Global Innovation Hotspots

A case study of São Paulo’s innovation ecosystem
local capabilities and global networks

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A case study of São Paulo’s innovation ecosystem
local capabilities and global networks

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Summary

This report presents an in-depth study of the innovation ecosystem of São Paulo (Brazil). We use georeferenced patent, scientific publication, and economic data to characterize one of the few global innovation hotspots in Latin America and the southern hemisphere. It attempts to understand what makes São Paulo different from the rest of Brazil and the Latin American region by mapping what its main potentialities and drawbacks are. The report finds that São Paulo is rich in scientific activity, but lags behind with respect to patent production. At the same time, it is a patent leader in Brazil and the region with characteristics resembling the large innovation hotspots of the world. The report also shows where São Paulo is in the global knowledge space, and how it can leverage scientific production and global networks to upgrade into more complex technological activities. The report also reviews the main innovation policies at national and subnational level, which may partially explain the São Paulo's success story.

Keywords: *São Paulo, innovation ecosystem, patents, scientific publications, clusters, geography of innovation, complexity, relatedness, Global Innovation Networks*

JEL: O30, F20, F60

"When you think about tapping into the Latin American innovation ecosystem, São Paulo comes first on the list"
Michel Porcino, Manager at SP Negócios[1]

The above statement is possibly an accurate reflection of how São Paulo is perceived in business and innovation circles worldwide. The city is considered an innovation powerhouse in Brazil, and by extension in all of Latin America. According to recent reports, it is highly positioned in worldwide start-up rankings. It holds the 20th position according to Global Startup Ecosystem Index 2021 (StartupBlink, 2021), not far from Washington, DC or Chicago, and ahead of any other Latin American city. It ranks 35th according to the Global Startup Ecosystem Report 2021 (Startup Genome, 2021), close to cities like Munich, Geneva and Delhi. The city is home to more than 50 percent of start-up investments in Brazil and 12 out of 20 Brazilian unicorns,[2] and concentrates the vast majority of venture capital (VC) firms and large corporations in the country, including the Latin American headquarters (HQ) of companies such as Google, Uber, Airbnb, Spotify, Netflix, Amazon and IBM, as well as large accelerators and incubators (Startup Genome, 2021). Part of this success is attributable to its fintech sector,[3] and it is considered the fourth worldwide city according to the Global Fintech Rankings Report (Mambu Compare, 2021) after only San Francisco, London and New York.

São Paulo's size and socioeconomic composition have played a big role in its success; Brazil is the largest country in Latin America, and São Paulo its largest city (with a metropolitan area of around 22 million people). It is also home to an increasingly affluent middle class, in part fostered by the social policies carried out since 2003, including direct cash transfers and minimum-wage policies. São Paulo's inhabitants are heavy users of smartphones and early adopters of new technologies, making it the ideal scenario for hundreds of smartphone start-ups. All this is well dressed with an abundance of talent, produced in good local universities, such as the University of São Paulo (USP),[4] or elsewhere in the country, as São Paulo welcomes large numbers of highly trained immigrants from the rest of the country every year (de Oliveira *et al*., 2021).

Yet, not only market forces are behind the surge of São Paulo as an innovation and start-up city. Despite barely any state-owned[5] firms and sectoral agencies being located there, the city has clearly benefited from the proactive innovation policies carried out in the country in the last 20 years. Like other emerging economies, such as China, India and South Korea, since the 2000s Brazil has developed a state-led innovation policy (Reynolds *et al*., 2019), which has played a great role in developing the innovation sector, and the necessary preconditions for the surge of innovative and start-up activities in the country and the city. After some years of a laissez-faire approach in innovation policy, direct intervention became again the rule in the country from the year 2000. This recent approach has created a share of research and development (R&D) over gross domestic product (GDP) in Brazil that is twice the size of the average in Latin America, thanks to the push of public R&D spending,

[1] www.forbes.com/sites/angelicamarideoliveira/2019/03/29/sao-paulo-the-brazilian-innovation-ecosystem-is-ready-for-business/?sh=12255a6810f9 (accessed September 14, 2021).
[2] A unicorn is a privately held startup company valued at over 1 billion US dollars.
[3] In particular, Brazil is one of the world leaders in bank automation, an activity that emerged from the need to cope with very high inflation rates in the 1980s, and which paved the way for the development of a software industry. By the year 2000, Brazil represented the seventh-largest world market in terms of domestic software sales (Mazzucato & Penna, 2016).
[4] USP is the first Latin American University in The Times Higher Education Ranking, located between the 201st and 205th position worldwide.
[5] Examples of this are several successful state-owned firms such as EMBRAPA or PETROBRAS.

though it is still far from the OECD average (1 percent against 1.5 percent, according to OECD statistics) (Reynolds *et al*., 2019). While Brazilian firms do spend in innovation, this is mostly concentrated on process innovation and the acquisition of capital goods (Reynolds *et al*., 2019).

Recent innovation-policy developments have been pushed by the passing of two crucial laws, the *Lei do Bem* (Law of the Goods) and the *Lei da Inovação* (Law of Innovation), which have facilitated the funding of innovation activities, innovative public procurement, the improvement of the research and education system and so on (Mazzucato & Penna, 2016).

The report is a follow-up project from the 2019 *World Intellectual Property Report* (WIPO, 2019), in which millions of geolocalized patents and scientific publications were used to identify abnormal concentrations of knowledge production worldwide. These are labeled as Global Innovation Hotspots and Niche Clusters, depending on whether they unconditionally concentrate large patents and scientific articles globally (Global Innovation Hotspots), or if they do it conditionally based on technological and scientific fields (Niche Clusters).

Most of these hotspots (GIHs) and niche clusters were located in the United States of America (US) and Western Europe, and to a large extent also in South and East Asia. However, the research in WIPO (2019) shed light to two interesting open questions. First, despite identifying Global Innovation Hotspots – including São Paulo – we know little about what has made them so successful (placing them on the list) and their main weaknesses in maintaining their status as attractors of talent and innovative capital. Second, while most empirical research on local innovation ecosystems and the geography of innovation is centered on the US and European cases, with some analysis of South Asian cases (mostly after the surge of China as an innovation powerhouse), we know little about local innovation in the Global South, and particularly in Latin America and Brazil (with notable exceptions, such as Suzigan *et al*., 2001; 2004).

This reports attempts to tackle these two question in three parts. Part A of this report aims to characterize the main patterns and trends of the São Paulo innovation ecosystem, and how it integrates within the regional and global systems of innovation from a global perspective. It does it by using geolocalized international patent families and scientific publications from Web of Science (WoS) from WIPO (2019), which allows for international comparability. Part B also studies the recent development of São Paulo's innovation ecosystem but from a national perspective. It is based on data from the Brazilian Office on Intellectual Property (BADEPI/INPI) and it is focused on comparing São Paulo with the rest of the country, including other city-innovation hubs. Part C complements these two analyses by reviewing the recent innovation-policy developments at the national and subnational level.

Part A – São Paulo's Global Innovation Hotspot

B.1 Introduction

This first part of the report aims to inspect a number of patterns and trends in order to better understand what makes São Paulo different from the rest of Brazil and the continent, and what the main potentialities and drawbacks are.

It finds that São Paulo is rich in scientific activity, but lags behind with respect to patent production. At the same time, São Paulo is a (patent) leader of the country and the region, and presents characteristics that resemble the large innovation hotspots of the world. It also presents some evidence that turning our focus on soft innovation indicators would give a more accurate picture of the local ecosystem, and would place São Paulo in a better position globally. These soft indicators are more complicated to identify. It also shows where São Paulo is in the global knowledge space, and how it can leverage scientific production and global networks to upgrade into more complex activities, which are usually ubiquitous and more complicated to replicate elsewhere.

Part 1 focuses on four main aspects: (1) the role of São Paulo as a national and regional innovation powerhouse, but its distance to more innovative global hotspots; (2) the technological and scientific capabilities of São Paulo that could allow the area to diversify into more complex, high-value technologies; (3) the role of the scientific sector; (4) the role of global innovation and knowledge networks in driving São Paulo's innovative success.

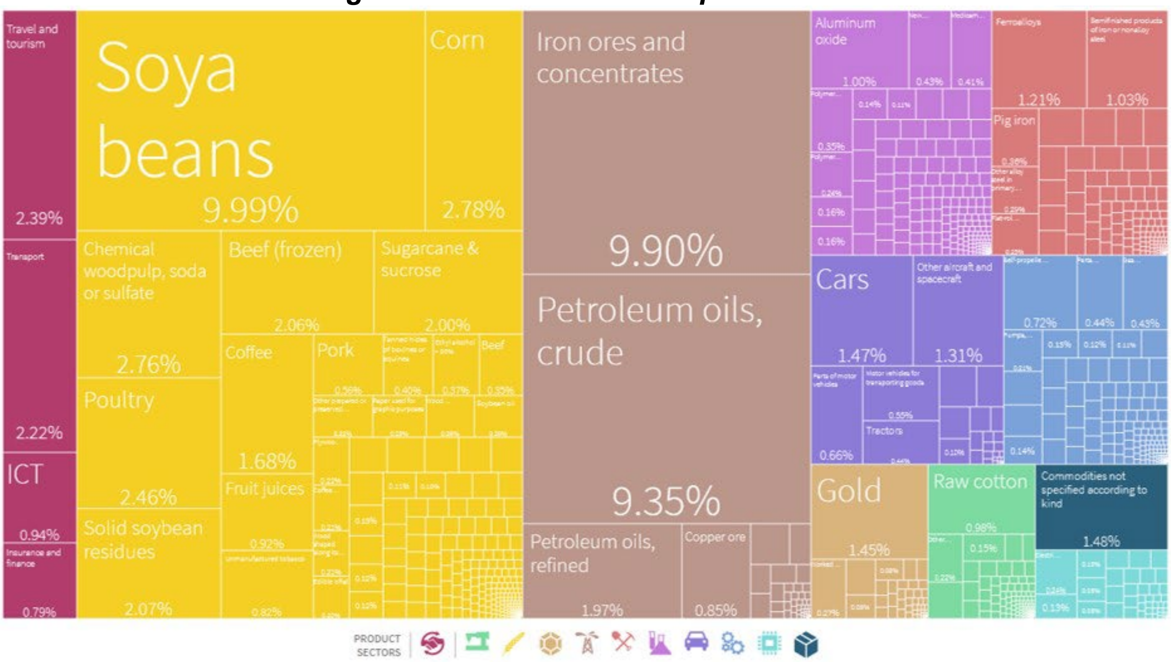
Part 1 is organized as follows: Section A.2 gives a general overview of the context into which São Paulo integrates. Section A.3 describes in more detail São Paulo's innovation ecosystem, while Section A.4 describes the technological portfolio of São Paulo and the opportunities for high-value tech development. Section A.5 evaluates the role of local scientific production in fostering the success of the ecosystem.

B.2 São Paulo: A regional champion in a challenging environment?

B.2.1Context

Brazil is considered by the World Bank to be a high-middle-income economy, alongside other emerging countries like China, India or South Africa. It is definitely one of the largest economies of the world according to GDP (at around eighth place in the ranking according to purchasing power parity (PPP) GDP), and is highly populated (with more than 200 million inhabitants, ranking in sixth position).[6] Brazilian GDP grew consistently between 2002 and 2008. The global economic crisis interrupted this growth in 2009, when GDP presented a small retraction (-0.13 percent). However, growth resumed in 2010 and continued until 2014. The main drivers of Brazilian economic growth until 2014 were the boom of commodity prices and the domestic policies of income distribution, mainly through social programs and wage increases. After that, the Brazilian GDP suffered a strong retraction and has not recovered to the 2014 level. With the economic crisis caused by the Covid-19 pandemic, the possibilities of economic recovery in 2020 and 2021 became more difficult, and the economic results were not very expressive. At the end of this period, we can see that the retraction in economic activity since 2014 was associated with the increase in unemployment and the retraction of wages, with negative effects on income distribution.

Figure A.1: Brazil's 2019 export basket



Source: The Growth Lab at Harvard University, Atlas of Economic Complexity, www.atlas.cid.harvard.edu (accessed December 2, 2021)

Brazil's exports are concentrated in agricultural, oil and minerals, and other low-complexity products, as shown in Figure A.1 (Hausmann *et al.*, 2014). However, Brazil is internationally competitive in sugarcane biofuel and deep-sea oil exploration, among other very successful niches (with an active role of government agencies such as EMBRAPA and PETROBRAS),

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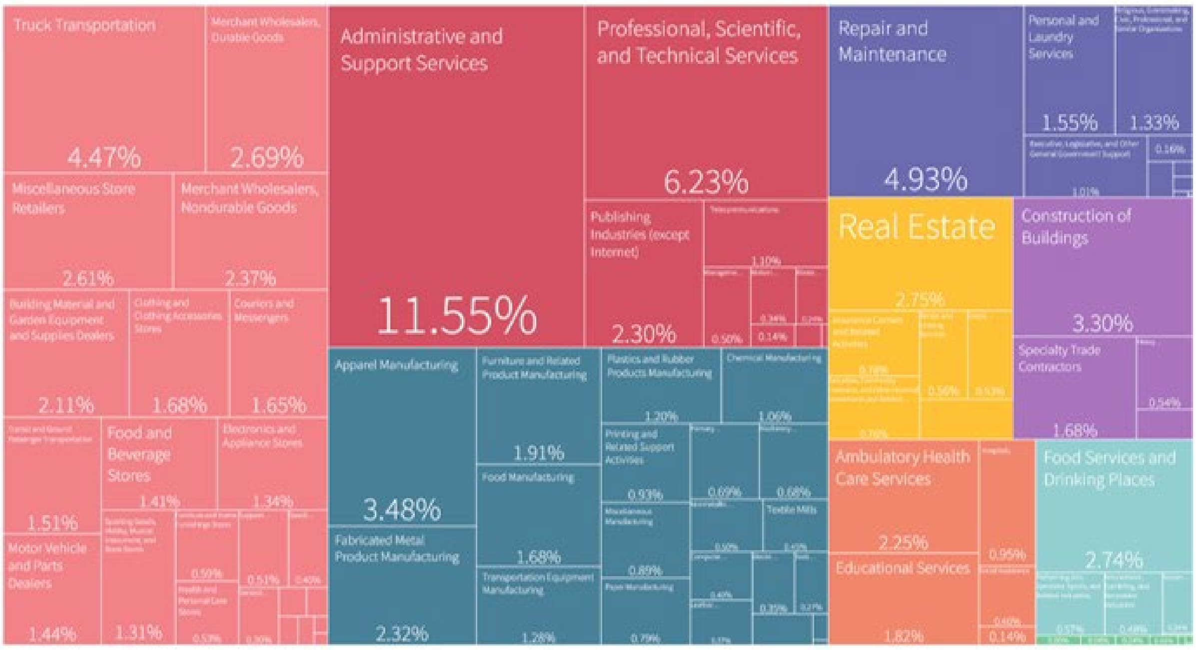
[6] World Bank data at https://data.worldbank.org/ (accessed December 2, 2021).

being a remarkable producer and exporter of oil and gas, biofuels, aviation, health, fintech, agritech and natural resources (Mazzucato & Penna, 2016).

The last edition of the Global Innovation Index (GII2021) (WIPO, 2021) ranks Brazil in 57th position (fourth in Latin America after Chile, Mexico and Costa Rica), up five positions from 2020. Among the strengths of the country, the report highlights that Brazil is performing above expectations given its level of development, being the only regional economy for which expenditures on R&D are above 1 percent of GDP (comparable to some European economies). Infrastructure and market sophistication are mentioned as the weakest elements.

Based on international patent family (IPF) data published in WIPO (2019), the US, China, Japan, Republic of Korea and Western Europe produced 93.2 percent of international patenting in the years 2015 to 2017. In those years, Brazil only accounted for 0.3 percent of IPF, 2.3 percent of scientific articles and around 3 percent of worldwide population, witnessing Brazil's underrepresentation in international technology production, similar to other developing countries. Yet, as shown in Table 1, Brazil accounts for half of Latin American patent production, and has more than doubled its proportion since the beginning of the period.

Figure A.2: São Paulo's economic composition (employment, 2015)



Source: The Growth Lab at Harvard University, Metroverse, https://metroverse.cid.harvard.edu/ (accessed August 10, 2022)

In 2019, the mesoregion of São Paulo was home to 23 million inhabitants (the largest in the country), 11.1 percent of the total Brazilian population. In the same period, the São Paulo region's share of GDP was around 17 percent (down from 22 percent in 2000–2002). In 2015, GDP per capita was estimated at 24,300 US dollars. Its size, disproportionate weight in Brazilian GDP and income per capita make São Paulo the engine of the country and a highly appreciated consumer market.

Table A.1: Evolution of patenting and scientific publishing, by regions and selected countries

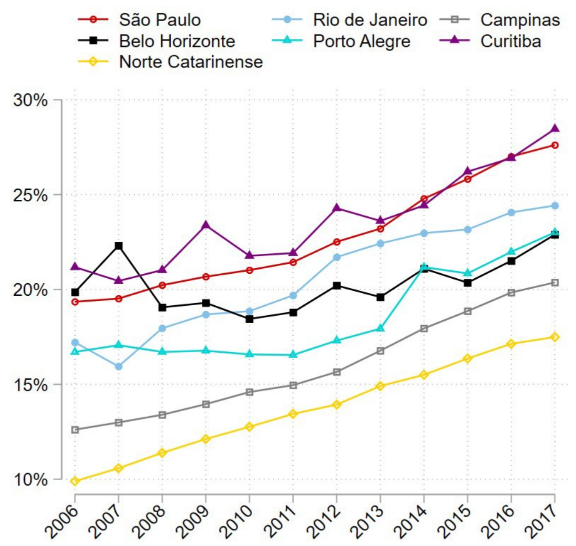
	Patents							Publications			
Region (Country)	**1970-79**	**1980-89**	**1990-99**	**2000-04**	**2005-09**	**2010-14**	**2015-17**	**2000-04**	**2005-09**	**2010-14**	**2015-17**
SCSE Asia	0.1%	0.1%	0.6%	1.0%	1.6%	2.1%	2.0%	3.2%	4.8%	6.7%	7.5%
India	0.0%	0.0%	0.1%	0.5%	1.0%	1.4%	1.3%	2.0%	2.6%	3.2%	3.5%
Singapore	0.0%	0.0%	0.1%	0.3%	0.4%	0.4%	0.3%	0.4%	0.5%	0.5%	0.5%
CEE	3.2%	3.8%	4.9%	1.1%	1.3%	1.4%	1.3%	5.8%	5.9%	5.8%	5.6%
Russian Federation	0.7%	1.4%	2.7%	0.4%	0.5%	0.5%	0.4%	2.4%	1.9%	1.7%	1.8%
Poland	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	1.1%	1.3%	1.3%	1.3%
LAC	0.3%	0.3%	0.3%	0.4%	0.5%	0.6%	0.6%	3.0%	3.5%	4.0%	4.0%
Brazil	0.1%	0.1%	0.1%	0.2%	0.2%	0.3%	0.3%	1.5%	2.0%	2.3%	2.3%
Western Asia	0.3%	0.3%	0.7%	1.1%	1.4%	1.6%	1.7%	2.3%	2.8%	3.0%	3.1%
Turkey	0.0%	0.0%	0.0%	0.1%	0.2%	0.3%	0.4%	1.0%	1.5%	1.7%	1.7%
Israel	0.2%	0.3%	0.6%	0.9%	1.2%	1.1%	1.1%	0.9%	0.8%	0.6%	0.6%
Oceania	0.8%	1.1%	1.1%	1.4%	1.3%	0.9%	0.9%	2.4%	2.4%	2.6%	2.8%
Australia	0.7%	1.0%	1.0%	1.2%	1.1%	0.8%	0.8%	2.0%	2.1%	2.3%	2.5%
Africa	0.3%	0.2%	0.2%	0.3%	0.2%	0.2%	0.2%	1.1%	1.3%	1.6%	1.8%
Egypt	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%	0.3%	0.4%	0.5%
South Africa	0.2%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.3%	0.4%	0.4%	0.4%
Total	**4.8%**	**5.8%**	**7.8%**	**5.3%**	**6.4%**	**6.8%**	**6.7%**	**17.8%**	**20.7%**	**23.6%**	**24.9%**

Notes: Source: WIPO (2019). Notes: CEE = Central and Eastern Europe; LAC = Latin America and the Caribbean; SCSE Asia = South, Central and Southeast Asia.

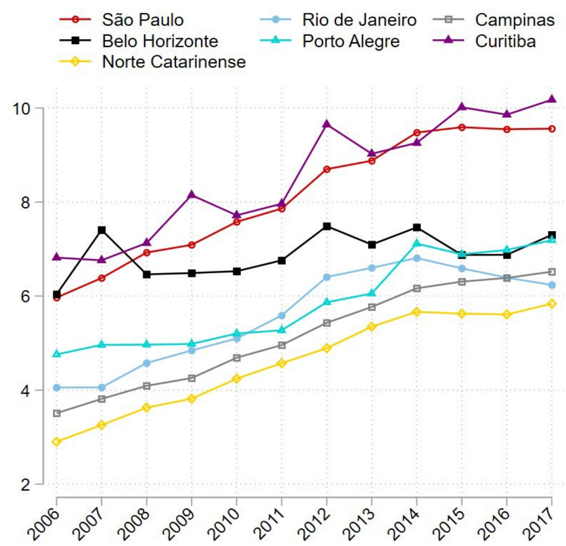
São Paulo’s main economic sectors, based on local employment, are service-based ones (e.g., education, health, and scientific and technical services). Among manufacturing activities, apparel manufacturing takes the largest share, followed by metal products, furniture and food manufacturing (Figure A.2).[7]

Population and economic size are key factors to explain the success of urban innovation hubs, as well as access to universities and pools of talent (Adler & Florida, 2021). In this sense, São Paulo has seen a uniform increase in the amount of high-skilled human capital. Figure A.3 shows, respectively, the share of employment and share of population with college degree, both in São Paulo metro regions and in comparable regions in Brazil. Clearly, São Paulo stands out among the largest metropoles (together with Curitiba).

Figure A.3: Talent in São Paulo and other regions



(a) Share of workers with college degree



(b) Workers with college degree per 100 inhabitants

For the rest of the analysis, this report looks at the São Paulo Global Innovation Hotspots, as defined in WIPO (2019) (with few exceptions, where it uses the borders of the mesoregion), including its outer borders. While the borders are not the same (the hotspots ones being smaller; see Figure A.4), most of the economic and patenting activity concentrates within the hotspot borders. Our estimations reveal that the hotspot borders account for around 75 percent of the population of the mesoregion of São Paulo.

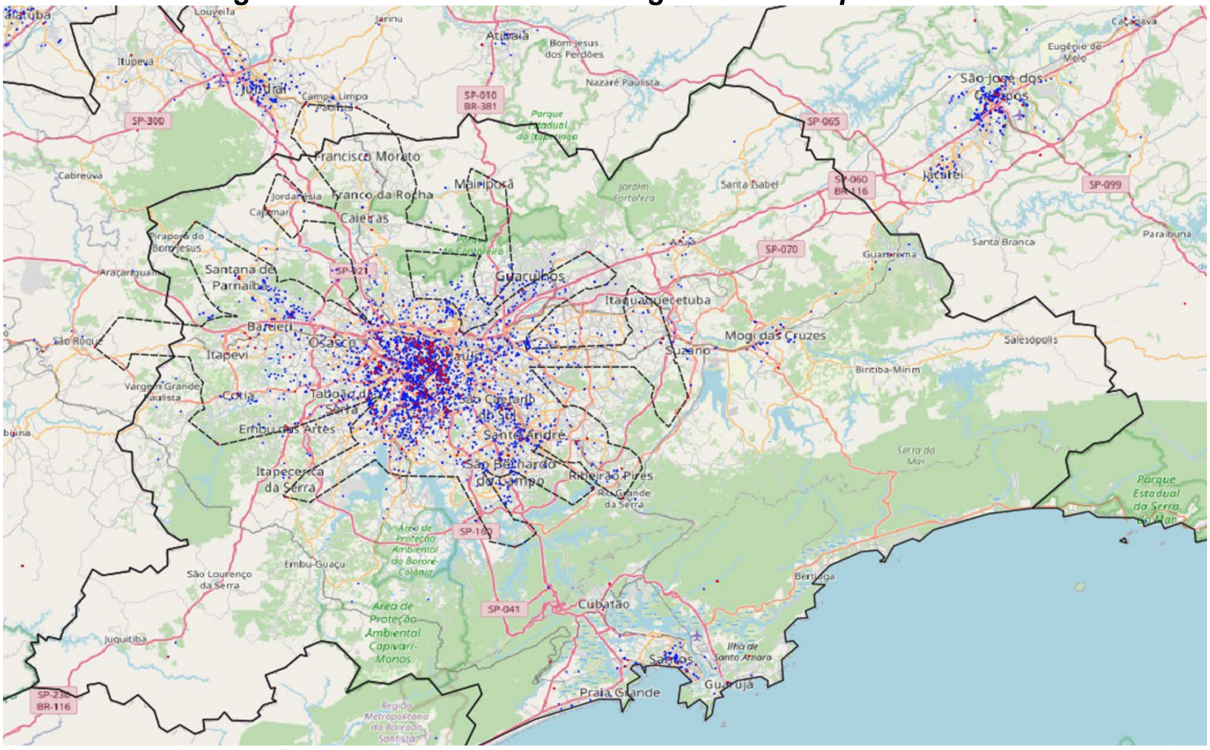
B.2.2São Paulo in the national, regional and global systems of innovation

This section aims to assess São Paulo’s innovation potential using IPF data from WIPO (2019), comparing it to other Global Innovation Hotspots and Niche Clusters in Brazil and in other countries. In order to better depict São Paulo’s position in relation to the rest of the country, the report also uses national office patents and utility models. This will be clearly specified, as the administrative unit is slightly different (mesoregions instead of hotspots and clusters).

