. Next, regions of the SPMA and state capitals, such as Rio de Janeiro (RJ), Vitória (ES), Aracaju (SE), Salvador (BA) and Belo Horizonte (MG), are also important hubs in attracting skilled workers.

The share of the inflow of workers in STEM occupations in 2014 is higher than in the other groups, evidencing that these workers move more across regions. Regions with an average of 70% of workers in STEM occupations varied in the analyzed period, such as Tomé Açu (PA) and Mata Setentrional Pernambucana (PE).

Finally, regarding the absolute inflow of workers in STEM occupations, the highest share of inflow is generally of regions in the interior of São Paulo State and in its Metropolitan Area, followed by other state capitals. Graph 3 shows the high concentration of worker inflow in STEM occupations, since 30 regions respond to 59.9% of all the mobility of STEM workers.

Graph 3
Inflow of Workers in Technical and Scientific Occupations in the 30 main microregions



Source: Own elaboration

The pattern of regional mobility of workers was also analyzed for the years 2003-2008, and the results are similar[1].

5 Discussion

Our findings show that the mobility of skilled workers is concentrated in the State of São Paulo and in the capitals of the Brazilian states, showing a greater dynamism of these regions for the attraction of skilled workers. The role of the State of São Paulo in the mobility of total workers can be seen in its economic dynamism. However, interior regions of several other states can also attract workers. Nevertheless, the movement of skilled workers differs from that of total workers during the analyzed period by emphasizing the role of state capitals

[1] The share of worker mobility observed in each of the analyzed segments is close those examined in this paper, with some changes in the composition of regions. To review the mapping and its variations, refer to Costa (2019).

and the São Paulo Metropolitan Area, which are important regions where these workers move. Previous literature on the importance of cities and agglomeration economies indicates several elements that justify this phenomenon.

Findings from our research can be summarized into some common characteristics, considering Brazilian regional specificities (Almeida & Kogut, 1999).

From the point of view of total workers, the São Paulo Metropolitan Area is the region with the greatest mobility of workers in general. Previous studies have shown that since the 1990s, the manufacturing industry of the SPMA has been losing its industrial dynamism (Comin & Amitrano, 2003; Diniz & Crocco, 1996; Torres, 2012). However, the results of the mapping show that the region continues to attract several workers, which reveals its centrality in the Brazilian economy. This phenomenon is mostly explained by the wide possibilities of employment in the region in diversified and complex economic activities. The diversification of the local knowledge base, together with the diversity of economic activities in the region, are the main factors that explain the economic dynamism of the region. High dynamism can also be seen in the mobility of skilled workers.

SPMA is also the region that attracts more skilled workers. This result reinforces the role and importance of local externalities arising from the diversification of the production structure and local knowledge base (Asheim et al., 2007; Storper & Venables, 2004). However, in addition to the SPMA, state capitals, such as Rio de Janeiro (RJ), Belo Horizonte (MG), Recife (PE) and Vitória (ES), can also be identified as regions that attract a high volume of skilled workers.

The diversification of the local productive structure can generate possibilities for the circulation of information and knowledge exchange among local agents. Diversified regions can often be considered local innovation hotspots, given their ability to generate and disseminate local and nonlocal knowledge, with spillovers to neighboring regions (Araújo & Garcia, 2019; Mascarini, Garcia & Roselino, 2019). The mobility of skilled workers, who are attracted to the region due to the greater complexity of the local production structure, can generate new positive externalities, promoting positive feedback with important effects on local development.

It is important to emphasize the role of the advantages of agglomeration economies linked to diversification, in line with Jacobs' approach and with other studies that emphasize the role of large cities in innovation (Asheim et al., 2007; Storper & Venables, 2004). These advantages range from greater employment possibilities for skilled workers to the broad exchange of knowledge through access to knowledge and business networks that can generate new opportunities for local actors. In addition, in the case of the SPMA and the state capitals, there are several characteristics that reinforce its role as important hotspots for economic development, especially knowledge-intensive activities. Large cities have already been identified in the literature, which highlights the spatial concentration of agents in so-called buzz cities, which are highly urbanized cities with great productive and social diversity (Asheim et al., 2007; Storper & Venables, 2004). In these regions, face-to-face contact and frequent interactions are fundamental mechanisms for knowledge externalities, as they are a means of communication that allows for the reduction of barriers to interaction among actors, facilitating and stimulating interactive learning processes (Storper & Venables, 2004).

In addition, it is possible to point out that even in the scenario of the COVID-19 pandemic and with the requirements of social distancing, which forced actors to use long-distance ways of communication, knowledge remains eminently local (Bailey et al., 2020). Actors transferring and sharing knowledge require the creation of mechanisms that involve

frequent interactions and face-to-face contacts, factors that are often pointed out as one of the advantages of large cities.