[7] GDP per capita and main economic sectors form The Growth Lab at Harvard University, Metroverse, 2020, https://metroverse.cid.harvard.edu/ (accessed August 10, 2022).

The section aims to show how São Paulo is a national and regional innovation powerhouse, but still lags behind other clusters in emerging economies.

Figure A.4: São Paulo's mesoregion and hotspot borders



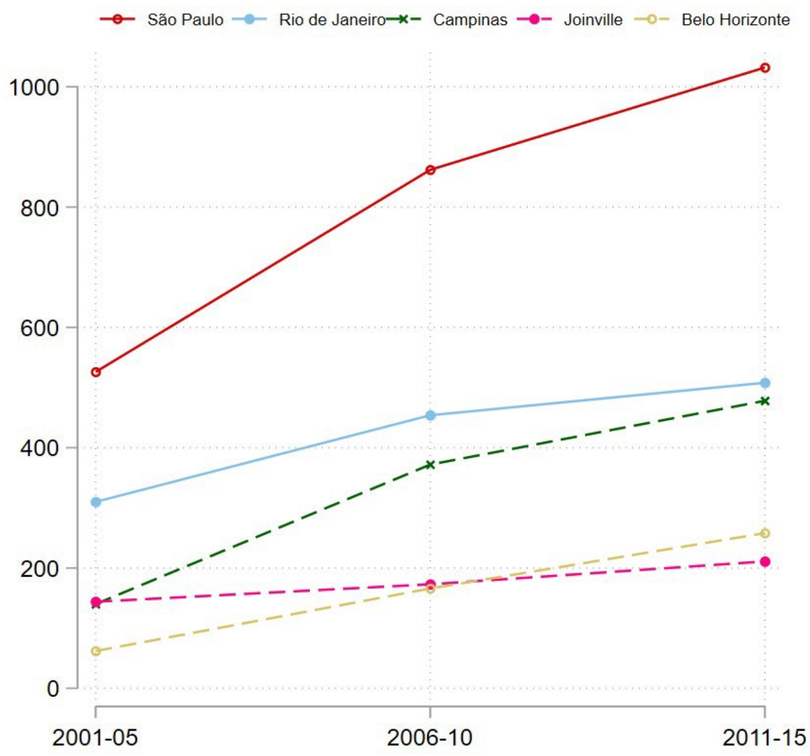
Source: Plotted from WIPO (2019) data.

São Paulo also leads the ranking among Latin American clusters, ahead of Rio de Janeiro, Mexico City, Buenos Aires and Santiago de Chile. Yet, despite this regional lead, São Paulo is still far from other clusters in emerging economies, such as those in China, India or Russia. As mentioned above, using other innovation indicators could provide a more accurate picture of the hotspots in relation to other areas in the world. Yet, in regard to patents in the international arena, while São Paulo is clearly a national and regional champion, it is still far from being competitive at an international level.

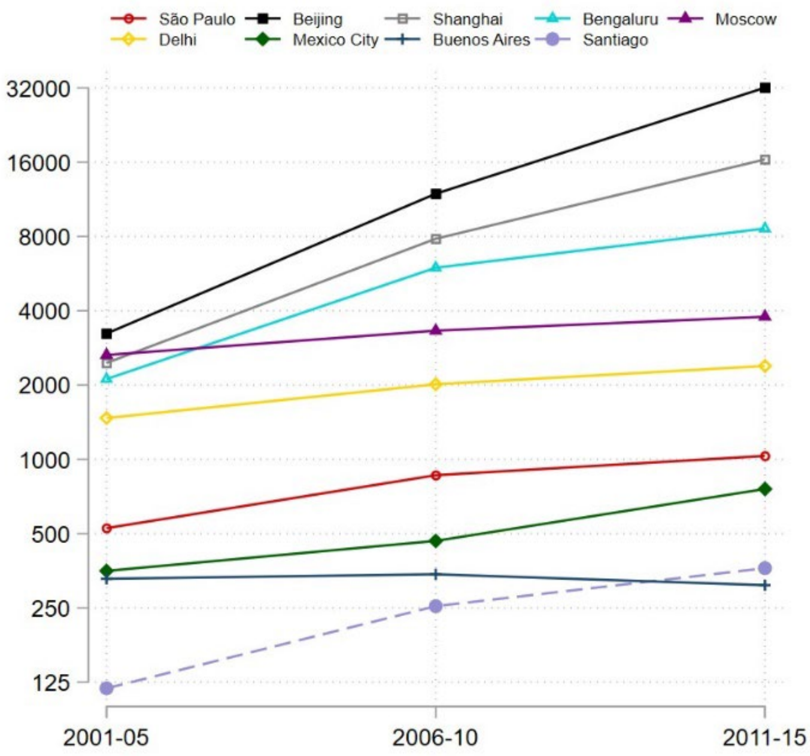
As a sample of "softer" innovation, we start by looking at national patents and utility models (UM), applied to National Institute of Industrial Property (INPI) data. In all countries, national patents are considered more accessible to a larger set of applicants, due to their lower economic cost and application time/difficulty. Of course, they tend to be of lower quality, especially for international standards. As can be seen in Figure A.6, only a proportion of all patents produced in São Paulo are also internationalized (note that the spatial unit for national patents and UM is slightly larger). Similarly, São Paulo applicants also outperform in UM. There seems to be certain convergence in number from 2006 to 2015, which would speak in favor of the internationalization strategy of São Paulo's firms. Unfortunately, data quality issues prevent us from making this statement; information of inventors' addresses is of poor quality in those years in INPI data, and this is essential for geolocalizing them in space. It is likely that the shrinking patterns of national patents and UMs are in large part explained by this information quality issue.

Figure A.5a shows the evolution of patenting (IPF data) from 2001 to 2015 for a selection of Brazilian hotspots and niche clusters and a selection of worldwide hotspots, including the most important (and comparable) ones in Latin America and other emerging economies. As can be seen, São Paulo stands out as the most patenting cluster of Brazil.

Figure A.5: IPF patents in hotspots and clusters, 2001–2015



(a) Brazilian hotspots and clusters

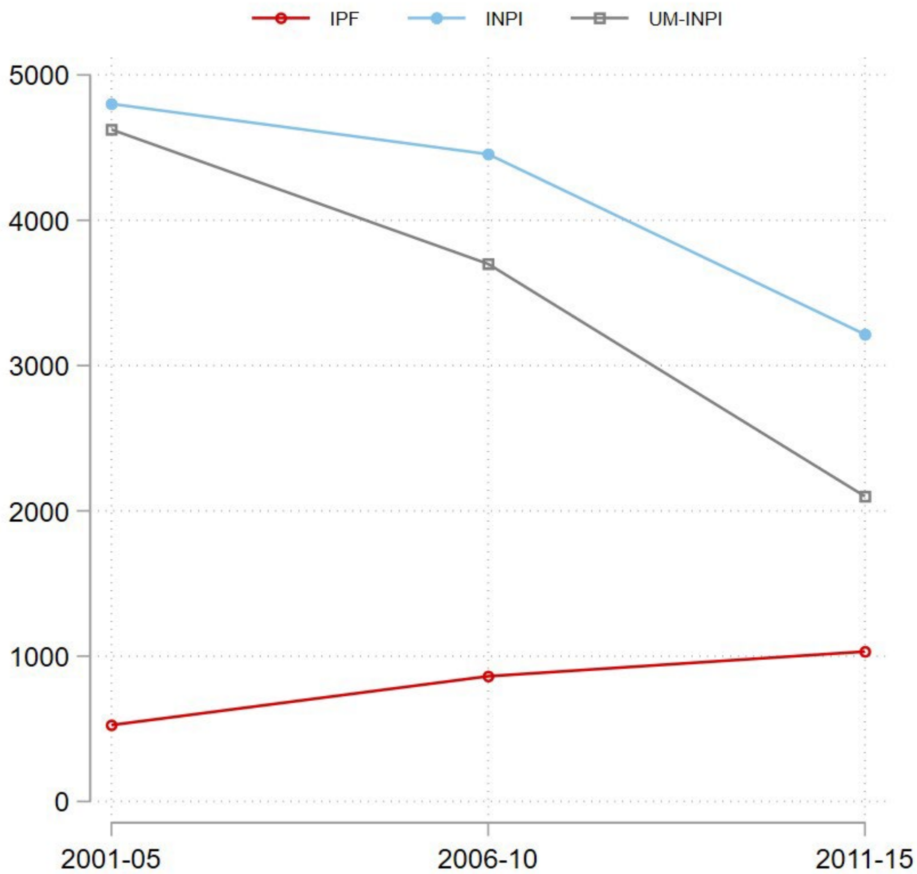


(b) Selection of hotspots and clusters (log scale)

Source: WIPO (2019) data.

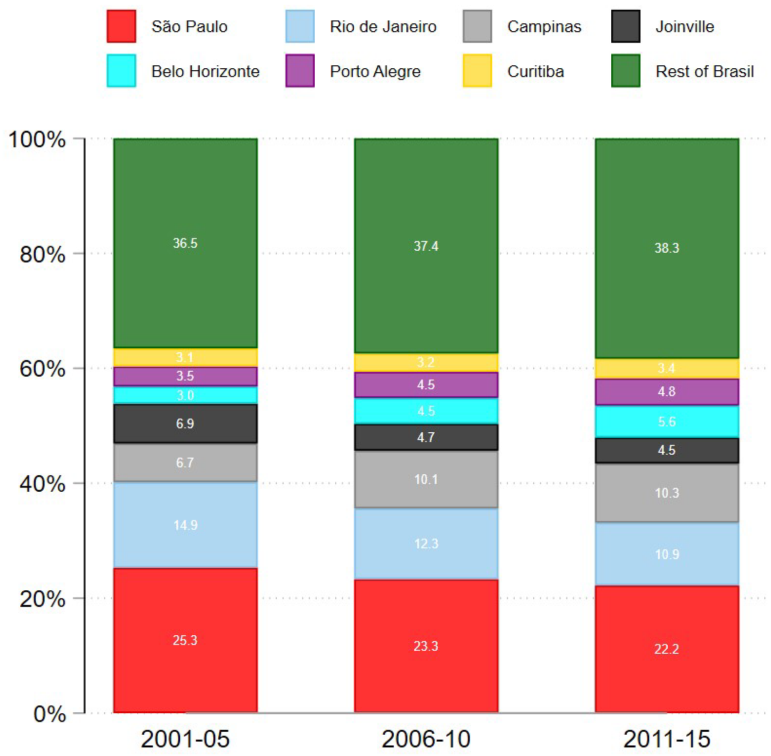
Using both IPF and INPI patent applications, we can further investigate the importance of São Paulo for the Brazilian national innovation system. Figure A.7 shows the share of IPF patents in the São Paulo hotspots (Figure A.5a) alongside the share in other hotspots and the rest of the county. In all years analyzed, São Paulo represents around 25 percent of Brazilian patenting in IPF, way ahead of the second cluster (Rio de Janeiro, around 10–14 percent). Interestingly, both hotspots have decreased their share slightly over time due to a slight increase in the Campinas share, as well as the production of IPF patents in the rest of the country. Figure A.5b reproduces the same figure, but using INPI patent data, for the mesoregions of Brazil. Again, São Paulo leads, with an even larger proportion than before (in almost all yeas), witnessing the relative specialization of São Paulo in national patents (on the contrary, Rio de Janeiro and Campinas show consistently lower shares when looking at INPI patents compared to IPF patents). This

Figure A.6: IPF, national patents and utility models in São Paulo, 2001–2015

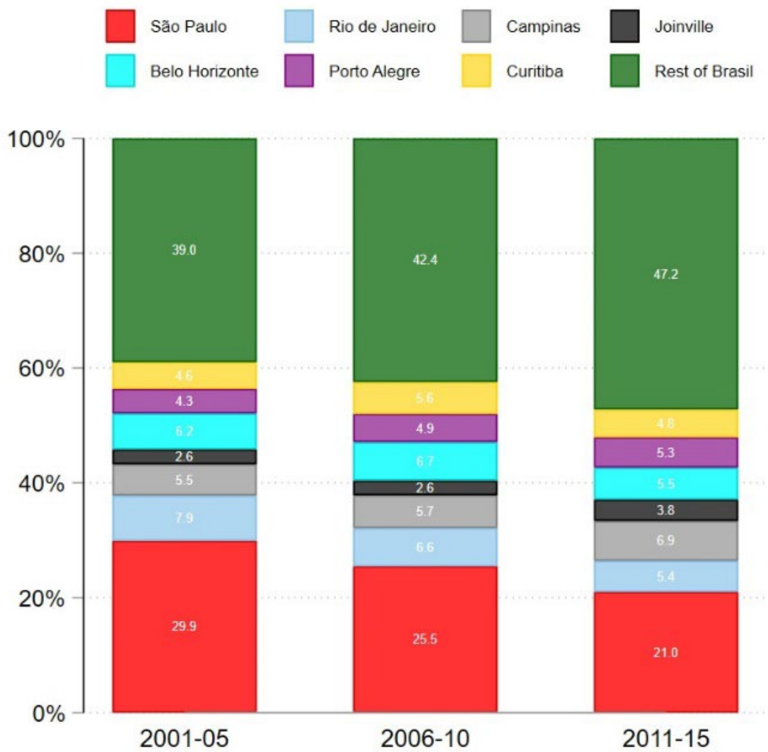


Source: WIPO (2019) and INPI data.

Figure A.7: Share of patents in Brazilian hotspots and mesoregions



(a) IPF data, hotspots and clusters



(b) INPI data, mesoregions

Source: WIPO (2019) and INPI data.

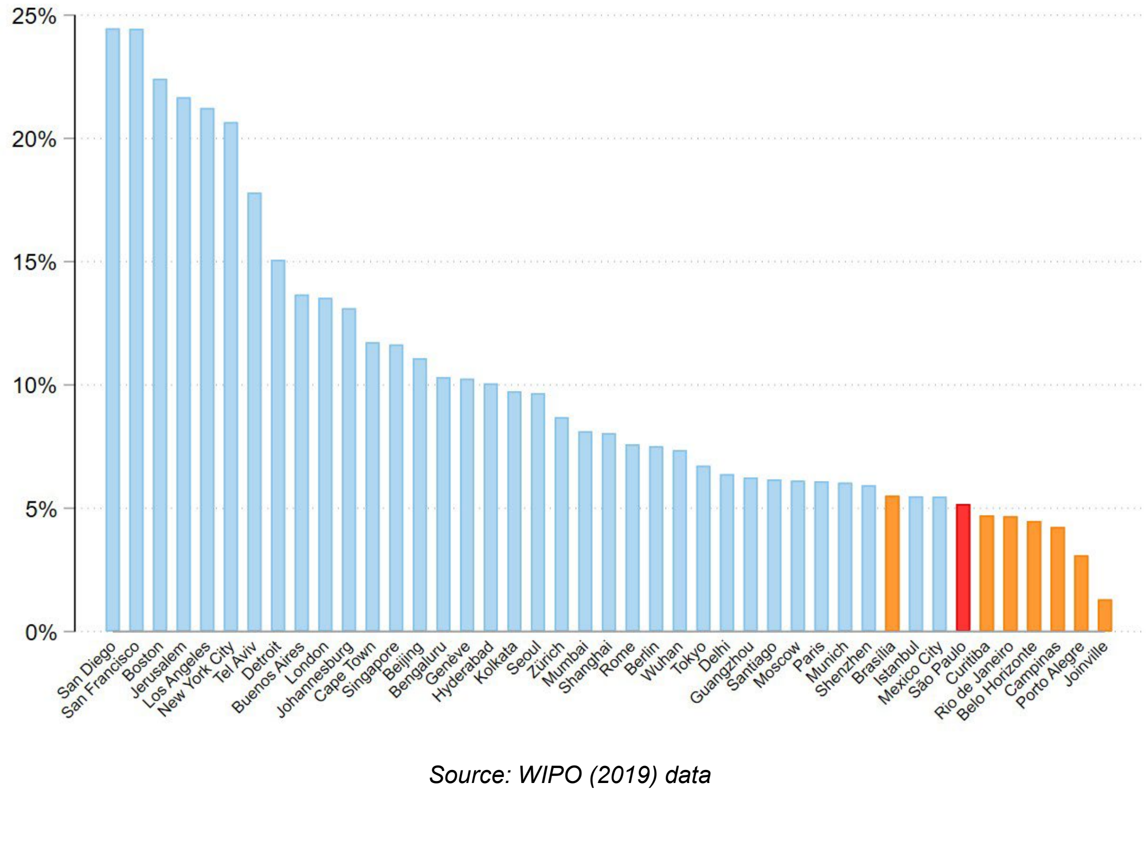
Now, we have seen that São Paulo is clearly a national and regional leader, but still lags behind the hotspots of other emerging economies. We have limited ourselves to counting patents across hotspots that are arguably very different, ignoring the importance of what they produce. We remedy this in two ways.

First, we measure such importance with the number of citations patents receive (forward citations) from other patents (Jaffe & Rassenfosse, 2017). Some correlation also exists between forward citations and economic value (Jaffe & Rassenfosse, 2017).

Second, we also establish whether patents produced are of high complexity or not (Balland *et al*., 2020) based on their International Patent Classification (IPC). To identify high-complexity patents, we follow Fleming and Sorenson (2004) and Sorenson *et al*. (2006).

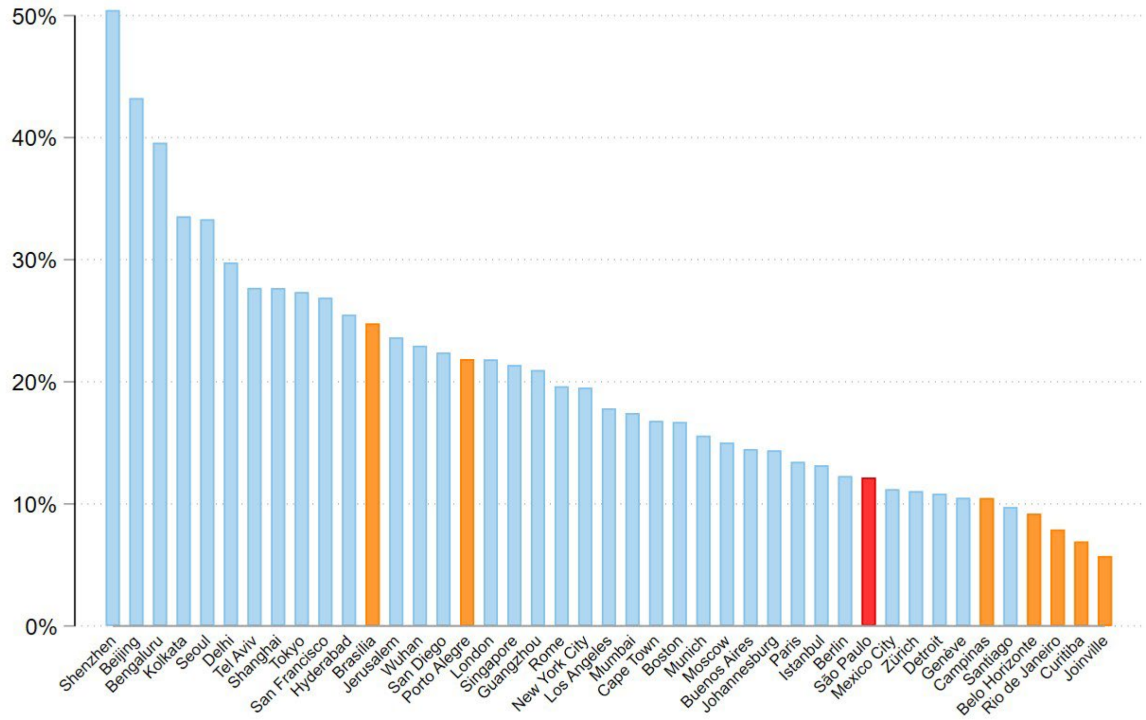
Figures A.8 and A.9 show the share of patents in São Paulo and other worldwide clusters that are highly cited or highly complex, respectively. As can be seen, again São Paulo leads in the country in almost all periods (though, of course, the differences with other areas are not that notable). Some differences emerge comparing São Paulo to a selection of hotspots in Latin America and emerging economies. While Indian and Chinese clusters tend to outperform others, in part due to their specialization in information and communication technologies (ICT), São Paulo is not as far behind as before, and shares space with other hotspots in the world.

Figure A.8: Share of highly cited patents in São Paulo and worldwide clusters, 2006–2015



Source: WIPO (2019) data

Figure A.9: Share of high-complexity patents in São Paulo and worldwide clusters, 2006–2015

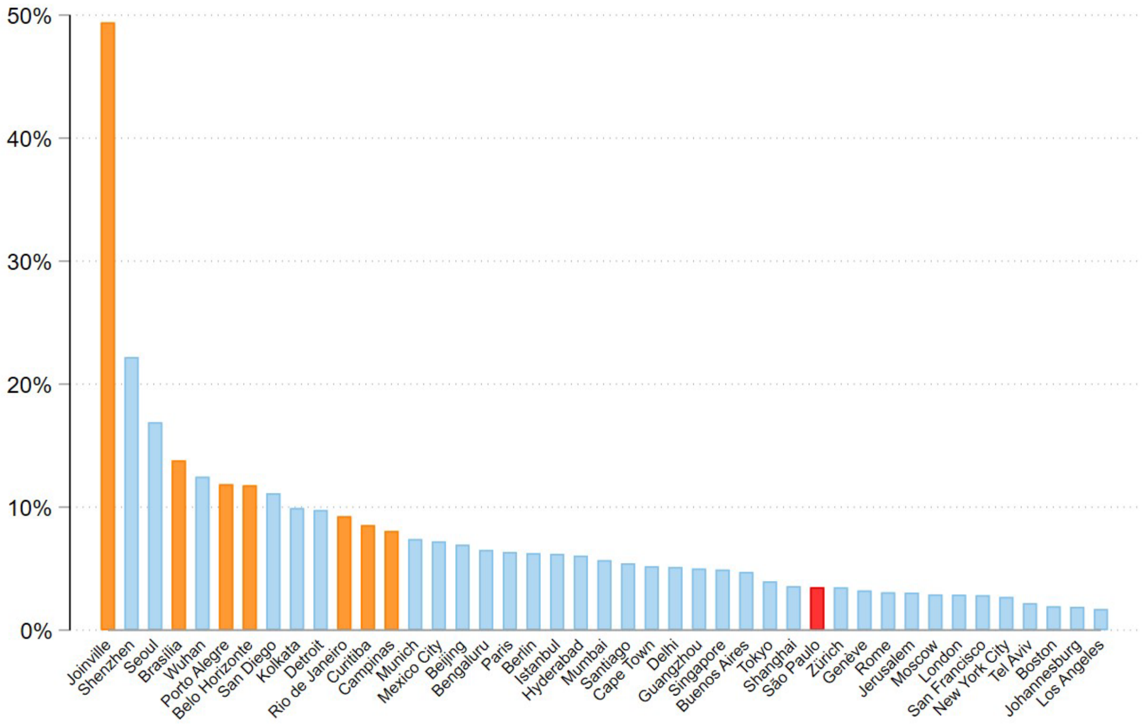


Source: WIPO (2019) data.

B.3 Innovation ecosystem

The take-off of the *innovation ecosystem* concept is attributed to Adner (2006), where it is defined as "the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution" (Adner, 2006, p. 2). Granstrand and Holgersson (2020) provide a recent conceptual review. The authors collect a comprehensive list of definitions, where the following aspects stand out: collaboration, multi-level, agent system, networks, innovation, knowledge, culture, social capital, inter-organization, synergistic and complex relationships, human capital, research, excellence in universities, complementarities, creativity, interactions, entrepreneurship, innovative mentality, upstream suppliers and diversity. One first aspect to look at on innovation ecosystems is their degree of market concentration, or firm concentration. That is, whether innovative firms tend to be small and abundant, or big and few (or a mix of the two). This is important to the extent that a given internal configuration may boost or hamper innovation via more or less diffusion of knowledge, as well as via more or less promotion of competition. Figure A.10 looks at the share of IPF patents owned by the three largest applicants in each time window. São Paulo is, by and large, the Brazilian hotspot/cluster where the first applicant takes the least share, evidencing the more atomistic and dynamic structure of the city, and its lower concentration in few tenants. This lower concentration is confirmed by looking at the Herfindahl-Hirschman Index (HHI) of patenting concentration among applicants present in the hotspots/clusters (Figure A.11).

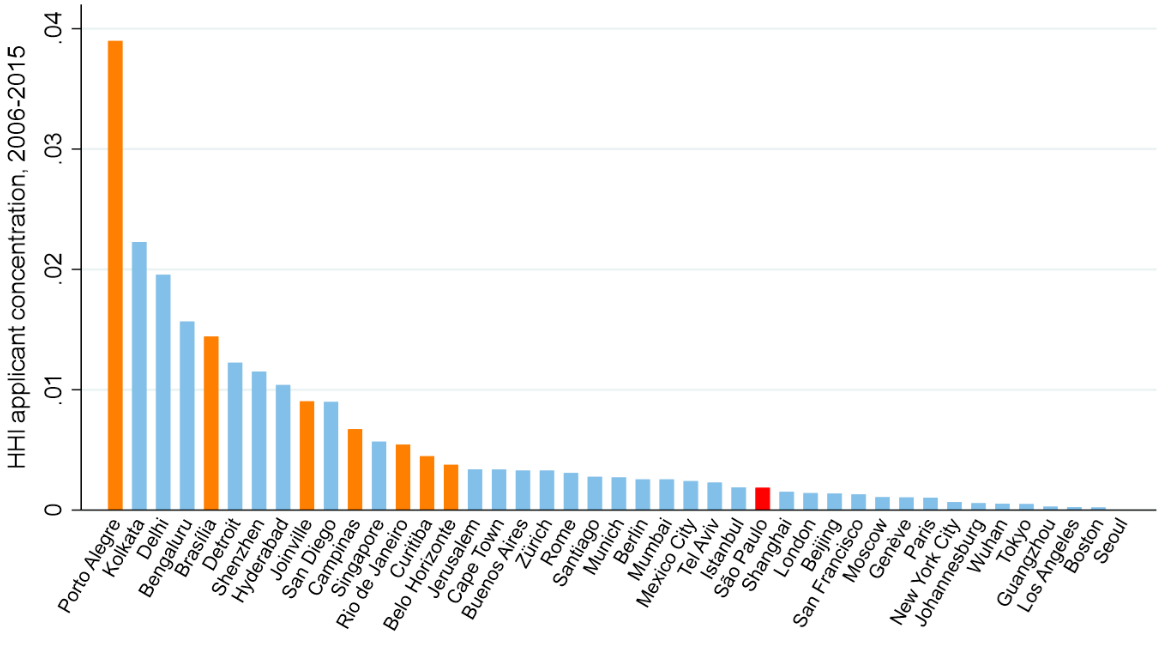
Figure A.10: Share of IPF patents owned by the three largest applicants, 2006–2015



Source: WIPO (2019) data.

As can be seen, São Paulo is among the less concentrated areas, and is far from other clusters in the rest of the country or Latin America.

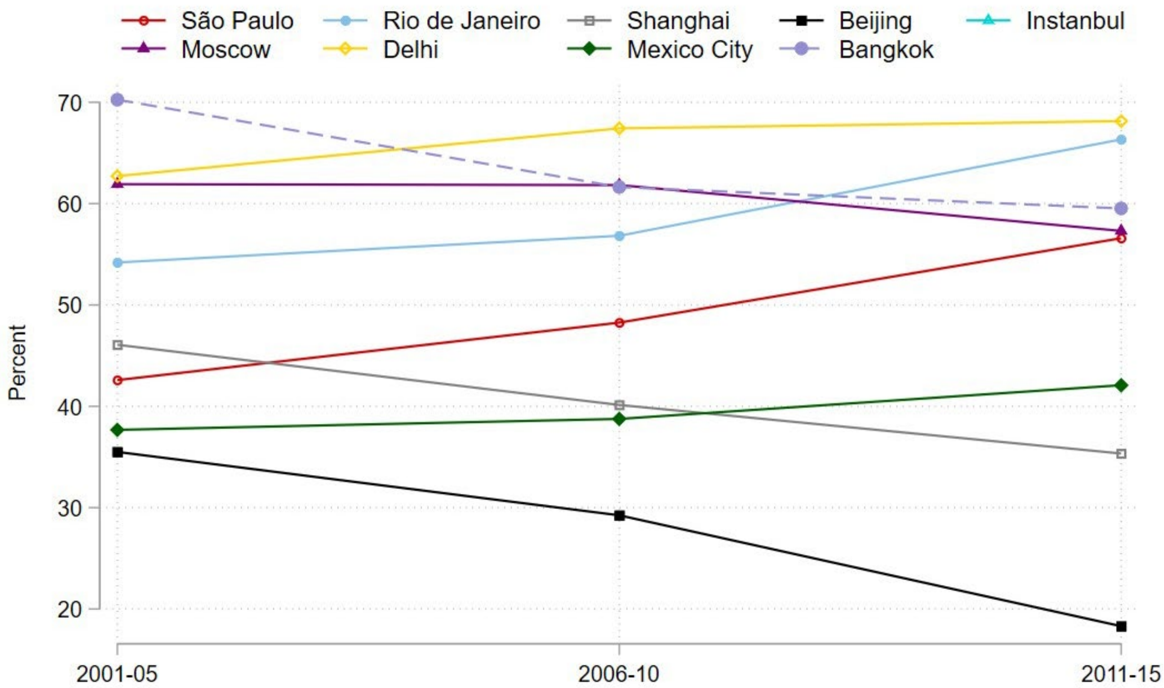
Figure A.11: HHI applicant concentration, 2006–2015



Source: WIPO (2019) data.

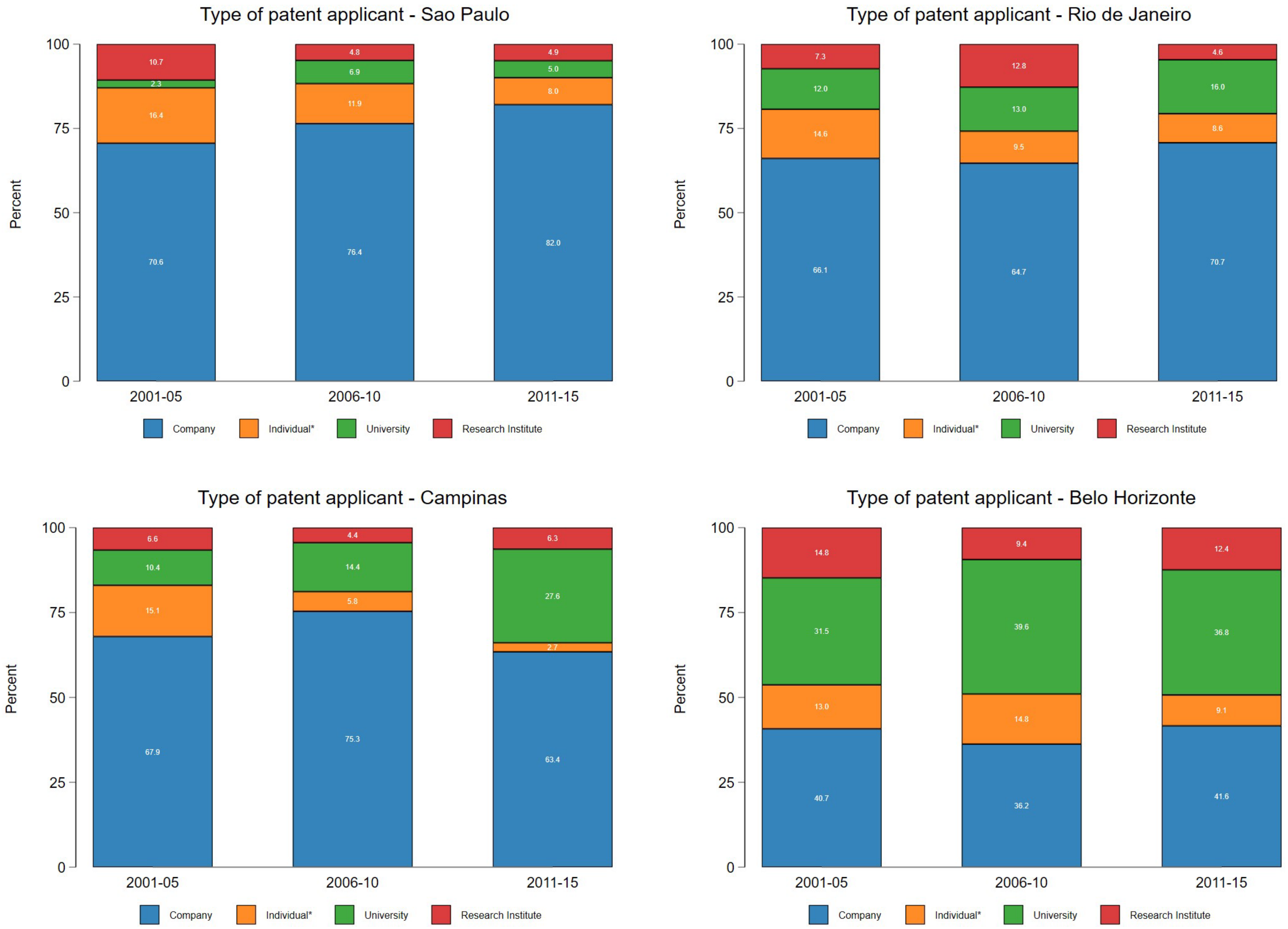
In a similar vein, the internal network configuration may also determine the internal diffusion of knowledge. Figure A.12 shows the share of patents produced in clusters and hotspots with more than one inventor. São Paulo's share has been increasing over the years, but it is not yet among the highest (contrary to Rio de Janeiro, for instance). This again reflects the characteristics of the São Paulo ecosystem, with smaller firms, and small teams too.

Figure A.12: Share of patents with more than one inventor, 2006–2015



Source: WIPO (2019) data.

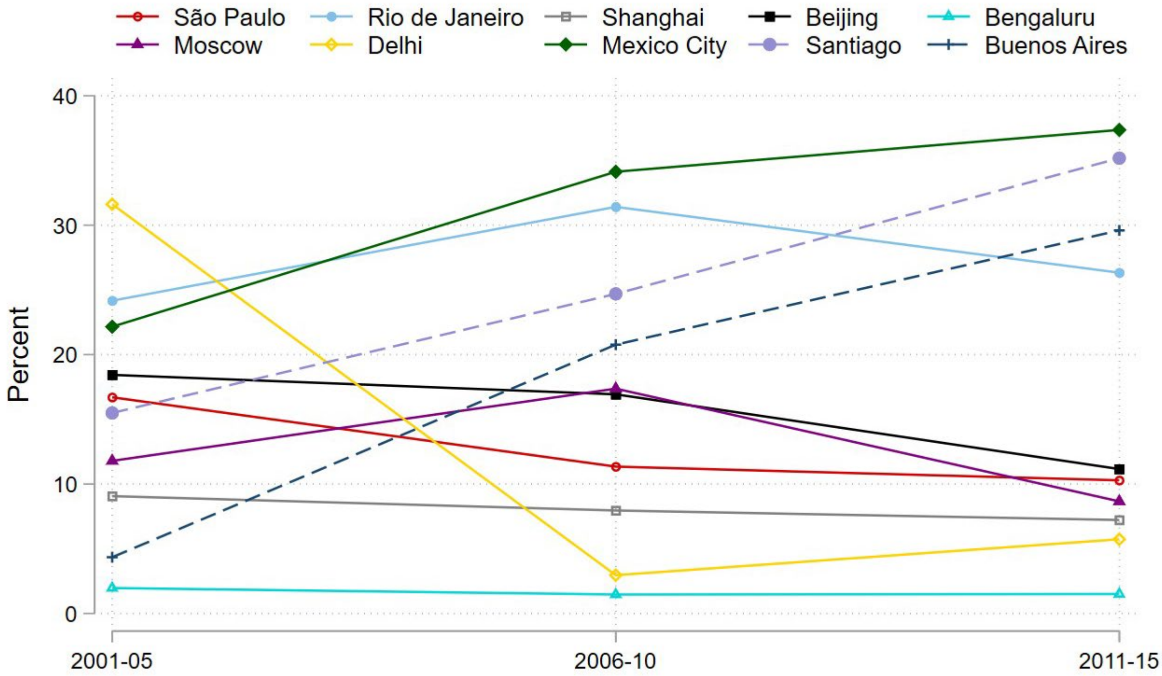
Figure A.13: Type of patent applicant, IPF data, 2001–2015



Source: WIPO (2019) data.

Figure A.13 depicts the types of applicants behind IPF patents in São Paulo over time, and compared to other clusters in Brazil. Corporate firms, compared to individuals, universities or public organizations, are by far the most prominent stakeholder behind innovation in São Paulo. Differences are striking with respect to Rio de Janeiro, and even larger compared to Campinas or Belo Horizonte. At the same time, the share of patents belonging to universities and research institutions is way smaller in São Paulo (despite the importance of universities for absolute patenting in São Paulo). Clearly, the characteristics of the innovation actors in São Paulo differ from the rest of the country. In fact, as shown in Figure A.14, São Paulo is closer to other worldwide, renowned clusters in terms of the share of publicly owned patents.

Figure A.14: Share of patents owned by research institutions, 2001–2015



Source: WIPO (2019) data.

In this framework, it is worth looking in more detail at who is behind IPF innovation in clusters. This is shown in Figure A.15, which lists the top 20 applicants of IPF patents in São Paulo, in three time periods. As can be seen, there are a few public institutions behind these patents (USP, Fundaçao Butantan, FAPESP), but they do not have the most prominent role in the cluster. Other firms, some of them multinational corporations (MNCs), seem to have a stronger role (Natura, IBM, Mahle, Dow Chemical and so on).

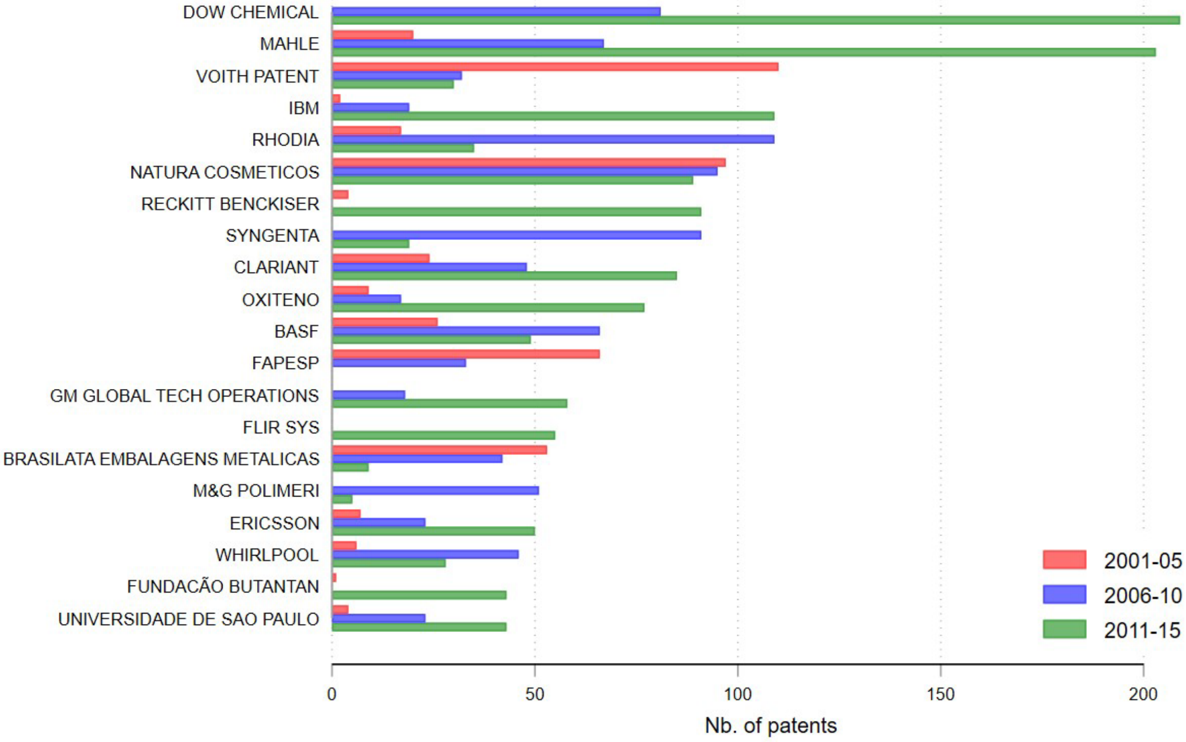
Now, in further exploring who is behind patents in clusters, we repeat the analysis exploiting information from patent applications at the INPI. This is shown in Table 2, depicting the top 20 INPI applicants in four time periods, from 2001 to 2020. Quite interestingly, the rankings using IPF and INPI data do not highly correlate. The most puzzling issue is the difference with respect to public applicants, such as USP, UNESP or FAPESP; when it comes to INPI patents, public institutions perform way better than with IPF, that is, they seem to specialize in local, lower-quality applications than those applying applications also abroad. Another explanation for this would be that USP patents are sold to MNCs (as well as local firms), who do apply for these patents abroad, and therefore we lose them in the figures.

Table A.2: Top 20 INPI applicants, 2001–2020

	2001-2005		2006-2010		2011-2015		2016-2020	
Rank	**Company**	**# patents**	**Company**	**# patents**	**Company**	**# patents**	**Company**	**# patents**
1	Whirlpool	130.0	Whirlpool	238.2	Whirlpool	434.3	USP	251.8
2	USP	90.0	USP	181.6	USP	270.6	UNESP	218.5
3	FAPESP	86.1	FAPESP	67.7	UNESP	90.3	Natura	61.0
4	Dana	50.8	Duratex	29.0	Agco	49.4	Whirlpool	33.5
5	UNESP	35.2	Compass Minerals	25.5	Senai	43.3	UFABC	30.7
6	Natura	32.8	UNESP	20.2	Natura	30.5	Butantan	29.5
7	Brasilata Metalicas	21.0	Brasilata Metalicas	18.0	IPT	27.0	Duratex	21.0
8	Ache Lab.	17.0	Agco	17.7	Duratex	23.5	Oxiteno	20.0
9	Copersucar	14.7	Senai	17.5	Oxiteno	19.8	Hypermarcas	18.0
10	Seb Domesticos	14.5	Natura	15.8	FAPESP	19.8	Lorenzetti	14.0
11	Arno	14.2	Rhodia	12.8	Ericsson	15.0	Synergy Em	14.0
12	Biosintetica	12.2	Sin Sistema	12.5	Mahle	14.7	IFSP	13.0
13	Jacto	11.5	Siemens	12.3	Hypermarcas	12.0	Einstein	13.0
14	Duratex	11.0	Bancaria	10.0	UFABC	11.7	UNIFESP	13.0
15	Johnson & Johnson	10.0	Genoa Biotecnologia	10.0	Origami Em	11.6	Man Veiculos	12.0
16	Sabo	10.0	UNIFESP	9.9	Do Metropolitano Sao Paulo Metro	11.0	Powerpic	12.0
17	Valeo	9.7	Oxiteno	9.8	UNINOVE	10.3	Ericsson	11.0
18	Techinvest	9.3	Mabe	9.5	Torniplast Artefatos	10.0	Probac Bacteriologicos	11.0
19	UNIFESP	9.3	Vicon	9.3	UNIFESP	9.8	ISESC	10.0
20	Invensys	9.0	Tyco Electronics	9.0	Siemens	9.5	ZIP-PAK	10.0

Source: INPI data. Notes: USP: Universidade de São Paulo; FAPESP.

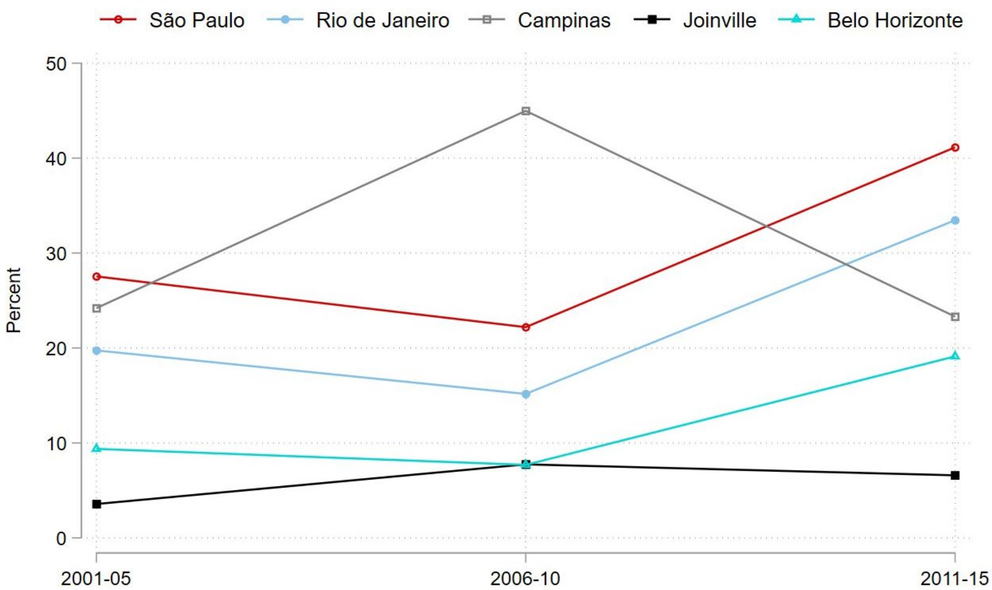
Figure A.15: Top 20 IPF applicants, 2001–2015, São Paulo



Source: WIPO (2019) data.

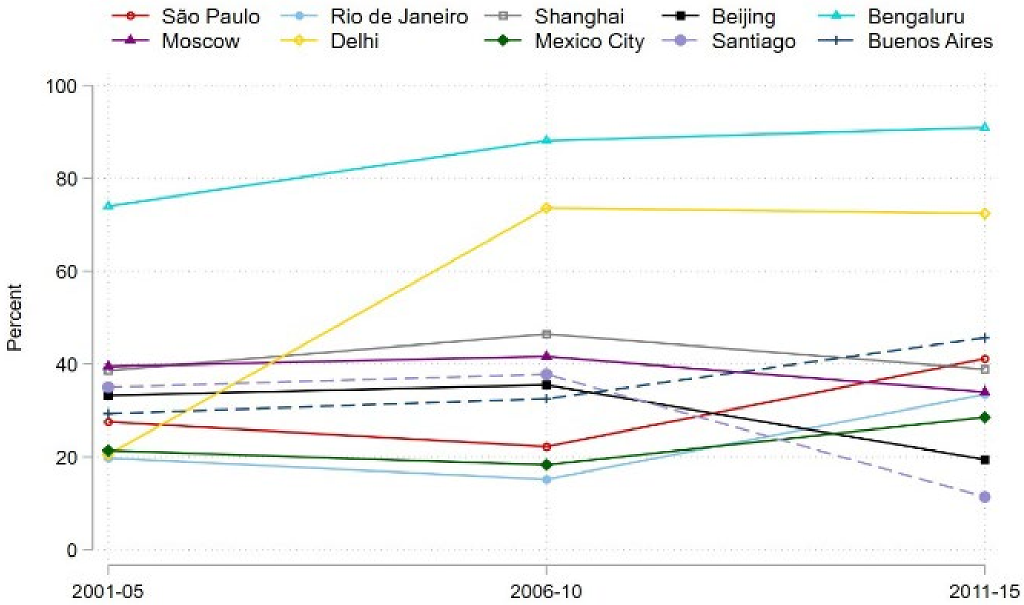
Another important aspect observable in Figure A.15 and Table 2 is the presence of MNCs in São Paulo's ecosystem. São Paulo is the Brazilian cluster/hotspot with the highest presence of foreign MNCs (Figure A.16), and it has the largest share among worldwide clusters, with the exception of Indian clusters.

Figure A.16a: Share of foreign-owned patents in Brazil



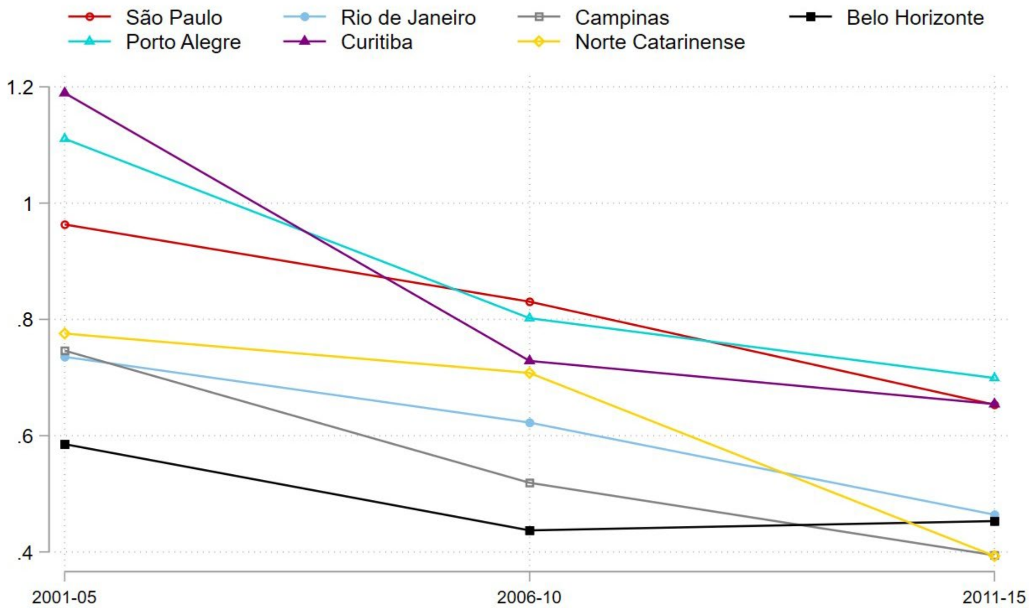
Source: WIPO (2019) data.

Figure A.16b: Share of foreign-owned patents in selection of GIHs



Source: WIPO (2019) data.