Additionally, state capitals are also configured as regional business hubs and have a set of advantages related to the possibilities of interactive learning in the regions. Even though it is possible to verify problems related to diseconomies of agglomeration, such as the high costs of rent and wages and traffic jams, large cities still concentrate and receive a relevant share of the skilled workforce. In fact, the disadvantages arising from static diseconomies of agglomeration are, in large cities, largely overcome by local dynamic learning externalities (Garcia, 2021). In other words, congestion costs become irrelevant given the wide possibilities of generating interactive learning through geographical clustering (Costa & Garcia, 2018).

Second, another result of the mobility patterns of skilled workers points to some regions that have important medium-sized cities in the interior of the states, such as Campinas and São José dos Campos, in the State of São Paulo, and Macaé, in the state of Rio de Janeiro. These cases show that the mobility of skilled workers occurs in larger regions in terms of employees (except for the SPMA). In addition, these cities also stand out in more knowledge-intensive activities, such as high-tech activities and applied technological research in oil and gas.

More technologically developed activities use a skilled workforce, acting in the supply and assistance of information technologies and providing high interaction among actors (Freire, 2006). In addition, these activities are directly related to knowledge-based activities, and they have a strong presence of technological activities, such as the regions of Campinas, Recife, and São Paulo in information technology and São José dos Campos in the aerospace industry. The external economies generated in these regions provide competitive advantages for local firms through the ability to share knowledge between different local actors. In addition, the entry of skilled workers into agglomerated regions can be beneficial for local firms since they can benefit from knowledge flows generated by these skilled workers (Miguelez & Moreno, 2015).

Finally, skilled workers move relatively more than total workers, which increases the possibilities of circulation and knowledge sharing, intensifying the benefits of local spillovers. These benefits are in line with the idea that the circulation of qualified personnel is beneficial for innovation and learning and for economic development. This argument is present in studies on worker mobility, as there is a perception that the benefits go beyond the supply of local labor and involve, from an increase in the flows of trade, investment and ventures, due to the change in the composition of the local workforce and the possibility of interactions with new knowledge and networks not present locally (Faggian et al., 2017; Maré et al., 2014, Gagliardi, 2015).

6 Final considerations and policy implications

Local knowledge spillovers and their role in regional development are prominent topics in regional studies and economic geography. Spillovers can occur in several ways, and there is a growing concern in the literature in the understanding of how the mobility of skilled workers can represent a way of generating and disseminating knowledge among local actors. The importance of worker mobility as a mechanism of interactive learning is based on the idea that in the movement of individuals, the tacit and idiosyncratic attributes of knowledge become transferable, with impacts on the opportunities for knowledge sharing. Mobility can occur either between firms in the same region, with important effects on the dissemination of knowledge among local actors, or from professionals from other regions, which represents an important source of innovation and new knowledge for the local system.

Inserted in this debate, the main novelty of this article is the identification and presentation of the main patterns of spatial mobility of skilled workers in the Brazilian regions. This mapping was performed using RAIS ID data, which allowed the identification of the main regions that received skilled workers between 2009 and 2014.

The mapping shows the relevant presence of total worker mobility in metropolitan regions, especially in the São Paulo Metropolitan Area. The focus of our research is the mobility pattern of skilled workers, and we find the role of SPMA, some state capitals and medium-sized cities in the interior of these states. It is also noteworthy that skilled workers move relatively more than total workers. The mapping shows a predominance of more diversified regions that can generate greater possibilities for the circulation of information and the exchange of knowledge among local actors.

The mapping presents evidence that can support public policies for regional development. In the case of large and diversified cities, policies should prioritize mechanisms that stimulate the intensification of interaction between economic actors since interaction will intensify the generation of local positive externalities. In the case of medium-sized cities, the recognition of the role of mobility in the generation of positive externalities should stimulate policies that are able to reinforce the main factors that attract skilled workers to the region, such as incentives for the establishment of new research and development units and public research institutes. In addition, skilled workers usually value the existence of urban amenities, especially cultural assets, which also need to receive attention from policymakers. For the cities that were not identified in the mapping and do not stand out in attracting qualified workers, policy should involve measures aimed at densifying or creating local skills, either by stimulating local businesses, especially when they involve more knowledge-intensive activities, or by strengthening local teaching and research institutions, especially in technological areas.

Finally, it is necessary to point out some limitations of the analysis. First, the RAIS data do not cover informal and self-employed workers, which restricts the analysis to the contingent of formal workers. Second, the mapping presented provides an overview of mobility patterns but does not present analyses that allow establishing relationships between the main variables. In this way, it opens a broad field of future research to analyze the impact of skilled worker mobility on regional development through the assessment of its effects on innovation in regions and on regional growth. In addition, it is also possible to analyze the relationship between mobility and other characteristics of the regions, such as the local productive structure, the number of firms in different industries, the presence of universities and research centers, and the creation of new ventures.

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