Figure A.17: Ratio of UM to patents filed at INPI, 2001–2015



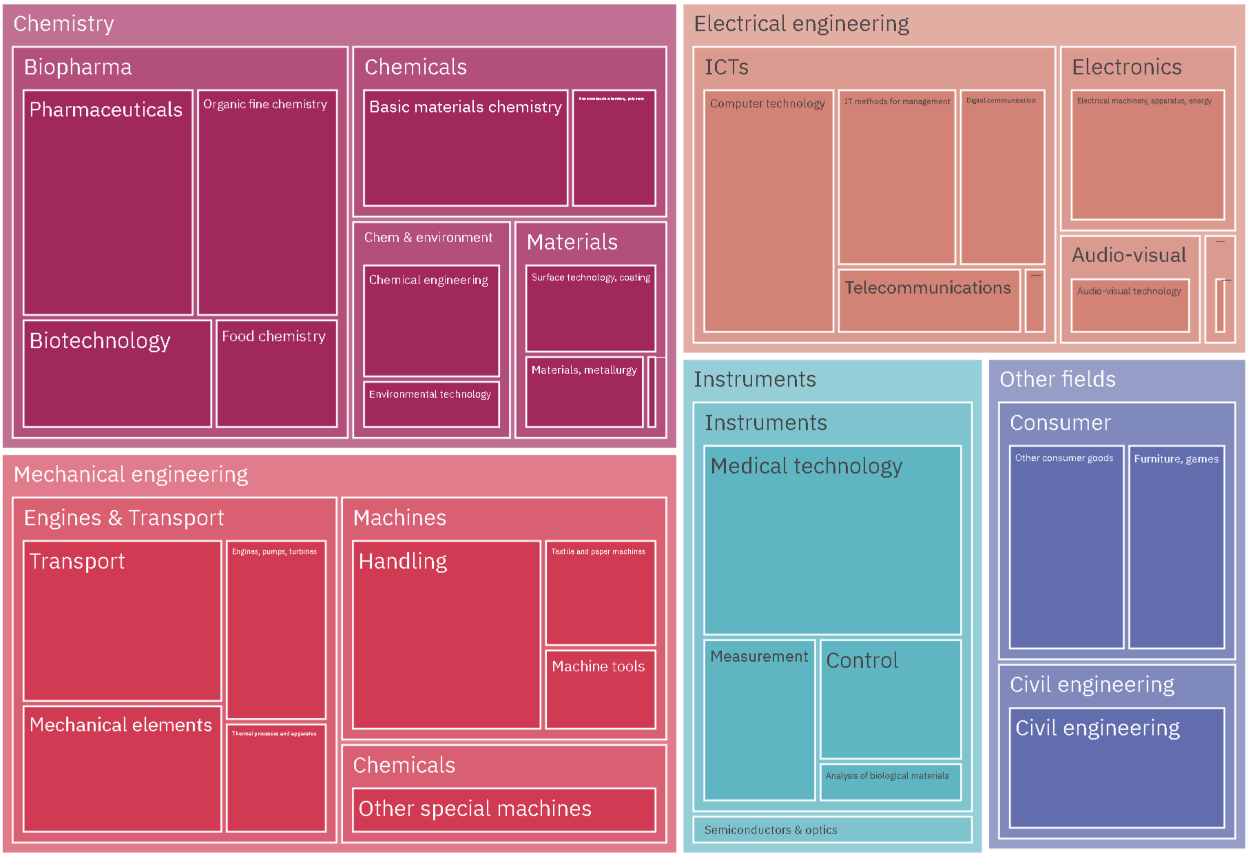
Source: INPI data. Notes: UM = Utility models

B.4 Local technological capabilities and opportunities for diversification

So far, we have seen that São Paulo is a national and regional champion, with local characteristics that resemble worldwide hotspots of innovation (and regional and national clusters), but also that it produces less highly impactful patents and complex technologies. The question now is which fields São Paulo specializes in, and if these are likely to offer opportunities for growth and development.

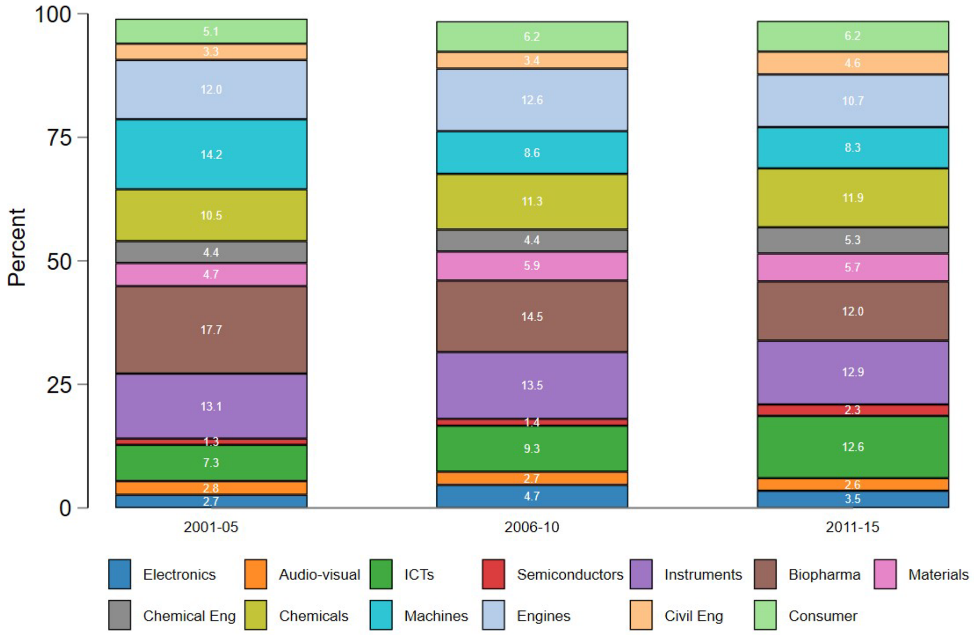
We first look at the distribution of IPF patent production across technologies, both in São Paulo and in the whole country (Figures A.18-A20). The largest patenting fields are instruments, ICT and biopharma. Interestingly enough, these are the same largest fields for the whole Brazil (with the exception of engines, which are also quite important for Brazil, but less so in São Paulo). We interpret this similarity as follows. São Paulo accounts for around a quarter of all Brazil IPF patenting, and therefore both follow a similar pattern. However, even when São Paulo is not considered in the Brazil field distribution (not shown), the pattern does not differ much, indicating that the country has a sort of subordinate position to its leading city in terms of technology production.

Figure A.18: São Paulo's IPF patents across tech fields, 2006–2015



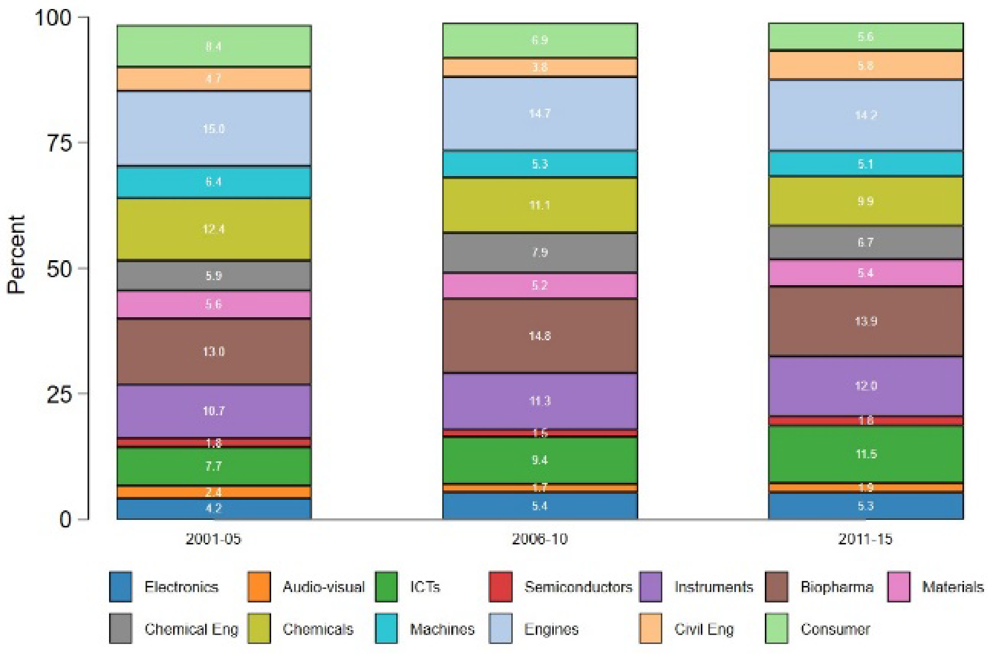
Source: WIPO (2019) data.

Figure A.19: Evolution of São Paulo's technological specialization IPF patents across tech fields, 2001–2015



Source: WIPO (2019) data.

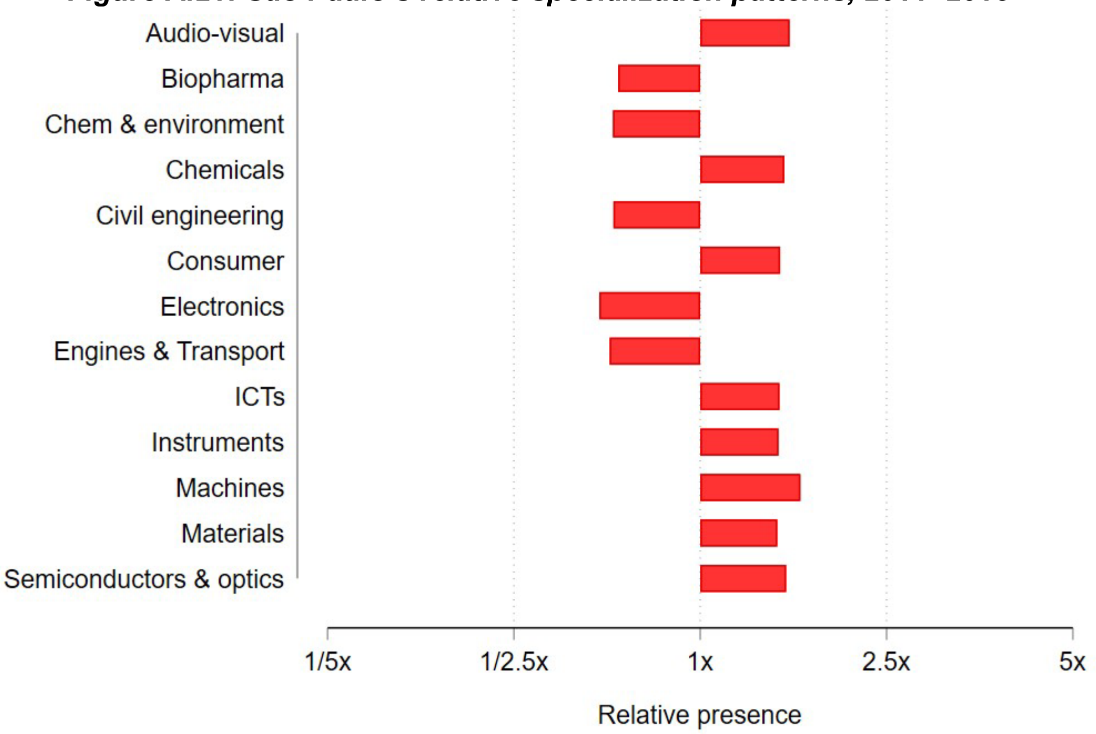
Figure A.20: Evolution of Brazil's technological specialization IPF patents across tech fields, 2001–2015



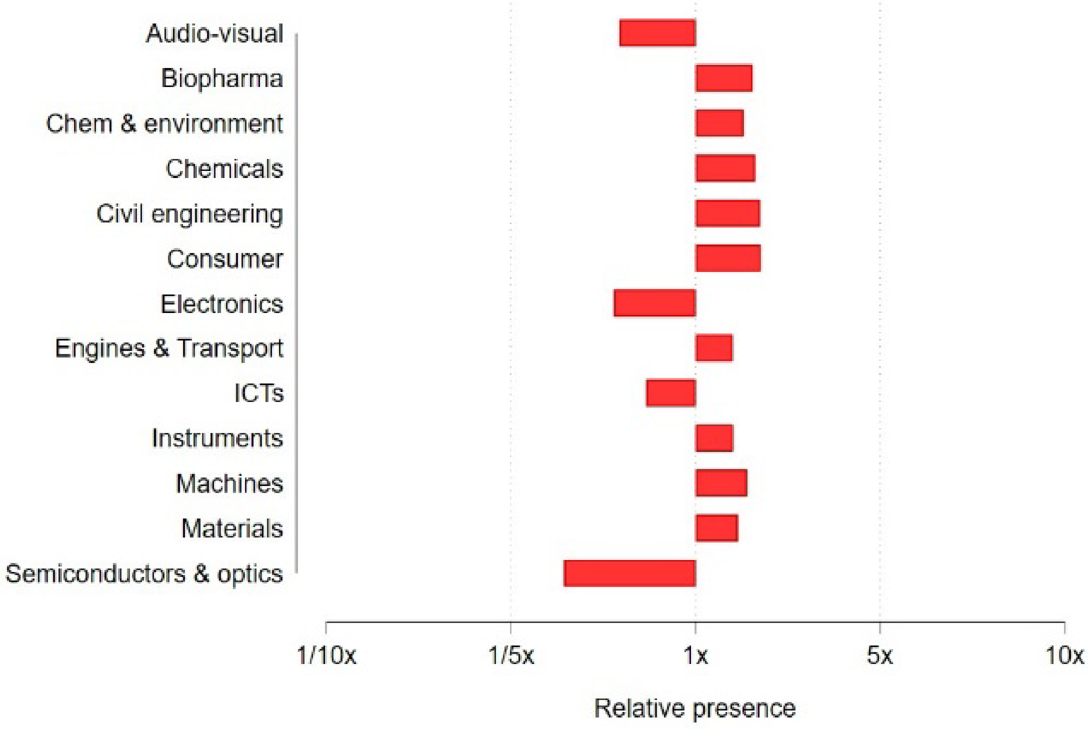
Source: WIPO (2019) data.

In fact, when the revealed technological advantage (RTA) of each field in São Paulo is computed (Figure A.21), results differ depending on whether the comparison is made with the whole of Brazil (Figure 21a) or the whole world (Figure A.21b).

Figure A.21: São Paulo's relative specialization patterns, 2011–2015



(a) with respect to Brazil

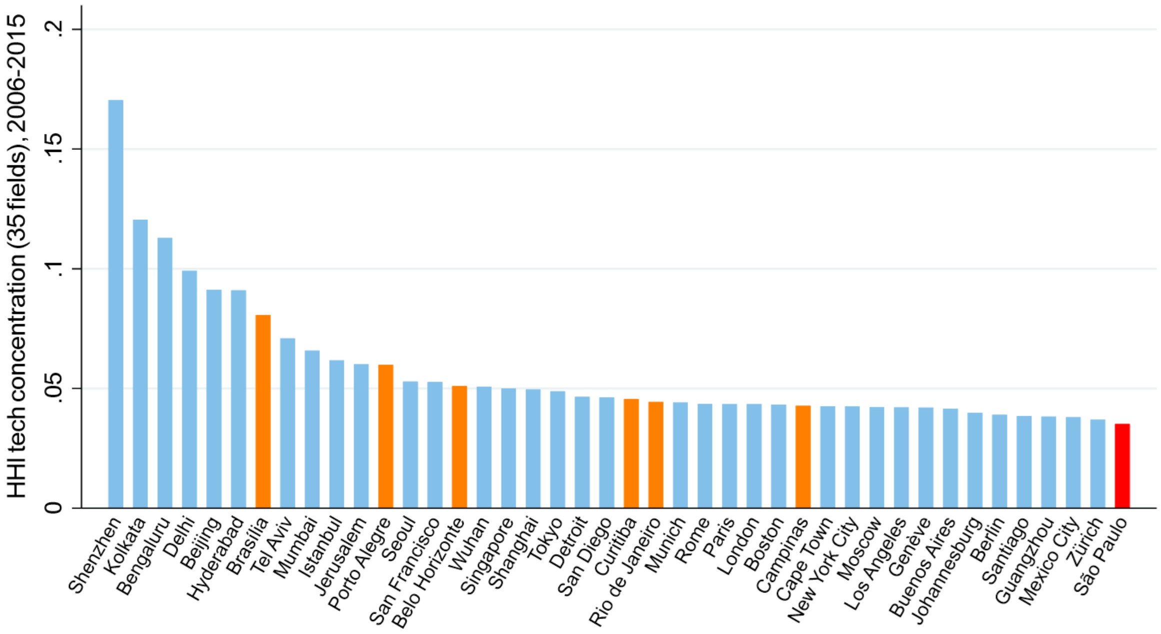


(b) with respect to World

Source: WIPO (2019) data. Notes: Relative presence computed as Revealed Technological Advantage (RTA) for 13 technological subsectors.

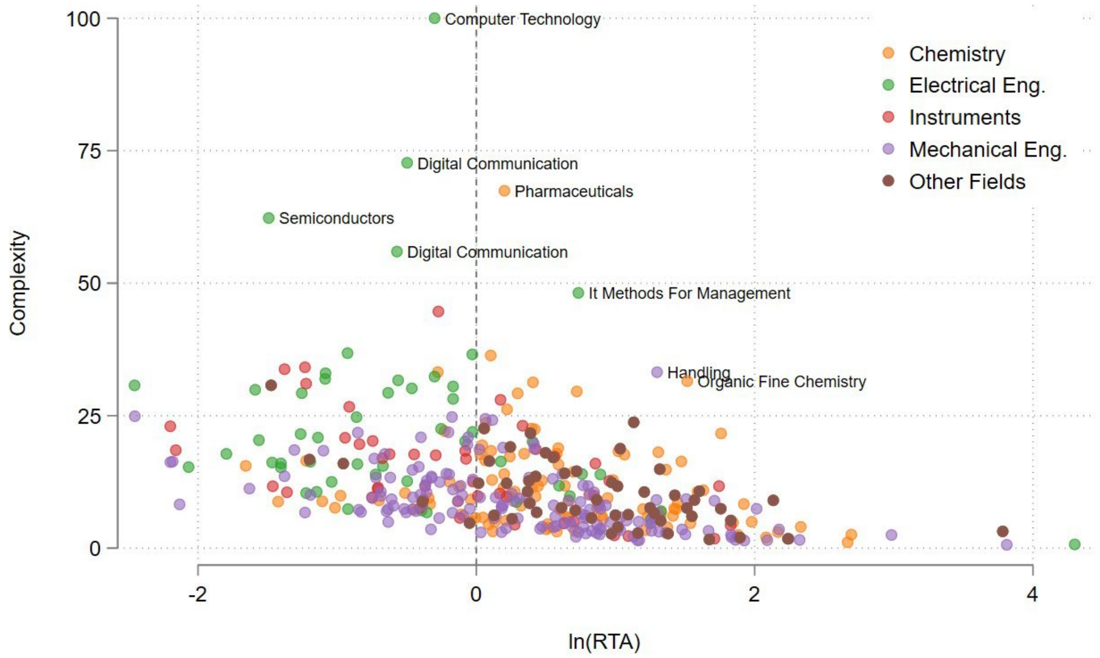
Another important conclusion from Figure A.19 is that despite São Paulo's major presence in certain fields, the city is quite diversified technologically speaking. This is something we can further explore in Figure A.22, where the HHI of concentration in IPF patent fields (35 WIPO fields; see Schmoch, 2008) is shown for the time window 2006–2015, across different hotspots and clusters. Clearly, São Paulo is among the less concentrated hotspots across technologies (i.e., it is highly diversified).

Figure A.22: Technological concentration, 35 fields (HHI), IPF, 2011–2015



Source: WIPO (2019) data. Notes: HHI computed for 35 technological fields.

Figure A.23: São Paulo's technological complexity and RTA, 2011–2015



Source: WIPO (2019) data. Notes: Complexity and RTA computed for 623 IPC classes.

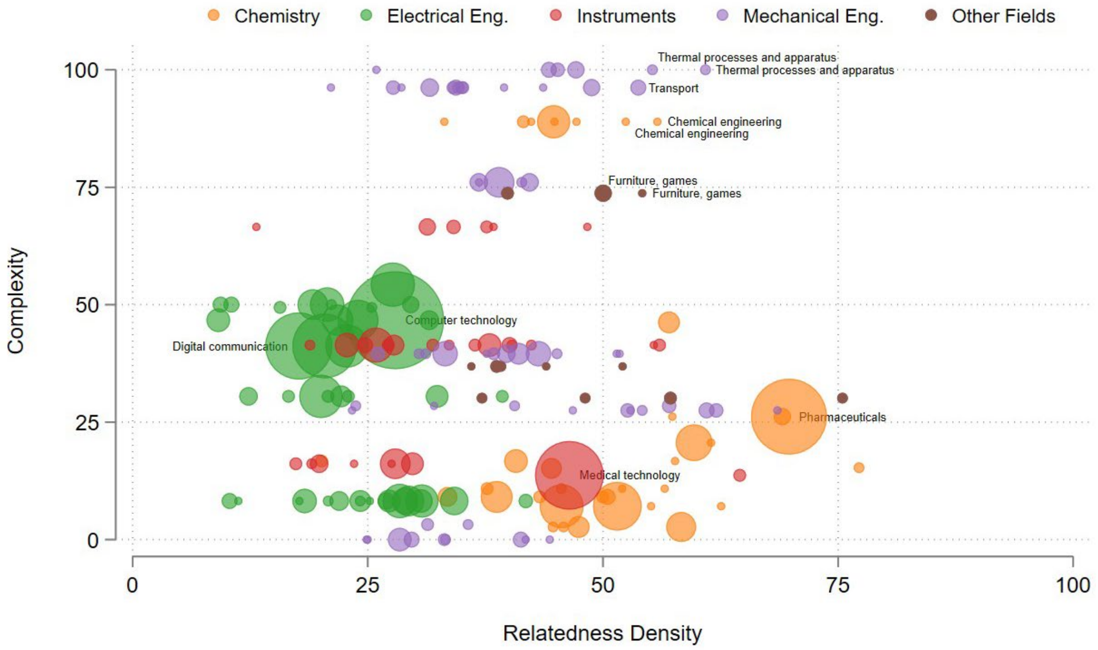
To further see this aspect, we look at the number of patent classes in which São Paulo shows specialization,[8] that is, it shows RTA > 1. This happens on 257 occasions, which is quite superior to many other hotspots and clusters worldwide. Figure A.23 plots the RTA of the 623 technological classes in São Paulo on the horizontal axis (in log scale). It also shows the level of complexity of these technologies, computed as in Balland and Rigby (2017). As can be seen, the majority of technologies for which São Paulo presents specialization (ln(RTA) > 0) are of low complexity, meaning they are more ubiquitous and more replicable elsewhere.

Now, is it possible to assess whether São Paulo would be able to diversify into more complex, highly valuable technologies? We make use of the concepts of relatedness density (Hidalgo *et al*., 2018) and technological complexity (Balland and Rigby, 2017) to evaluate the high-value technological opportunities, as presented in Balland *et al*. (2018). The idea is to identify the technologies to which São Paulo could easily move, given its core competences, and could mean a gain in terms of knowledge complexity.

Figure A.24 shows all technological classes in which São Paulo does not have RTA > 1, and plots both their level of relatedness density (the number of related technologies, based on co-occurrence in patent documents that are present in the hotspot – i.e. RTA > 1 – as well as their level of complexity. Thus, technologies with larger values of relatedness density are easier to reach, while technologies with higher levels of complexity are the more rewarding if achieved. As a result, those technologies in the right-up quadrant are the most desirable targets for innovation policies.

As can be seen in Figure A.24, São Paulo does not have a large amount of technologies in that quadrant, except for some in mechanical engineering (e.g., thermal processes and apparatus) and chemistry (e.g., chemical engineering). These technologies should be the target of policymakers.

Figure A.24: Diversification opportunities, 2011–2015

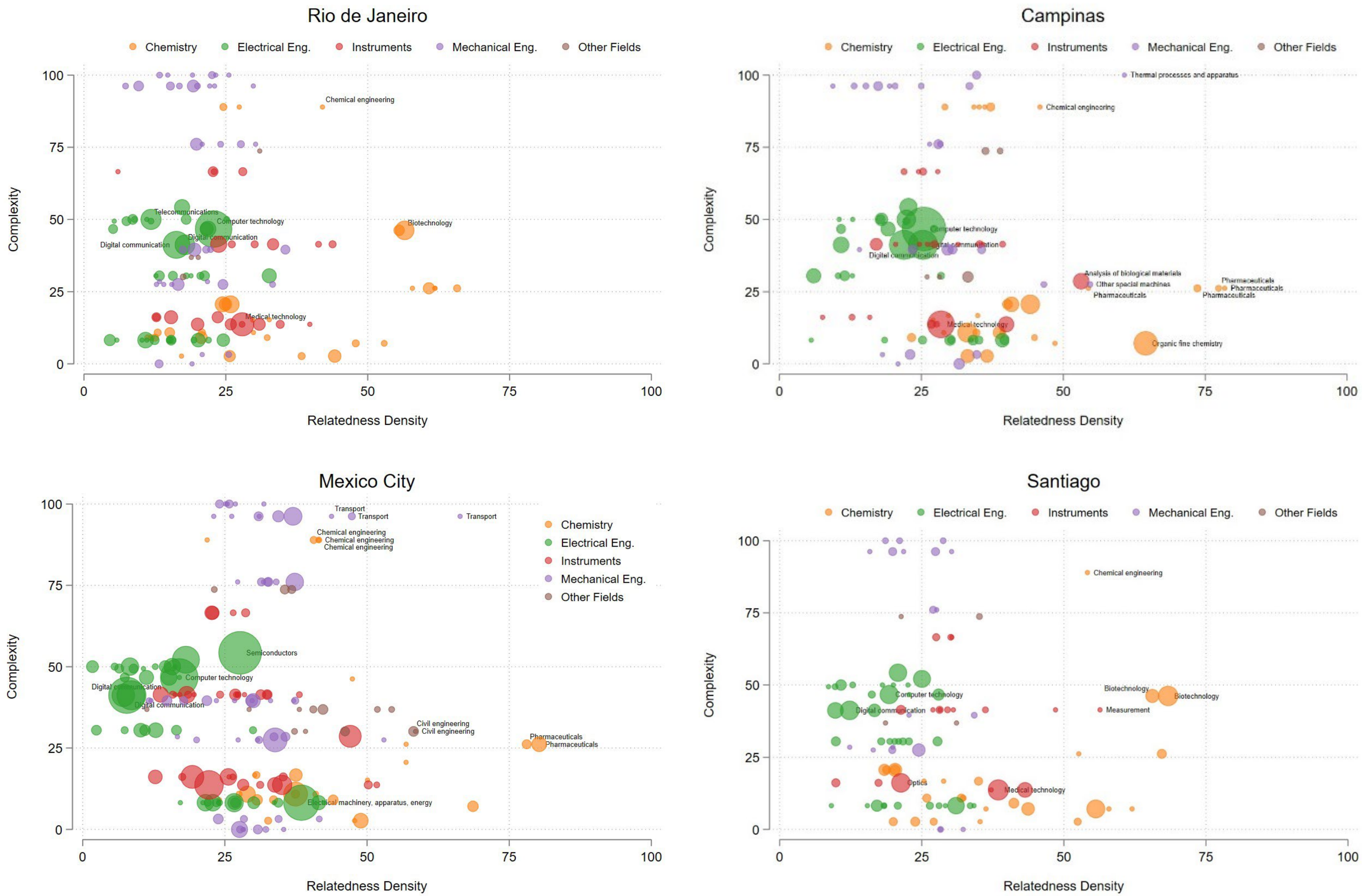


Source: WIPO (2019) data. Notes: Complexity and Relatedness computed for 623 IPC classes.

[8] We have 623 patent classes in our dataset, which are computed using the first four digits of the IPC codes listed in patents.

In order to compare São Paulo with other cities, Figure A.25 replicates the same exercise but for Rio de Janeiro, Campinas, Mexico City and Santiago de Chile. As can be seen, São Paulo is in a better position to diversify into more complex, highly valuable technologies.

Figure A.25: Diversification opportunities, 2006–2015



Source: WIPO (2019) data. Notes: Complexity and Relatedness computed for 623 IPC classes.

B.5 Scientific capabilities and science–industry relations

The role that universities and research institutions play in the local and national economy has been widely investigated, and can be more of less classified into three pillars: teaching (and hence provision of talented human capital for local corporations), research (more or less basic) and the *third mission,* which includes a wide range of activities, such as know-how and technological transfer to local firms, networking and international connectedness, academic entrepreneurship and so on (Drucker & Goldstein, 2007; Drucker, 2016).

Brazil has for long understood the importance of a solid research infrastructure. According to Mazzucato and Penna (2016), Brazil has a well-developed system of research that has substantially improved in the last decades, even producing *frontier* research in certain fields. The University of São Paulo, for example, is considered Brazil's leading research institution and is ranked high in The Times Higher Education Institutions' rankings. São Paulo is a particular case of scientific success and is seen as a worldwide cluster of scientific production. Thirty years ago the city was a small but highly specialized hub, while now it is a "global force."[9]

Yet, despite this generalized acknowledgement of Brazil and São Paulo's achievements in scientific production, it is lamented that, to a certain extent, there is still fragmentation between the system of education and research and the system of innovation (Mazzucato & Penna, 2016). While Brazil and São Paulo have good research infrastructure, this has not always translated into locally usable research and commercial innovations (Mazzucato & Penna, 2016; Cassiolato *et al*., 2014).

Measuring the integration of science and industry in a given location, or how scientific capabilities serve local firms, is not straightforward, so we deal with this with a collection of indicators based on scientific publications from Web of Science (WoS), as well other data when necessary. The scientific publication data used in this report come from 27,726,805 records published from 1998 to 2017 in the Science Citation Index Expanded (SCIE) of WoS, the citation database operated by the Clarivate Analytics company. The analysis focuses on 23,789,354 observations referring only to scientific articles, conference proceedings, scientific abstracts and data papers. Scientific articles constitute the bulk of the resulting dataset. Figure A.26 depicts the number of scientific publications, in three time windows. Several things stand out. First, the number of publications in São Paulo is much larger than in other cities in Brazil (Figure A.26), with the difference more remarkable than with patents. Second, the growth in publishing is very steep; São Paulo more than duplicated the number of publications per time window from 2001–2005 to 2011–2015. Finally, São Paulo does quite well compared to other worldwide hotspots, with bigger numbers than Indian clusters and comparable to Moscow, and not that far off Chinese clusters (Figure A.26b).

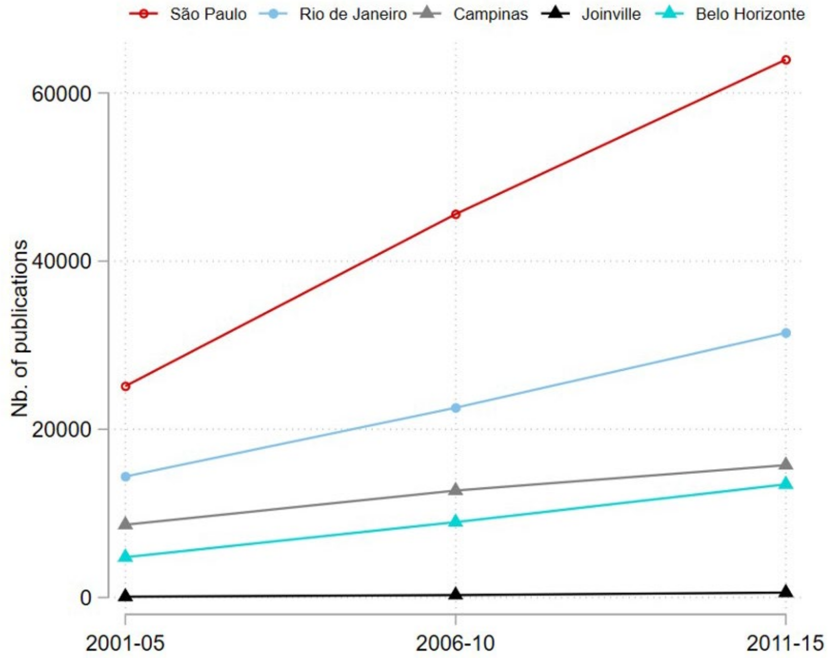
This can be further seen in Figure A.27, where counts of publications (2011–2015) and percentage growth (2001–2015) is presented. São Paulo is ranked fourth in percentage growth in those years, after only Shanghai, Beijing and Seoul. In absolute terms the city is well positioned, too, being first in Latin America, and has similar absolute numbers to Copenhagen, Oxford, Zurich, Seattle and Atlanta.

São Paulo shows big growth and presence, but is it of sufficient quality? In a recent op-ed article, Ricardo Hausmann[10] showed a narrowing education (and scientific) gap between high-income economies and the Global South, but that this is not accompanied by a narrowing income gap, which he attributes to a widening technological gap. Indeed,

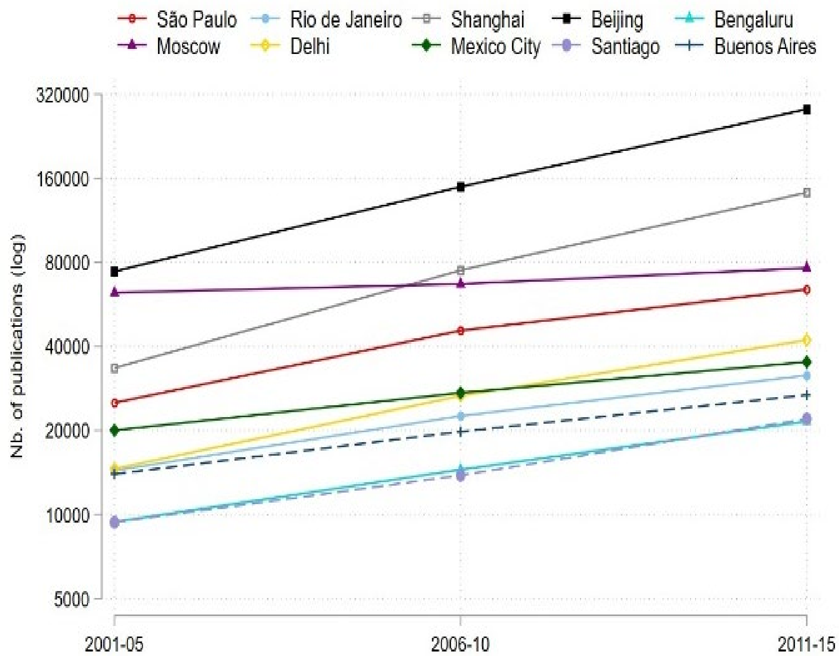
[9] https://revistapesquisa.fapesp.br/en/the-dna-of-innovation-in-the-metropolises/ (accessed December 13, 2021).
[10] www.project-syndicate.org/commentary/global-technology-gap-hindering-convergence-by-ricardo-hausmann-2021-08 (accessed August 10, 2022).

patenting rates in Latin America and the Caribbean (LAC) and São Paulo are far from their counterpart high-income countries (and some emerging ones). However, the gap is incredibly large compared to the gap in scientific publications. He attributes this mismatch to businesses and universities in middle-income countries.

Figure A.26: Number of scientific publications, 2001–2015



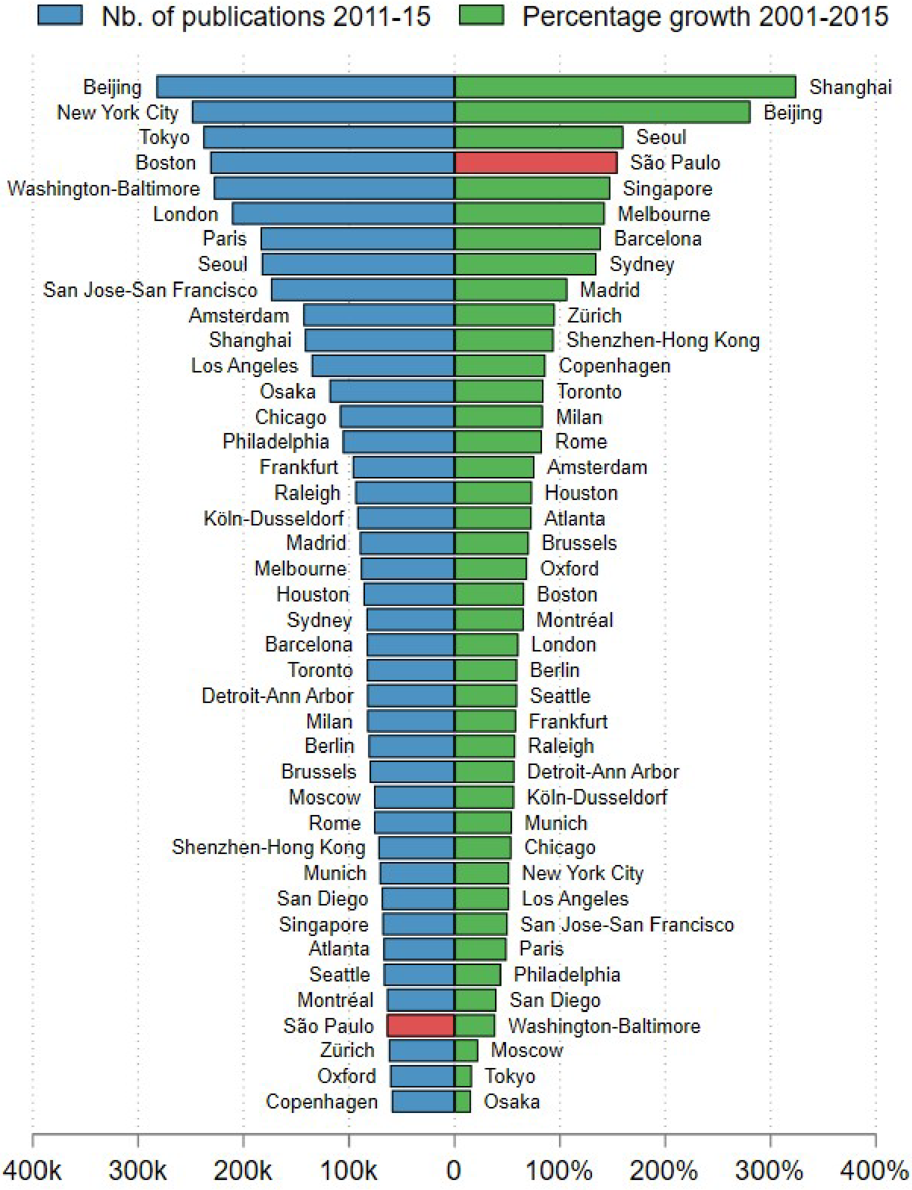
(a) Brazil



(b) World

Source: WIPO (2019) data.

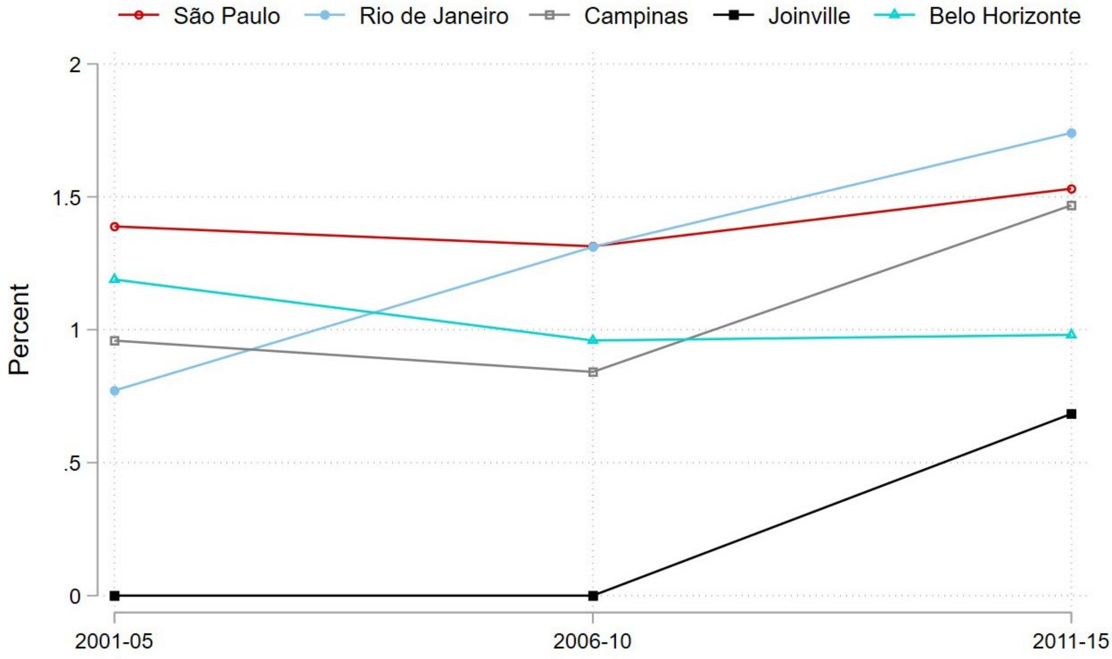
Figure A.27: Scientific article production and growth



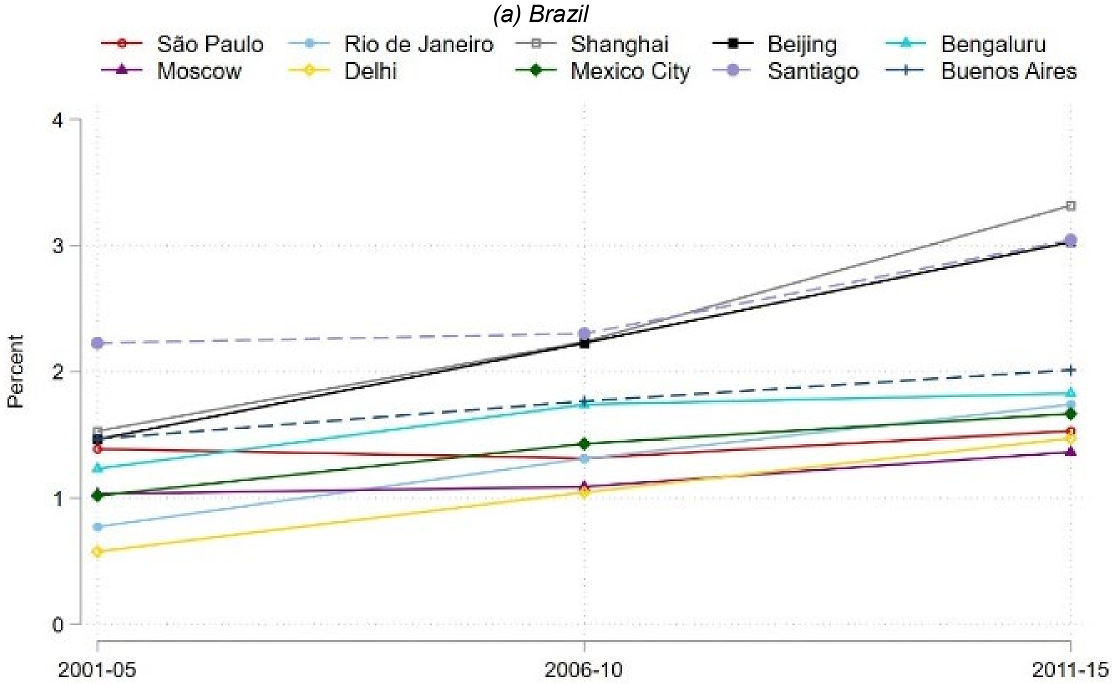
Source: WIPO (2019) data.

Where does São Paulo stand in quality, measured by forward citations received, compared to other clusters? Figure A.28 looks at the share of highly cited articles per field, in each hotspot/cluster and time window. São Paulo's performance is less strong in this case, with even Rio de Janeiro being, on average, more cited than São Paulo, and even Santiago de Chile receiving, on average, more recognition for its scientific work than São Paulo.

Figure A.28: Share of highly cited publications, 2001–2015



(a) Brazil

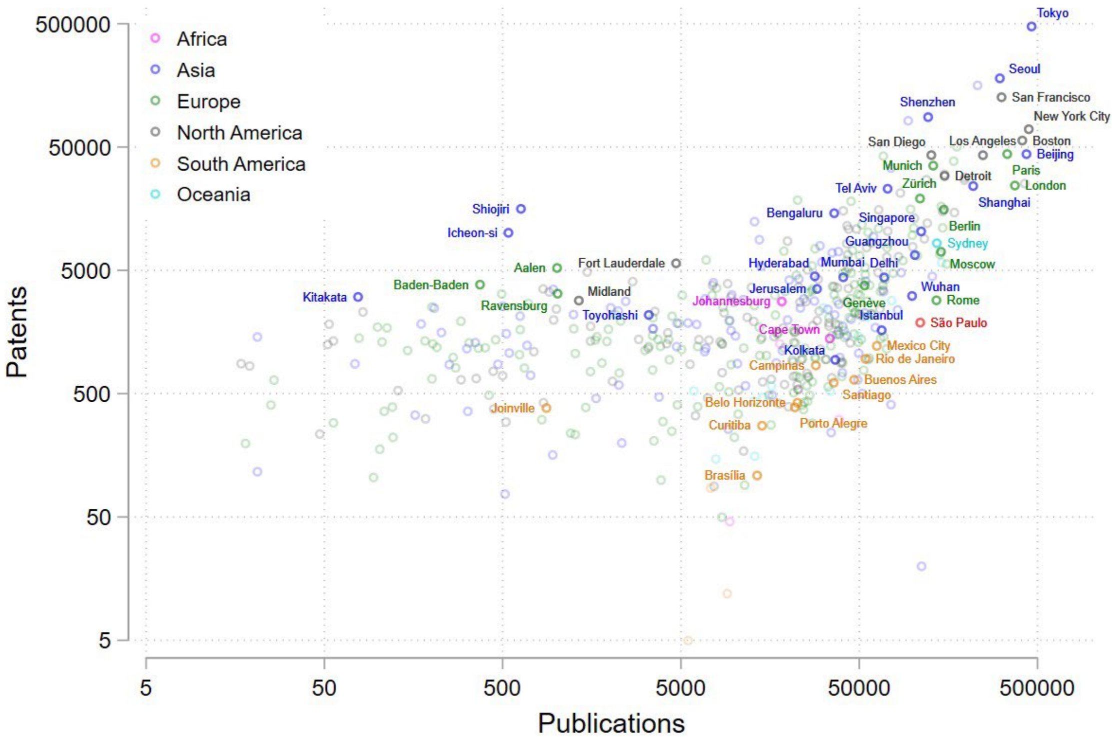


(b) World

Source: WIPO (2019) data. Notes: Highly cited publications defined as those in the top 5% of their scientific field.

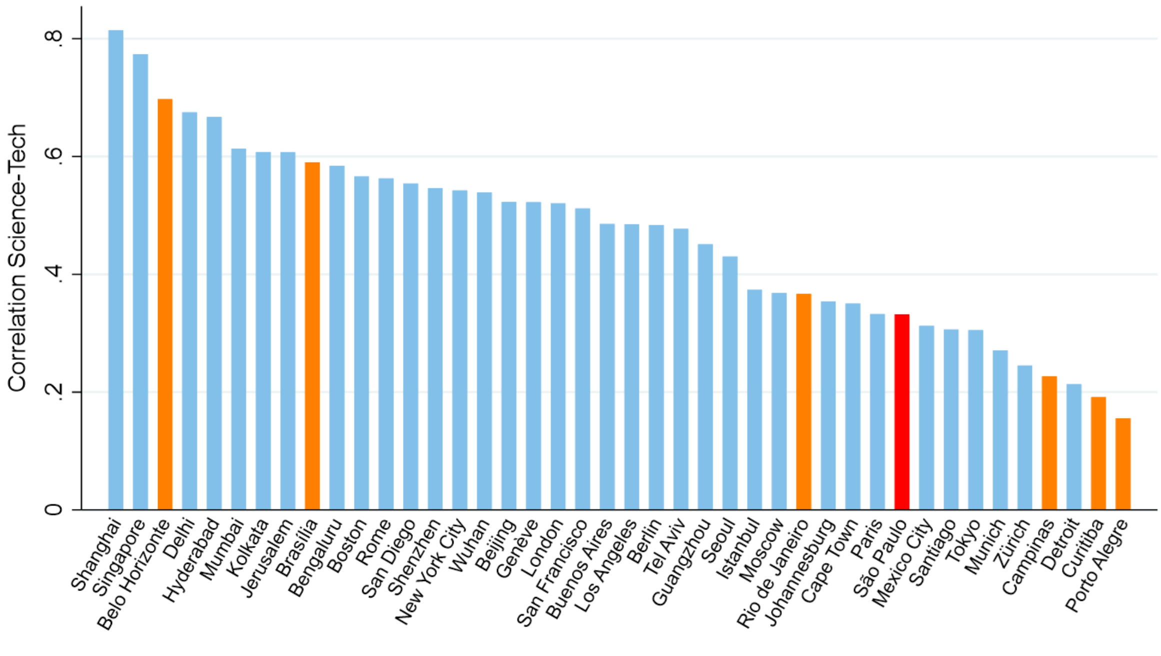
Now, while São Paulo shows a strong international presence in scientific production – both in level and growth rate – we know little about how this contributes to the local innovation ecosystem. The first way to look at this is to observe the correlation between science and technology production across clusters, and how São Paulo fits among its counterparts. Figure A.29 shows such a correlation in a scatter plot, with São Paulo featuring in the bottom part of the scatter (with an average-to-good level of publications, but low in patenting).

Figure A.29: Patenting vs. scientific publishing activity in hotspots and niche clusters, 2006–2015



Source: WIPO (2019) data.

Figure A.30: Science–industry correlation, 2006–2015



Source: WIPO (2019) data.

One way to see how industry relies on scientific production is to look at non-patent literature (NPL) citations recorded in patents produced in São Paulo. We would look at the cosine similarity (e.g., uncentered correlation) between the shares of patents vs. the shares of publications. Of course, the first obstacle to overcome is how one could harmonize scientific fields and technologies. We suggest using NPL citations to determine the stronger links between science and technology (Balland & Boschma, 2021). Figure A.30 computes the science–technology correlations per cluster and sorts them in descending order. As can be seen, São Paulo's correlation is among the lowest, together with other Brazilian clusters, as predicted by the theory.

Part B – São Paulo’s Local Capabilities and National Network

B.6 Introduction

Part B of this report presents the main results of the role of São Paulo’s innovation hotspot as the main hub of innovation in the Brazilian innovation system. It presents the main characteristics of the São Paulo innovation hotspot, including the profile of the technological production of the São Paulo innovation ecosystem; the pattern of technological collaboration; the role of human capital and the local productive structure; the role of multinational companies (MNCs); academic patenting; and the collaboration patterns and the network of inventors.

The analysis of the profile of technological production in the São Paulo ecosystem is based on data from the Brazilian Office of Intellectual Property (BADEPI/INPI), in addition to other Brazilian databases regarding innovation inputs and outputs, such as data from the Ministry of Labor (RAIS) and from the Ministry of Education (GeoCapes). It shows the high share of the São Paulo ecosystem in technological production in Brazil, even though it has been decreasing in the last three decades. In addition, the São Paulo ecosystem’s technological production is quite diversified, which does not allow for a clear identification of specialization in any specific technological field. The decrease in the share of the São Paulo ecosystem is due to the significant increase in academic patenting in Brazil, which raises the share of several regions. However, our results show that the share of the São Paulo ecosystem in industrial patents is much higher than in total patents, due to the share of both domestic private firm and MNC patents.

Results also show the centrality of the São Paulo innovation ecosystem in the creation and diffusion of technological knowledge across the whole country. The São Paulo ecosystem not only presents the best indicators of innovation outputs, but also has a central position in the network of inventors. Despite the geographical decentralization of the production of technological knowledge in Brazil, the São Paulo innovation hotspot has a prominent position in the generation of technological knowledge, especially because of its importance in terms of industrial innovation. São Paulo presents the best innovation output indicators and has a central position in the co-patenting networks of both domestic firm and MNC patenting activities.

Based on these results, we are able to answer our main research questions of this project. Is the São Paulo innovation ecosystem the main innovation hotspot in Brazil? Which role does the São Paulo ecosystem play in the Brazilian innovation network and the national innovation system? What are the main effects of the geographical decentralization of technology production in Brazil on the role of the São Paulo ecosystem in the Brazilian innovation system? Our results allow us to conclude that the São Paulo innovation hotspot has increased its role in the innovation system due to some main drivers: it still has the most important indicators of innovation output; its importance in the innovation network has increased in industrial patenting, both among domestic firms and MNCs; local actors have increased their international and domestic technological collaboration.

The next section presents the technological production profile of the São Paulo innovation hotspot, with some brief methodological notes followed by the presentation of the basic characteristics and the profile of the technological production of the São Paulo ecosystem, the pattern of technological collaboration, the role of human capital and the local productive structure, the role of MNCs and academic patenting, and the collaboration patterns and the network of inventors. Finally, we present the final remarks, and we discuss our main research questions.

B.7 Technological production profile of the São Paulo ecosystem

B.7.1 Some brief methodological notes

We are using data from the Brazilian Office of Intellectual Property (BADEPI/INPI), for the period 1997–2020. In this period, there were a total of 83,890 applied patents in Brazil. We geolocalized the inventors of the patents according to the Brazilian regions. As mentioned in the previous report, we use the Brazilian mesoregions as the geographical unit of analysis, which correspond to the EU NUTS-2.

As usual in patent literature, it is necessary to unify the different ways of writing the name of the same company (Raffo & Lhuillery, 2009). We performed this procedure to identify Brazilian subsidiaries of MNCs and for universities and public research institutes (PRIs).

The first step of the unification in patent applicants' names was by the national fiscal code (CNPJ). All the patents of companies of the same group were unified in the fiscal code of the main company headquarters in Brazil. However, the fiscal code is not present in the patent database with Brazilian inventors filed abroad. In these cases, it was necessary to unify names, for which we chose the Matchit routine for Stata by Raffo (2017), with preliminary exclusion of very common sectorial, topological and societal terms. We used a token as an option of "string matching method" and unified names with a similarity index greater than 0.7. For omitted cases, we supplemented with a flag using corporate terms from foreign countries ("ag, co, inc, llc, nv, spa, gmbh, etc"). Finally, we checked the results for all MNCs with more than four patent applications, which corresponds to a share of 84 percent of the MNC patents in the period. Using this procedure, we were able to ensure that the MNCs groups were well formed and we also could indicate the country of origin.

A similar process was carried out for the universities and PRIs that were unified due to their similarity in the innovation ecosystem, but without unification by Matchit and with a previous identification step by keywords for the sector such as university, faculty, institute and others.

B.7.2 Basic characteristics and profile of technological production in the São Paulo ecosystem

Before the analysis of the data on the basic characteristics of the technological production of the São Paulo ecosystem, it is worth mentioning the basic data from the BADEPI/INPI database during the period 1997–2020. Data summarized in this section were presented in detail in the second report.

We collected 83,890 applied patents in Brazil. Regional distribution of patents shows the importance of the São Paulo ecosystem, whose share is 23.1 percent, with 19,280 patents. The São Paulo ecosystem is followed by Rio de Janeiro, with a share of 7.5 percent; Belo Horizonte, 6.1 percent; Campinas, 5.6 percent; Curitiba, 4.8 percent; Porto Alegre, 4.5 percent; Joinville, 2.5 percent; Jundiai-Sorocaba, 2.4 percent; Sao Jose dos Campos, 2 percent; and Caxias do Sul, 1.8 percent. The high share of the São Paulo ecosystem confirms our expectation in classifying it as an innovation hotspot, as it is the most important region for the creation and dissemination of new knowledge throughout the country. The other identified regions can be defined as the main innovation niche clusters in Brazil, since patent applications indicate their importance for the creation and dissemination of technological knowledge in the country.

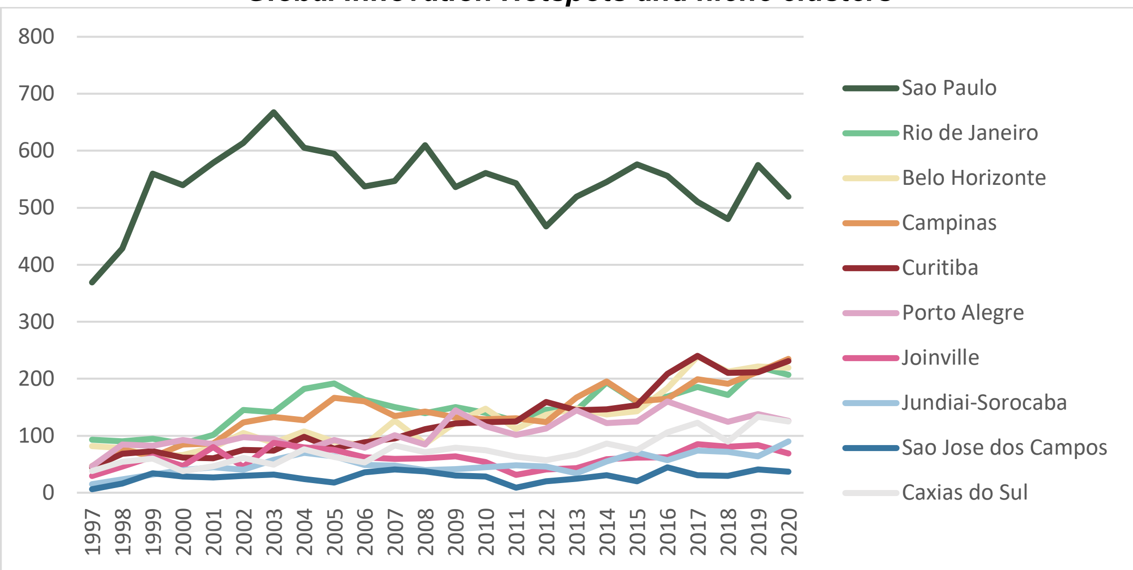
The regional distribution of patents in Brazil is facing an important decentralization. The share of patents from the traditional centers of creation of technological knowledge has decreased in the last three decades. The share of the top 10 regions of patent application decreased from around 70 percent in the period 1997–2000 to around 50 percent in 2016–2020. Talking only the share of the São Paulo innovation hotspot, it decreased from 30 percent in the period 1997–2000 to 17 percent in 2016–2020. Nevertheless, there is still a strong geographical concentration of patents in the southern regions of the country.

Regarding its technological profile, we can see that the São Paulo innovation hotspot is highly diversified. By measuring technological specialization by both the revealed technological advantage (RTA) index and the Hirschman-Herfindahl index (HHI), we can see that the highest indices are relatively low, indicating a strong specialization. In the last period of analysis, 2016–2020, the top three technological domains were biopharma, chemicals and instruments.

The technological collaboration of local actors of the São Paulo innovation hotspot has also increased. Co-patents had increased from around 14 percent in 1997 to 25 percent of total patents in the São Paulo ecosystem in 2020, as the average inventors per patents grew from around 1.5 in 1997 to almost five inventors per patent in 2020. We can see the same movement in international co-patents, as international collaboration in the São Paulo innovation hotspot reached around 7 percent of total local patents in 2020.

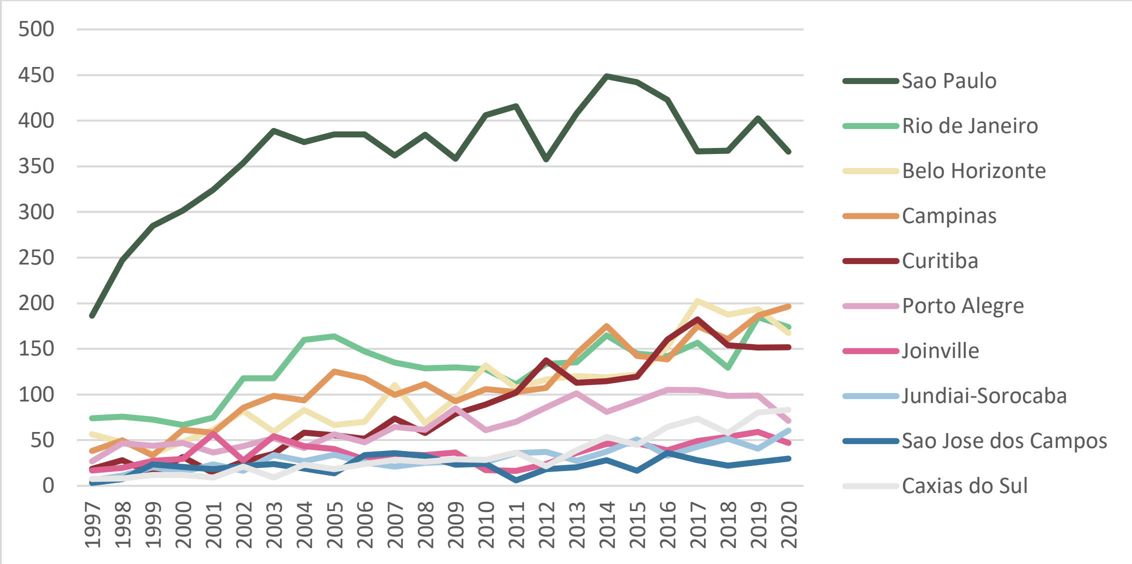
The same picture can be seen in the analysis of patent applicants. The regional distribution of patent applicants in Brazil also shows that the São Paulo hotspot stands out as the region with the highest share. This leading position of the São Paulo hotspot in Brazil can be verified both through of the aggregate analysis of patents for invention and utility models (Figure B.1), as well as just for patents (Figure B.2). These data show the importance of the São Paulo innovation hotspot as a leader in the technological production in Brazil, and the main disseminator of new technological knowledge for the whole Brazilian economy. This can be verified by the technological collaborations that are carried out by the local actors.

Figure B.1. Patent applicants: Invention patents and utility models, top 10 regional Global Innovation Hotspots and niche clusters



Source: BADEPI/INPI

Figure B.2. Patent applicants, top 10 regional Global Innovation Hotspots and niche clusters



Source: BADEPI/INPI

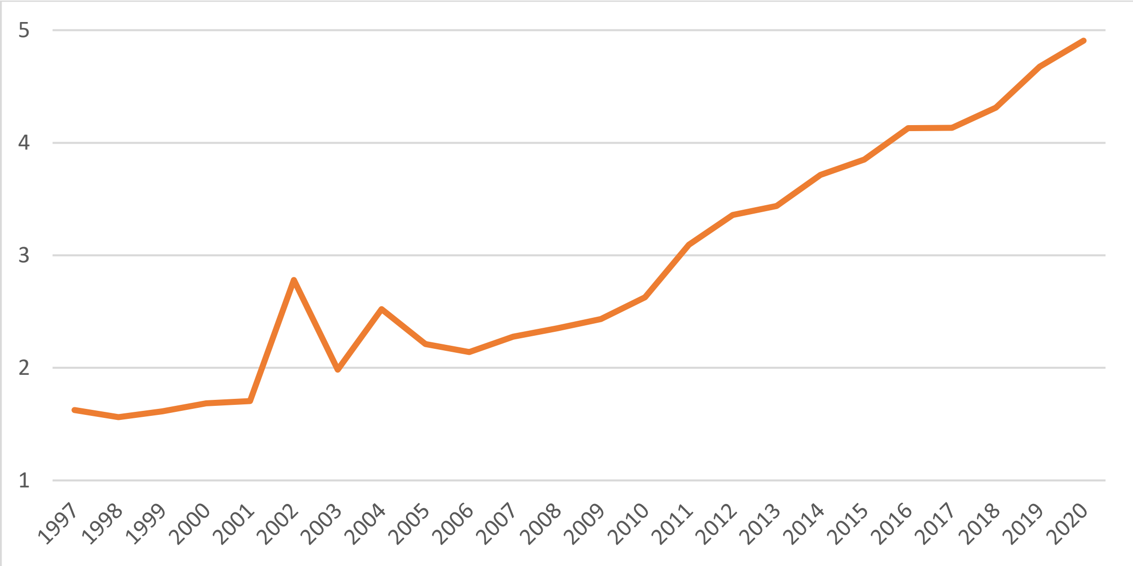
B.7.3 Technological collaboration

We can examine the technological collaboration of the São Paulo innovation hotspot by looking at the number of inventors per patent (Figure B.3). We can see that in general the number of inventors per patent in Brazil has increased from 1.6 in 1998 to 4.9 in 2020. Following the global trend, Brazilian inventors are increasing the practices of sharing knowledge with technological partners, due to the growth in the complexity of the required knowledge for innovation. This increase seems to be consistent over time.

We cannot see an increase in the international collaborations of Brazilian inventors. The collaboration of Brazilian inventors with foreigners has remained mostly stable in the last two decades, despite some fluctuations over the analyzed period (Figure B.4). Data from the BADEPI/INPI shows that patents registered in collaboration are mainly with domestic inventors, and only a share of around 5 percent of total patents in collaboration takes place with international partners. This reveals that the collaboration networks are predominantly local. To some extent, this characteristic of the technological collaborations of Brazilian inventors can be mitigated by the important presence of MNCs in Brazil. In these cases, an important share of the collaborations occurs with the Brazilian subsidiary of the multinational company, in which the registration is carried out as if it were a domestic inventor. For this reason, it is important to consider the role of MNCs as important channels for the internalization of external knowledge in Brazil, a fact that can be verified in other developing countries (Garcia et al., 2022; Wang *et al*., 2016).

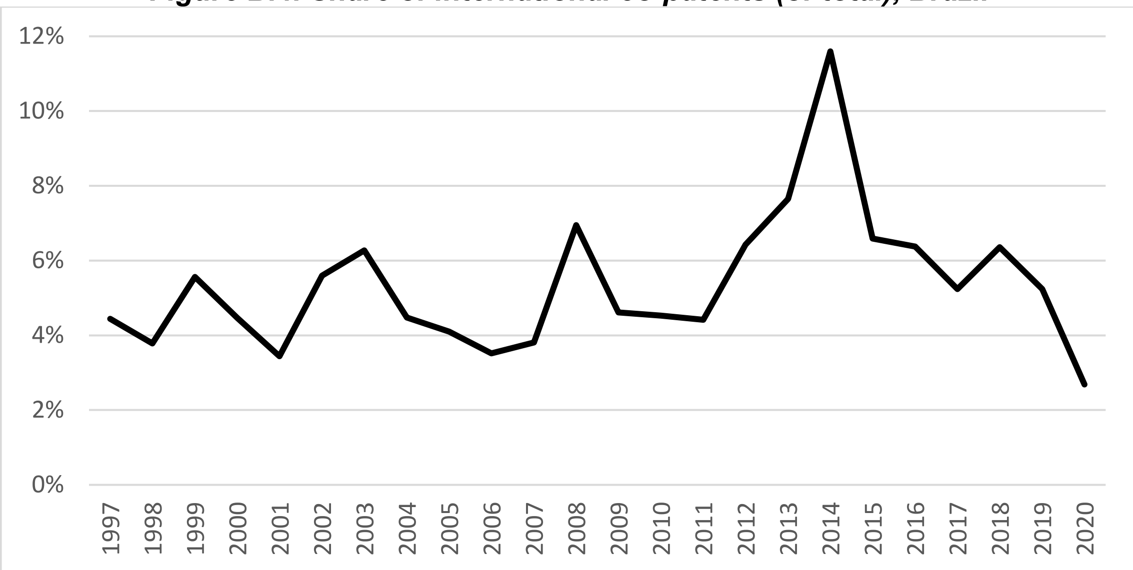
However, the regional distribution of international patent collaborations shows a somewhat different scenario. International collaborations from innovation hotspots and niche clusters are to some extent higher than the Brazilian average (Figure B.5). This can be seen in some niche clusters, especially around the São Paulo region, such as Jundiai-Sorocaba, Sao Jose dos Campos and Campinas, and with special emphasis at the São Paulo innovation hotspot, the main innovation hotspot in Brazil. These data reinforce the conclusion about the central role played by the São Paulo innovation hotspot in the Brazilian innovation system. The international collaborations of the São Paulo innovation hotspot show that local agents are connected to the Global Innovation Networks, since they can participate in important channels of global knowledge-sharing. The ability to grab external knowledge from Global Innovation Networks has made it possible for local actors to disseminate this knowledge to the whole Brazilian innovation system and to other Brazilian regions. In addition, another fact that reinforces this argument is the existence of spatial knowledge spillovers to regions close to São Paulo, as is the case in the regions of Campinas, Jundiai, Sorocaba and Sao Jose dos Campos.

Figure B.3. Average inventors per patent by year (Invention Patents), Brazil, 1997–2020



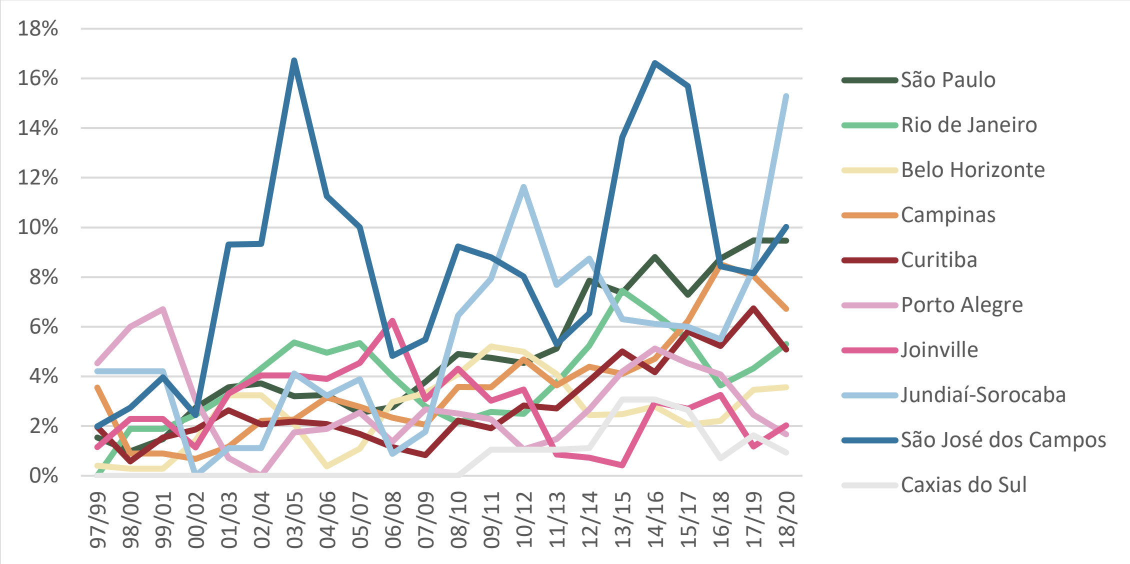
Source: BADEPI/INPI

Figure B.4. Share of international co-patents (of total), Brazil



Source: BADEPI/INPI

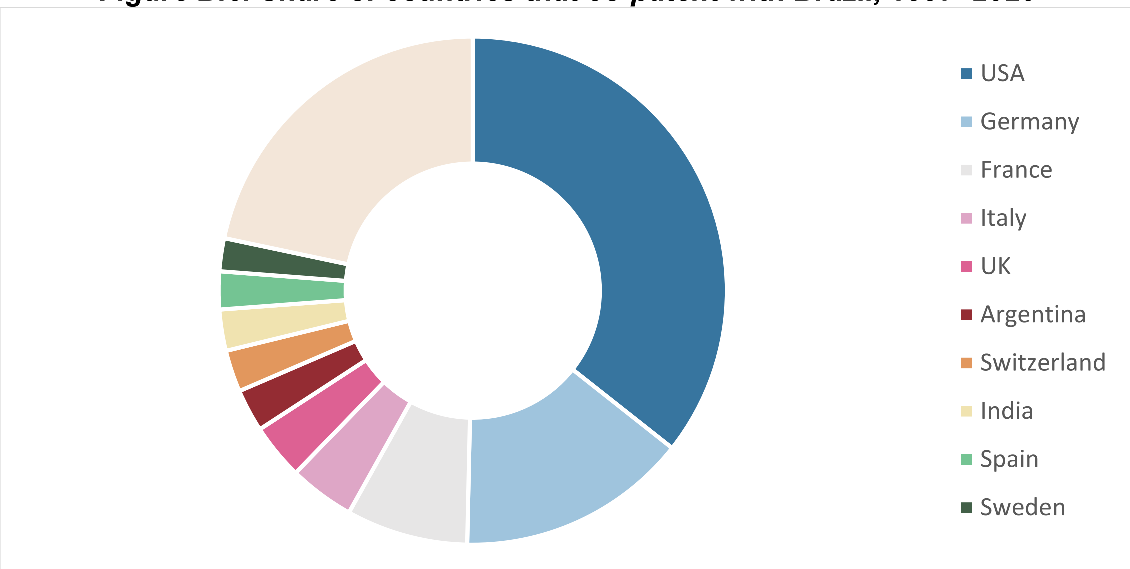
Figure B.5. Share of international co-patents (of total), regional Global Innovation Hotspots and niche clusters (3 year moving window)



Source: BADEPI/INPI

The main technological partners of the Brazilian domestic actors in patent collaboration are from the US and Europe (Figure B.6). Following the US are Germany, France, Italy and the UK. Eighty percent of total international collaboration in patents are concentrated in the top 10 countries. The low share of Asian countries, such as Japan, China and Korea, in patents in international collaboration with Brazilian actors is noteworthy, especially due to the growing importance of these countries in Global Innovation Networks (Crescenzi *et al*., 2019; Miguelez *et al*., 2019).

Figure B.6. Share of countries that co-patent with Brazil, 1997–2020



Source: BADEPI/INPI

Table B.1. Revealed technological advantage of main Brazilian Global Innovation Hotspots and niche clusters, 1997–2020

	São Paulo	Rio de Janeiro	Belo Horizonte	Campinas	Curitiba	Porto Alegre	Joinville	Jundiai-Sorocaba	São Jose dos Campos	Caxias do Sul
Electronics	1.120	0.844	0.857	0.976	1.044	0.865	2.709	1.455	1.356	0.989
Audiovisual	1.677	1.127	0.842	0.865	1.061	0.776	0.472	1.072	0.658	0.470
ICTs	1.109	1.009	1.023	2.201	1.063	1.017	0.384	0.753	1.021	0.466
Semiconductors and optics	1.007	1.327	0.583	1.952	2.402	1.221	0.258	0.718	0.693	0.101
Instruments	0.954	1.079	1.171	1.059	1.131	1.092	0.430	0.840	1.516	0.462
Biopharma	0.707	1.091	1.009	1.204	0.919	0.714	0.143	0.616	0.500	0.407
Materials	0.866	0.875	2.014	0.926	0.978	0.860	0.963	1.410	1.298	0.676
Chem. and environment	0.765	1.473	1.304	1.124	0.819	1.106	0.698	1.076	0.766	0.569
Chemicals	0.769	0.871	0.646	1.021	0.805	1.078	0.449	0.887	0.693	0.993
Machines	1.302	0.729	0.810	0.958	0.890	1.062	1.110	1.303	0.876	1.517
Engines and transport	1.056	0.919	1.030	0.755	0.983	0.993	2.197	1.222	1.464	2.045
Civil engineering	1.093	1.537	1.115	0.656	1.135	0.848	0.976	1.137	0.880	1.112
Consumer	1.266	0.754	0.823	0.539	1.163	1.265	1.665	0.885	0.828	1.172

Source: BADEPI/INPI

Finally, another important indicator of the characteristics of Brazilian innovation hotspots and niche clusters is the revealed technological advantage (RTA) index, which provides an indication of the relative specialization of a given region in selected technological domains (Table B.1). For the São Paulo innovation hotspot, we cannot see strong technological specialization, since the RTA is in general low, around 1. In comparison to other niche clusters, we can see higher specialization of most of the niche clusters in some technological domains.

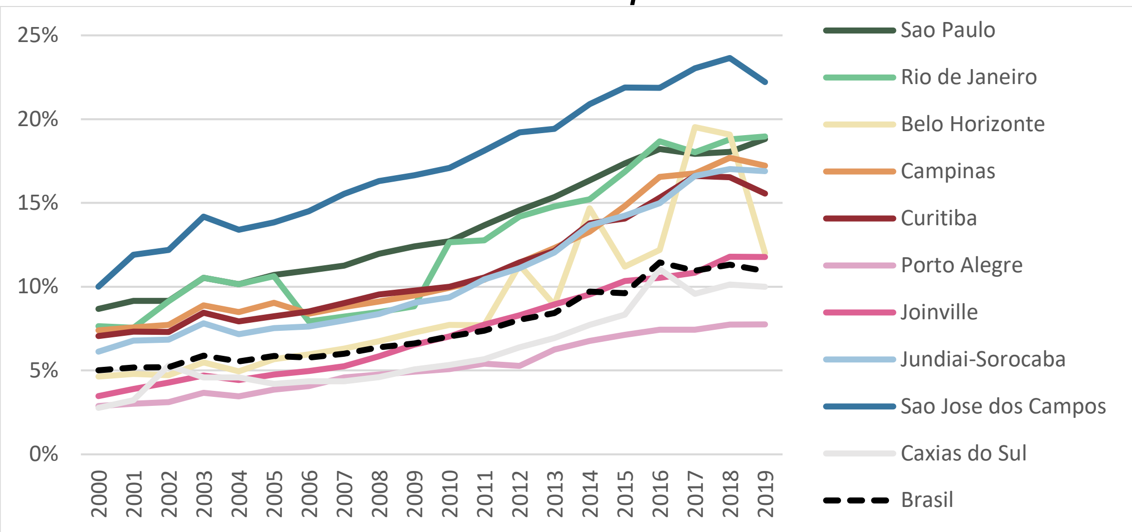
B.7.4 Human capital and the local productive structure

Another important issue characterizing the São Paulo innovation hotspot is the role and the characteristics of human capital. In the literature, human capital is one of the most important innovation inputs. Several scholars have shown empirical evidence regarding the correlation between a qualified workforce and innovation, at the national, regional and even the firm level (Audretsch & Feldman, 2004; Fagerberg *et al.*, 2010).

In general, we can see a huge growth of human capital in all Brazilian hotspots and niche clusters (Figure B.7). In addition, almost all niche clusters present a higher share of qualified workers than the Brazilian average, even if the selected regions that have a high share in the total Brazilian qualified workforce, which influences their average. The share of workers with higher degrees in the São Paulo innovation hotspot increased during the analyzed period, growing from 10 percent in 2000 to almost 20 percent in 2019.

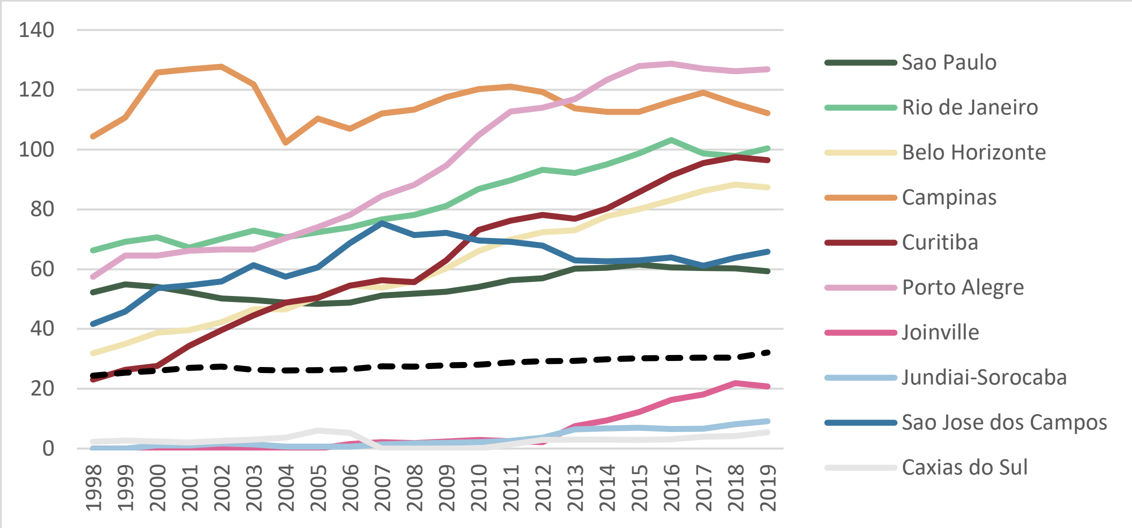
We can also analyze the share of STEM graduate students per 100,000 inhabitants in the Brazilian innovation hotspots and niche clusters (Figure B.8). First, we can see that in all hotspots and niche clusters, the share of STEM graduate students is well above the Brazilian average. Second, there is a general increase in the share of STEM graduate students in all hotspots and niche clusters, although with strong fluctuations. In the São Paulo innovation hotspot, the share of STEM graduate students is around 50 to 60 per 100,000 inhabitants in the whole analyzed period, above the Brazilian average.

Figure B.7. Share of human capital with college degree in manufacturing of main Brazilian Global Innovation Hotspots and niche clusters



Source: RAIS/MTE

Figure B.8. STEM graduate students per 100,000 inhabitants of main Brazilian Global Innovation Hotspots and niche clusters

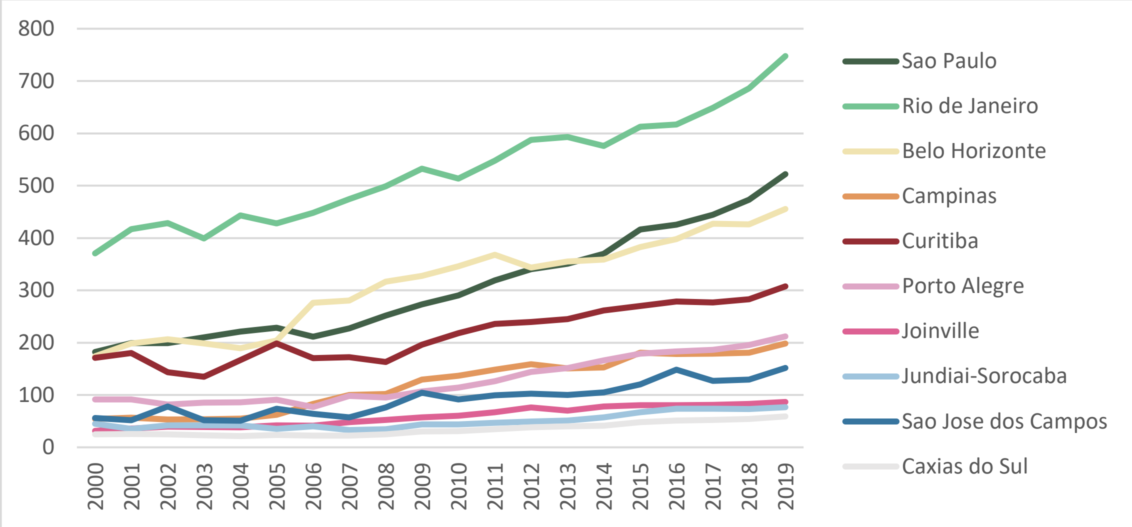


Source: GeoCapes

Another important actor in the regional innovation system is knowledge-intensive business services (KIBS) sector, since they can act as important channels to disseminate new knowledge among local producers (Costa & Garcia, 2018; Shearmur & Doloreux, 2019). In order to assess the importance of KIBS in Brazilian innovation hotspots and niche clusters, we take data on the total employment in KIBS in each Brazilian hotspot and niche cluster and compare it to the employment in local manufacturing (Figure B.9). In general, we can see that there was an increase in the ratio between employment in KIBS and in manufacturing in all hotspots and niche clusters. Despite this growth, three regions presented outstanding performance in the relation between KIBS and manufacturing: Rio de Janeiro, São Paulo and Belo Horizonte, the three major metropolitan areas in Brazil. The growth of the ratio can be explained by two complementary factors. First, on the numerator side, we can observe an increase in KIBS activities in these regions. It is important to mention that KIBS activities are often closely associated with the urban structure of big cities (Shearmur & Doloreux, 2019). Second, on the denominator side, these regions have experienced a decrease in manufacturing employment, which has moved to other regions, often adjacent to them (Costa & Garcia, 2018; Diniz & Crocco, 1996).

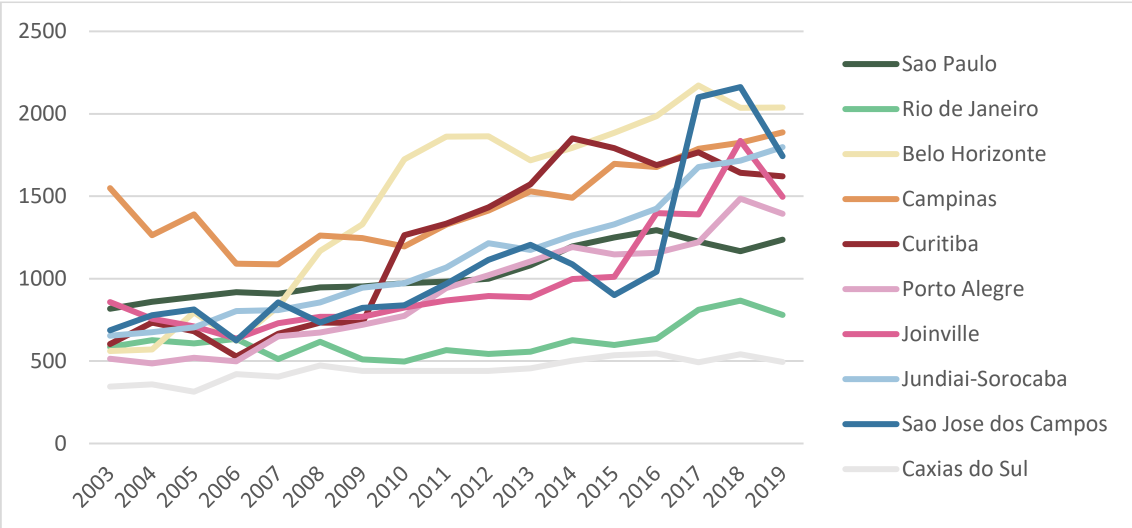
Another important indicator of the innovative efforts of Brazilian innovation hotspots and niche clusters is R&D expenditure. However, since there are no data available on R&D expenditures at the regional level, we used as a proxy expenditure on R&D staff in the regions, based on data on salaries of industrial scientists (Figure B.10). Data are presented in Brazilian reals from 2010, divided by 100,000 employees. In general, we can see an increase in the R&D expenditure in all innovation hotspots and niche clusters. In the São Paulo innovation ecosystem, the expenditure increased from around 850 Brazilian reals in 2003 to 1,250 Brazilian reals in 2019.

Figure B.9. Employees in knowledge-intensive business services per 1,000 employees in manufacturing of main Brazilian Global Innovation Hotspots and niche clusters



Source: RAIS/MTE

Figure B.10. Industrial R&D: Ratio between wages of R&D staff and wages in manufacturing per 100,000 employees of main Brazilian Global Innovation Hotspots and niche clusters, 2003-2019



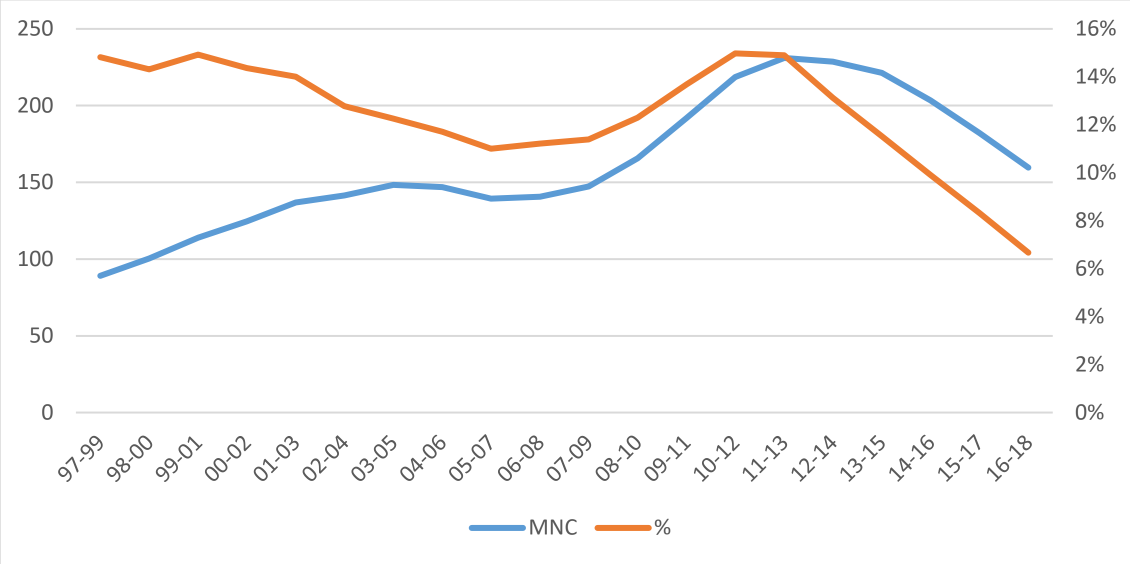
Source: RAIS/MTE

B.7.5 The role of multinational companies

An important role is played, not only for the São Paulo innovation ecosystem, but also for the whole Brazilian innovation system, by multinational companies (MNCs). Since the postwar period, MNCs have been an increasingly important actor in the Brazilian productive structure. Nowadays, in addition to the huge presence in the manufacturing sector, they account for around half of private R&D expenditures in the country (Suzigan *et al*., 2020). In this way, MNCs represent an important channel for the internalization and the dissemination of technological knowledge in the Brazilian economy, since they can bring new knowledge from the Global Innovation Networks they participate in, and they also can spread this new knowledge among local economies. Previous empirical studies have also shown that Brazilian regions that receive inward Foreign Direct Investment (FDI) tend to present better innovative performance (Garcia *et al*., 2022).

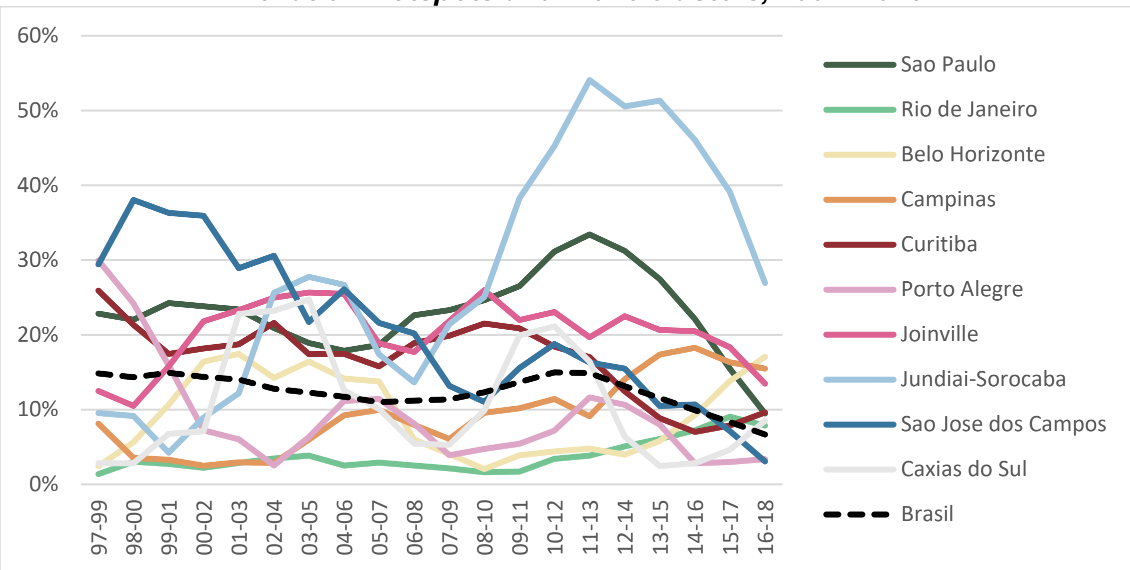
MNCs were responsible until 2013 for around 15 percent of total patent applications in Brazil, which means a total amount of 200 patents annually on average (Figure B.11). From 2014 onwards, however, both the amount of applied patents and the share of MNCs in patent applications decreased. This could mean that the technological activities of MNCs in Brazil have been decreasing in the last decade and that, consequently, their capacity to disseminate new technological knowledge has also become more restricted.

Figure B.11. Patent applications from multinational companies, Brazil, 1997–2018



Source: BADEPI/INPI

Figure B.12. Patent applications from multinational companies, main regional Global Innovation Hotspots and niche clusters, 1997–2018



Source: BADEPI/INPI

Separating data by the main Brazilian innovation hotspots and niche clusters, a similar scenario can also be seen (Figure B.12). However, some niche clusters have a high participation of MNCs in local technological activities, especially some niche clusters in the areas neighboring São Paulo, as is the case for Sorocaba, Jundiai and Sao Jose dos Campos. In large part, the technological activities of MNCs in these regions are related to spatial technological spillovers from the São Paulo innovation ecosystem. Looking at the São Paulo hotspot, the share of MNCs reached its maximum in 2011–2013, with a share of

33 percent of total patent applications, and decreased after that period, reaching 9 percent in 2016–2018.

Table B.2. Top 20 MNCs by patent applications, Brazil, 1997–2018

Company	Country	PI	% PI
Whirlpool	US	883.3	24.2
Robert Bosch	DE	177.3	4.9
Electrolux	SE	175.0	4.8
Agco	US	153.9	4.2
Case New Holland	IT	138.5	3.8
Mahle	MX	78.9	2.2
Dana	US	77.1	2.1
Johnson & Johnson	US	72.0	2.0
Samsung	KR	70.0	1.9
FMC Corporation	US	58.5	1.6
Oki Electric Industry	JP	56.8	1.6
Furukawa Electric	JP	52.0	1.4
Magneti Marelli	IT	50.0	1.4
Rhodia	BE	48.8	1.3
Valeo	FR	43.2	1.2
Springer Carrier	US	43.0	1.2
Seb Domesticos	FR	41.5	1.1
Mabe	MX	40.3	1.1
Ericsson	SE	39.7	1.1
Fiat	IT	39.3	1.1

Source: BADEPI/INPI

Table B.3. Top 20 MNC patent applicants, Sao Paulo innovation ecosystem, 1997–2018

Company	Country	PI	% PI
Whirlpool	US	883.3	51.2
Dana	US	70.9	4.1
Agco	US	69.6	4.0
Rhodia	BE	46.8	2.7
Seb Domesticos	FR	41.5	2.4
Ericsson	SE	39.7	2.3
Compass Minerals	US	35.0	2.0
Siemens	DE	32.3	1.9
Johnson & Johnson	US	32.0	1.9
Mabe	MX	31.3	1.8
Valeo	FR	26.0	1.5
Tyco Electronics	CH	21.5	1.2
Saint Gobain	FR	21.3	1.2
General Motors	US	21.0	1.2
Mahle	DE	20.7	1.2
Dow	US	19.5	1.1
Invensys Appliance	UK	18.0	1.0
Thyssenkrupp	DE	12.5	0.7
Mercedes Benz	DE	12.0	0.7
Volkswagen	DE	11.7	0.7

Source: BADEPI/INPI

Table B.4. Top 10 patent applicants by inventor location in Top 10 Brazilian Global Innovation Hotspots and niche clusters, 1997–2018

#	São Paulo				Rio de Janeiro				Belo Horizonte				Campinas			
	Company	Type	PI	% PI	Company	Type	PI	% PI	Company	Type	PI	% PI	Company	Type	PI	% PI
1	USP	University	355.3	5.1	Petrobras	Domestic	658.7	26.0	UFMG	University	711.6	35.8	Unicamp	University	682.7	24.2
2	Natura	Domestic	118.3	1.7	UFRJ	University	247.5	9.8	Vale	Domestic	112.4	5.7	CQPD	PRI	263.9	9.3
3	Duratex	Domestic	96.8	1.4	L'oreal	MNC	75.6	3.0	UFOP	University	85.0	4.3	Robert Bosch	MNC	134.9	4.8
4	CNEN	PRI	87.9	1.3	UFF	University	56.7	2.2	Case New Holland	MNC	37.6	1.9	Samsung	MNC	61.0	2.2
5	Dow	MNC	74.4	1.1	FMC Corporation	MNC	44.9	1.8	CEFET	University	31.1	1.6	CNPEM	PRI	48.4	1.7
6	Dana	MNC	74.0	1.1	INT	PRI	44.8	1.8	Fiat	MNC	30.1	1.5	3M	MNC	46.2	1.6
7	IPT	PRI	59.9	0.9	IME	PRI	35.1	1.4	Belgo Bekaert	MNC	23.5	1.2	Unilever	MNC	33.5	1.2
8	Mahle	MNC	53.5	0.8	PUC Rio	University	34.2	1.3	CNEN	PRI	22.7	1.1	Rhodia	MNC	33.3	1.2
9	Arno	Domestic	52.5	0.7	UERJ	University	34.0	1.3	Magnesita	MNC	21.8	1.1	Positron	Domestic	31.2	1.1
10	Oxiteno	Domestic	51.2	0.7	Fiocruz	PRI	25.2	1.0	UFSJ	University	20.8	1.0	USP	University	23.8	0.8

#	Curitiba				Porto Alegre				Joinville				Jundiai-Sorocaba			
	Company	Type	PI	% PI	Company	Type	PI	% PI	Company	Type	PI	% PI	Company	Type	PI	% PI
1	UFPR	University	270.8	15.7	UFRGS	University	281.3	16.6	Whirlpool	MNC	607.5	41.7%	Mahle	MNC	53.6	6.3
2	Electrolux	MNC	155.9	9.0	PUC RS	University	90.8	5.3	Embraco	Domestic	152.9	10.5%	Dow	MNC	23.4	2.7
3	PUC PR	University	101.0	5.9	Grendene	Domestic	62.0	3.7	Weg	Domestic	68.3	4.7%	Emicol	Domestic	21.0	2.5
4	Furukawa Electric	MNC	44.6	2.6	Springer Carrier	MNC	54.9	3.2	Tigre	Domestic	35.8	2.5%	Unicamp	University	19.1	2.2
5	LACTEC	Domestic	41.2	2.4	Agco	MNC	51.0	3.0	Docol	Domestic	31.0	2.1%	UNESP	University	18.2	2.1
6	UTFPR	University	39.0	2.3	CEITEC	PRI	40.0	2.4	Termotécnica	Domestic	28.5	2.0%	Siemens	MNC	18.0	2.1
7	Boticario	Domestic	38.7	2.2	Braskem	Domestic	34.6	2.0	Amanco	MNC	21.0	1.4%	Schaeffler	MNC	17.3	2.0
8	Robert Bosch	MNC	36.8	2.1	Azaleia	Domestic	24.0	1.4	Sintex	MNC	18.0	1.2%	Chemyunion	MNC	14.6	1.7
9	Case New Holland	MNC	27.7	1.6	Petrobras	Domestic	19.3	1.1	TGM	Domestic	15.0	1.0%	Tyco Electronics	MNC	14.5	1.7
10	Natbio	Domestic	18.0	1.0	Universidade Feevale	University	16.9	1.0	Schulz	Domestic	12.0	0.8%	Valeo	MNC	13.7	1.6

#	Sao Jose dos Campos				Caxias do Sul			
	Company	Type	PI	% PI	Company	Type	PI	% PI
1	Johnson & Johnson	MNC	107.7	15.2	Randon	Domestic	119.5	15.4
2	Embraer	Domestic	81.2	11.4	UCS	University	116.7	15.0
3	ITA	University	43.8	6.2	Marcopolo	Domestic	63.5	8.2
4	UNESP	University	31.9	4.5	Fras Le	MNC	19.5	2.5
5	USP	University	28.7	4.0	Grendene	Domestic	18.5	2.4
6	Amsted Maxion	Domestic	17.5	2.5	Soprano	Domestic	18.0	2.3
7	INT	PRI	12.5	1.8	Sazi	Domestic	16.0	2.1
8	Orbisat Aerolevantamento	Domestic	9.7	1.4	Invensys Appliance	MNC	15.0	1.9
9	Compsis	Domestic	9.3	1.3	Sulmaq	Domestic	13.0	1.7
10	Cognis	MNC	9.3	1.3	Lohr	Domestic	12.0	1.5

Source: BADEPI/INPI

The MNCs that present higher patent applications in Brazil are Whirlpool (US), Bosch (Germany), Electrolux (Sweden), Agco (US) and Case New Holland (Italy) (Table B.2). It is worth mentioning that the common point among all these firms is that they have a large market share of their products in the domestic market. In fact, technological activities of MNCs in Brazil are strongly associated with their operating strategies in the domestic market, and also in the neighboring Latin American country markets. Taking only MNCs that are located in the São Paulo innovation hotspot (Table B.3), the most important companies are Whirlpool (US), Dana (US), Agco (US), Rhodia (Belgium) and SEB (France). The same conclusions apply – all the firms have important operations in Brazil, and their technological activities are related to their operations in domestic markets.

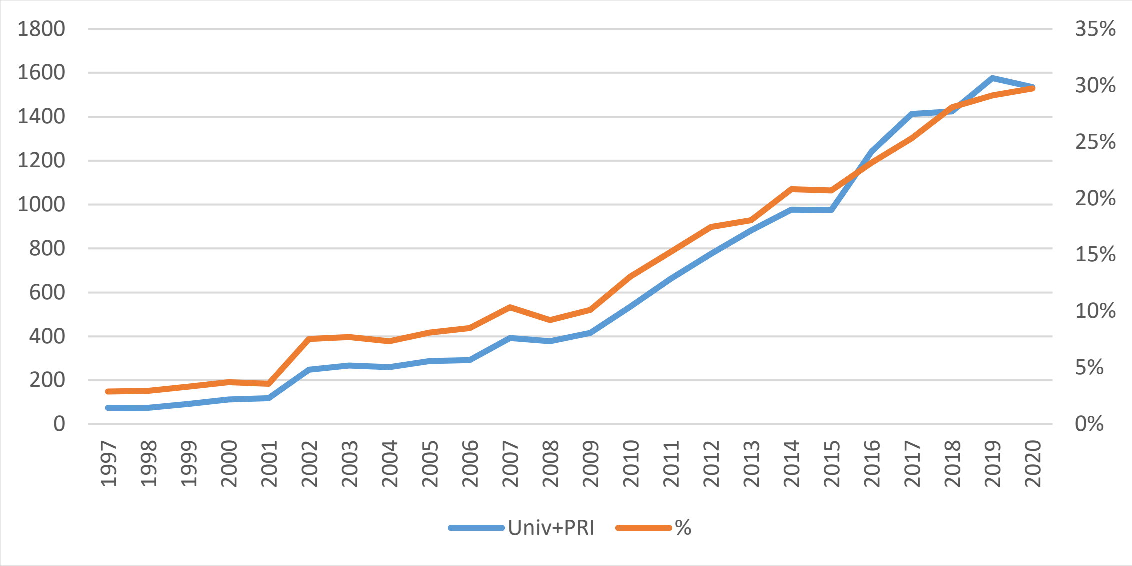
We can also see the main applicants for each Brazilian innovation hotspot and niche cluster (Table B.4). It is important to mention that in many regions, local universities play a prominent role in patent applications, since they present a high share of the total patent applications. In the case of the São Paulo innovation hotspot, we can observe the importance of the University of São Paulo (USP), which is the largest Brazilian research university. Following the USP, we can basically see private companies, both domestic and foreign, that maintain innovative activities in the São Paulo innovation hotspot. Nevertheless, the importance of the academic patent in Brazil must be highlighted.

B.7.6 Academic patenting

Regarding the technological activities carried out by universities and public research institutes (PRIs), the commercialization of academic research resulting through academic patenting is one of the most used channels for transferring knowledge from academic research to firms (Breschi *et al*., 2007). Academic researchers make an important contribution to the development of science-based technologies by expanding the scientific base that underlies the development of these technologies, and by inventions that generate industrial applications. Specifically, in the last decades, patent applications by universities have significantly increased in several countries. In the US, the growth of university patents has been much higher than the growth in the total number of patents applications, resulting in an increase in the share of academic patenting, which reached around 4 percent of the total patents at the beginning of the 2000s (Crescenzi *et al*., 2016). This expansion was associated with a growing trend of intensifying patenting activities by universities in the US, incentives from the Bayh-Dole Act and generous funding programs for academic research, especially in the areas of health sciences (Mowery *et al*., 2004). Similarly, in the UK, universities are responsible for 4.2 percent of total patent filings (Lissoni, 2012).

In Brazil, following this trend, we can see a huge expansion of academic patenting during the analyzed period (Figure B.13). The share of academic patenting in the beginning of the period, 1997, was around 3 percent, rising to 30 percent in 2020. The growth of academic patenting in Brazil is outstanding in comparison to the most important experiences worldwide. This huge growth is related to the international trend of universities to increase patenting of academic research inventions. Nevertheless, in the Brazilian case, there are two main drivers from the local institutional context that reinforce this trend. The first is the Brazilian Technological Innovation Law, enacted in 2004, which created strong stimulus for academic patenting. Second, Brazilian universities established bold strategies to stimulate patenting during this period. Almost all Brazilian universities established strategies to increase the patenting of academic research, which included increased recognition by the local regulations of patents as an academic output; the increased reputation of patenting among peers; and the creation of structures to support patenting, especially through Technology Transfer Offices (TTOs).

Figure B.13. Academic patenting, Brazil, 1997–2020



Source: BADEPI/INPI

Table B.5. Top 20 universities and PRIs in academic patenting

University or PRI	Total	%
Unicamp	1034.1	7.8
USP	822.8	6.2
UFMG	798.6	6.1
UFPR	467.7	3.5
UFPB	435.7	3.3
UFRGS	372.9	2.8
UNESP	370.6	2.8
UFRJ	324.0	2.5
UFPE	288.8	2.2
CPQD	273.6	2.1
FAPEMIG	232.8	1.8
UFPEL	226.7	1.7
Embrapa	207.8	1.6
UTFPR	204.0	1.5
Senai	190.3	1.4
UFSE	185.0	1.4
FAPESP	180.0	1.4
UFCG	177.3	1.3
UFC	173.5	1.3
UFU	164.3	1.2

Source: BADEPI/INPI

We can also see the universities that have a higher volume of patents (Table B.5). Unicamp, in the Campinas region, has 1,034 patents; USP, located in São Paulo, 822 patents; UFMG, from Belo Horizonte, 798 patents; UFPR, from Curitiba, 467 patents; and UFPB, from the city of Joao Pessoa, 434 patents. The table also includes PRIs, such as CPqD, which is specialized in ICT technologies, and Embrapa, which produces strong new applied knowledge to agriculture technologies, as well as funding agencies, such as Fapemig and Fapesp.

B.7.7 Collaboration patterns and networks of inventors

We can identify some important differences in the patterns of patenting of the different agents of the regional innovation systems in Brazil. For this reason, for comparison purposes, we have separated the patents of three of the main actors of the innovation ecosystems: a) universities and PRIs; b) MNCs; c) domestic private companies, which include private firms and state-owned enterprises (SOEs), such as the Brazilian oil and gas company Petrobrás, and former SOEs, such as the aircraft maker Embraer and the mining company Vale.

We can analyze the pattern of patent specialization of the three actors by using the RTA indicator (Table 6). The indicator shows that the main specialization of patents applied by universities are in the areas of biopharma, and semiconductors and optics. The specialization of patent applications for MNCs is mainly in engines an transport. Among domestic firms, on the other hand, specialization is more diffuse, as indicated by the lowest RTAs in areas such as audiovisual, civil engineering, machines and consumer appliances. In this way, it is possible to clearly see that there are strong differences among the main patterns of patenting among the different actors of the Brazilian innovation system (Figure B.14).

Table B.6. RTA per inventor type, 1998-2018

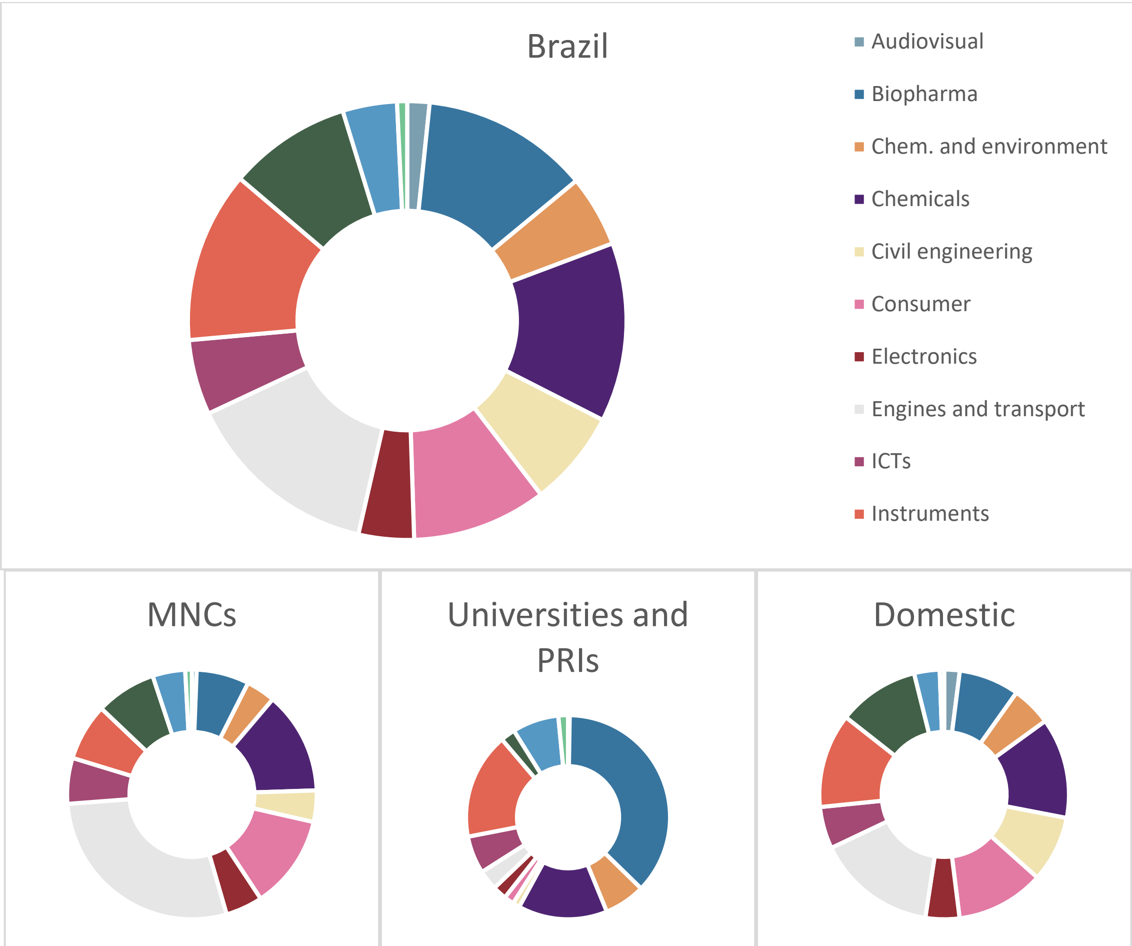
	University/PRI	MNC	Domestic
Audiovisual	0.160	0.371	1.227
Biopharma	2.996	0.552	0.633
Chem. and environment	1.231	0.715	0.979
Chemicals	1.071	1.005	0.986
Civil engineering	0.158	0.575	1.209
Consumer	0.157	1.226	1.151
Electronics	0.541	1.174	1.077
Engines and transport	0.219	1.956	1.074
ICTs	1.074	1.071	0.981
Instruments	1.335	0.583	0.967
Machines	0.255	0.865	1.163
Materials	1.838	1.055	0.826
Semiconductors and optics	2.061	1.157	0.764

Source: BADEPI/INPI

These differences can also be seen in the Brazilian innovation hotspots and niche clusters. To do that, we present data of total patents; academic patenting; patents from MNCs; patents from domestic firms (national); and Patent Cooperation Treaty (PCT) patents. We also separate them by innovation hotspot and niche cluster (Figure B.15). We can see that patents of MNCs and PCT patents are much more geographically concentrated than both total patents and academic patenting. In this way, the importance of the São Paulo innovation hotspot is much higher for patents of MNCs and PCT patents. In addition, the main driver of the regional decentralization of patent application in Brazil was the expressive growth of academic patenting, since academic research in Brazil is more spread across the territory than industrial research activities, which are more concentrated in the Brazilian innovation hotspots and niche clusters.

In this scenario, the role of the São Paulo innovation hotspot stands out, since its share in total patents is 23 percent, while in academic patenting it is 8 percent and in patents of MNCs it is 26 percent; in domestic firms’ patents it is also 26 percent, and in PCT patents it is 30 percent (Figure B.15). In this way, even with the strong decentralization of patents in Brazil in the last three decades, the São Paulo innovation hotspot has maintained its prominent role for private technological knowledge creation, as shown by its share in private patents, even domestic firms or MNCs, and in world-class patents, as shown by its share in PCT patents.

Figure B.14. Share of distribution of patens per technological domain and type of inventor, 1998–2018

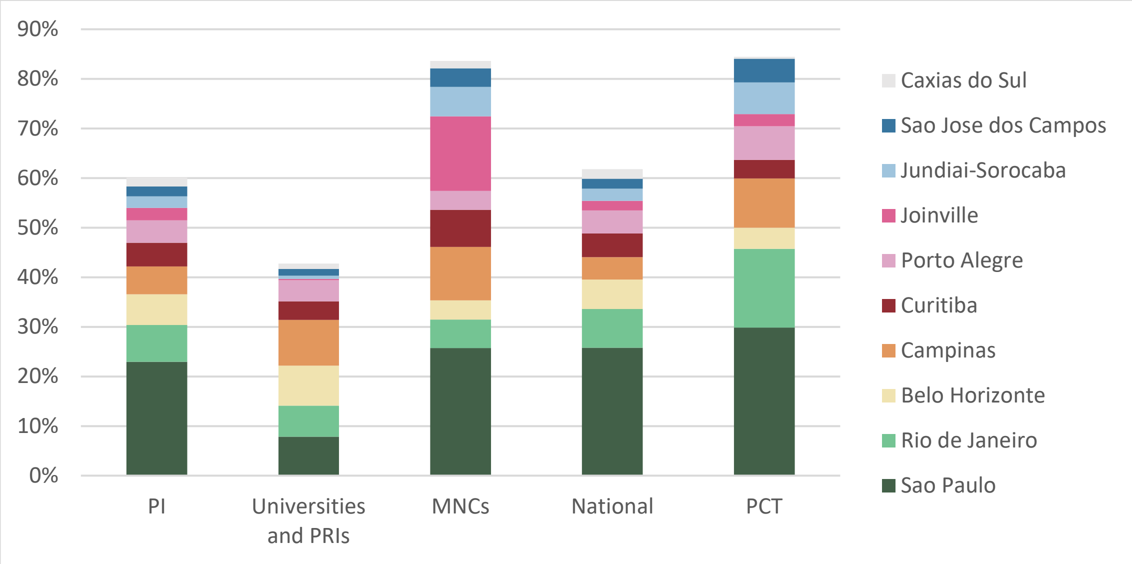


Source: BADEPI/INPI

This phenomenon can also be seen by the role of the São Paulo innovation hotspot in the network of inventors (Map B.1). To measure the network's linkages, we use two indicators: closeness, which is calculated by the centrality level of the region in the co-patenting network; and betweenness, which estimates the probability that a region is a connection path between other nodes in the network.

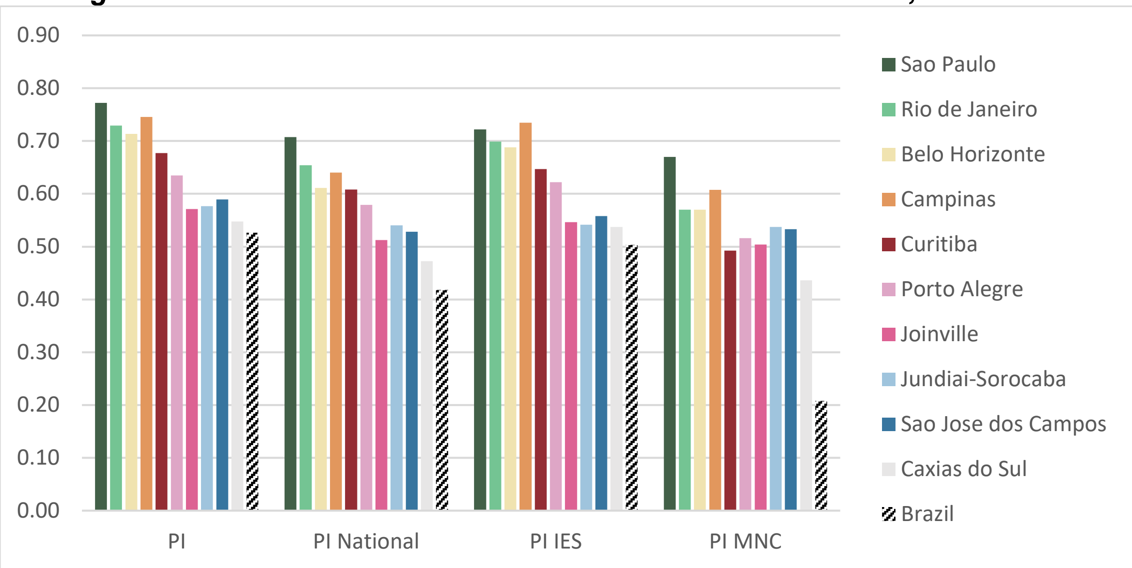
The indicators of the network analysis show that the São Paulo innovation ecosystem plays a central role in the network of inventors. The São Paulo innovation hotspot is placed in the center of the coinventors' network, since it is the closer to all other regions, acting as a hub in the co-patenting network. The importance of São Paulo is higher in the MNC network, which is very concentrated in São Paulo and in other niche clusters, especially those that are close to the São Paulo hotspot (Figure B.16). Once more, we can infer the existence of strong spatial knowledge spillovers from São Paulo to its neighboring regions. Finally, the São Paulo innovation hotspot presents a higher betweenness indicator in both domestic firm and MNC co-patents networks. The centrality of the São Paulo ecosystem demonstrates its importance in the connection of other regions. In this way, it acts as a broker or gatekeeper in regional innovation (Figure B.17). Therefore, our results show the important role played by the São Paulo innovation hotspot in the creation and diffusion of technological knowledge among the Brazilian system of innovation.

Figure B.15. Share of each innovation hotspot and niche cluster in total Brazilian patents per type of inventor, 1998–2018



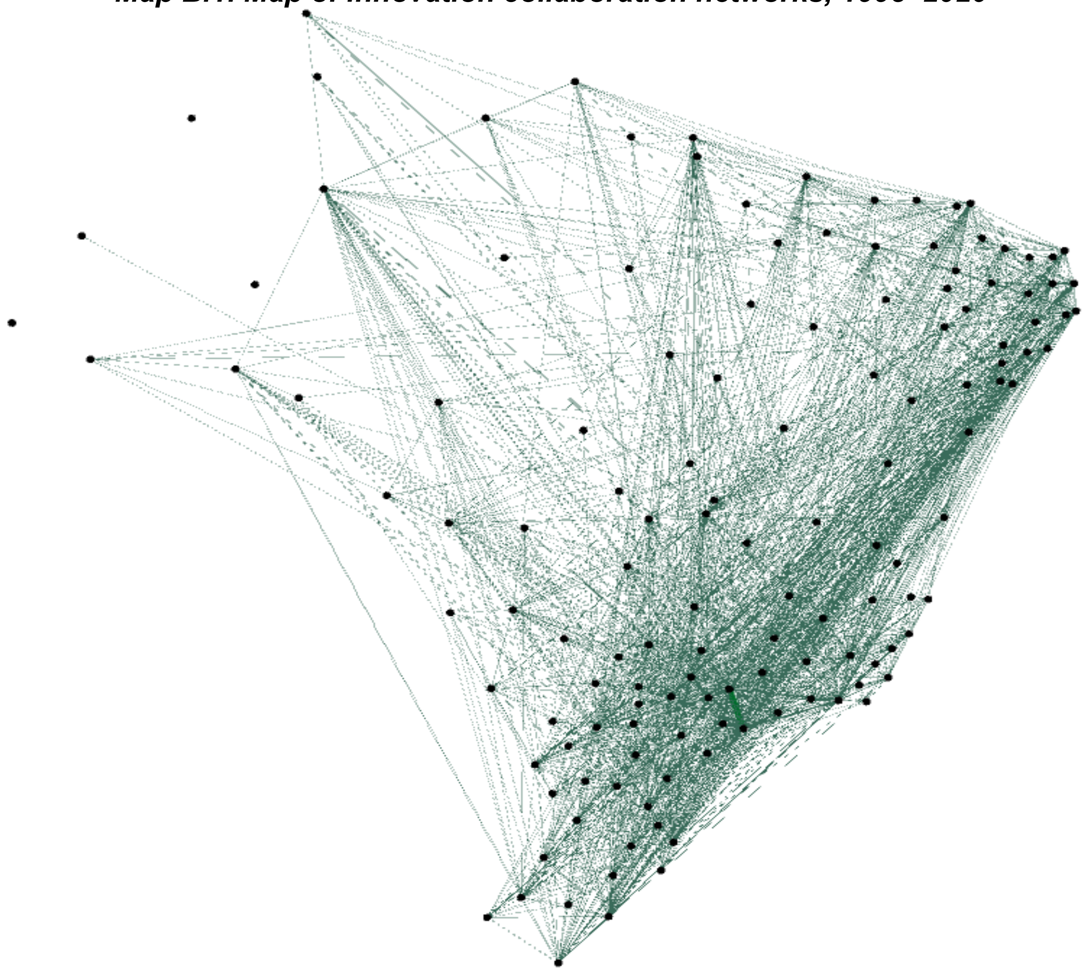
Source: BADEPI/INPI

Figure B.16. Closeness of innovation collaboration networks, 1998–2020



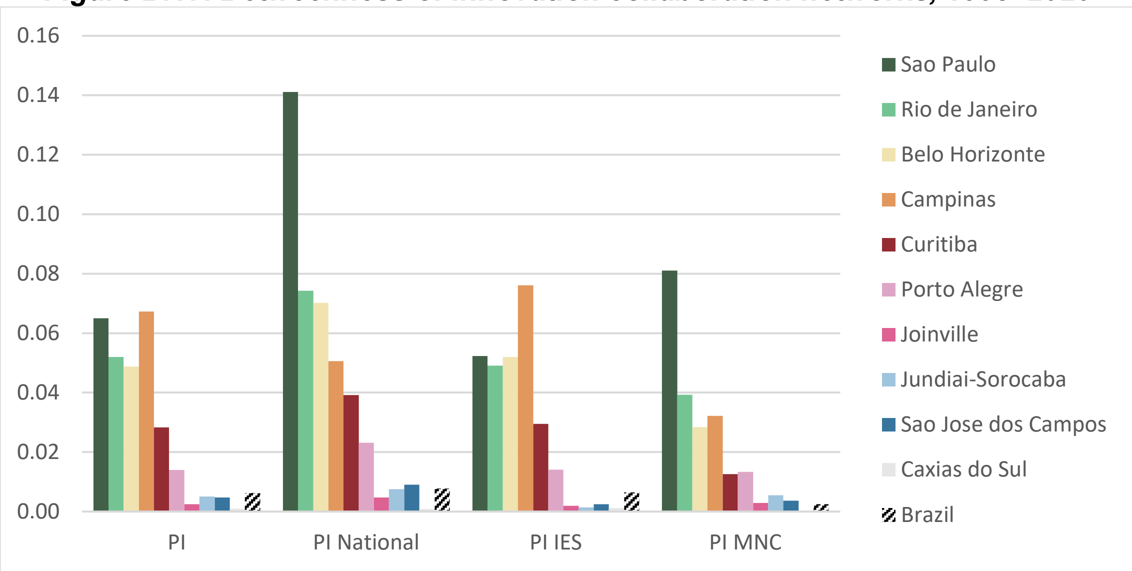
Source: BADEPI/INPI

Map B.1. Map of innovation collaboration networks, 1998–2020



Source: BADEPI/INPI

Figure B.17. Betweenness of innovation collaboration networks, 1998–2020



Source: BADEPI/INPI

Part C – Innovation policies in Brazil

C.1 Federal measures: General purpose

C.1.1Background

Before the introduction of the Law of Good ("Lei do Bem"), the tax incentives policy for innovation was based on Law 8661/93. This instrument represents the resumption of the mechanism of tax incentives as an instrument of technological policy in Brazil (Corder, 2006; Guimarães, 2006; Zucoloto, 2010). Obtaining tax incentives was subject to the implementation of Industrial and Agricultural Technological Development Programs (PDTI and PDTA, respectively) by firms. PDTI and PDTA had to be approved by the Ministry of Science and Technology; or by the federal agencies and entities for technological promotion; or even by research agencies that were accredited by the Ministry of Science and Technology for the exercise of this assignment. The complexity of these forms was considered one of the main barriers to the diffusion of this instrument, since it discouraged many firms to fill all the commitments. In 1997, the incentives of Law 8661/93 underwent deep changes, basically related to the significant reduction in the percentages involved on the main incentives (Law 9532/97). Subsequently, new changes have included the authorization to grant economic subsidies to firms engaged in the selected federal programs (Law 10332/01) and the expansion of tax incentives (Law 10637/02).

C.1.2The Law of Good ("Lei do Bem")

The Law of Good was launched in 2005 as part of a broader set of incentives for innovation and for manufacturing, launched under the federal industrial policy and innovation program known as PITCE (Industrial, Technological and Foreign Trade Policy). Chapter III of the Law of Good (Law 11196/05) is currently the most comprehensive fiscal incentive to foster innovation in Brazil, focused on the stimulus to increase R&D expenditures by private firms. The definition of R&D expenditures comprises a broad set of activities, which involve basic and fundamental research; applied research; and experimental development. It complies with the determination of Law 10973/04, which established that the federal government should encourage innovation in private firms by granting tax incentives (Suzigan *et al*., 2020; Zucoloto, 2010).

In 2005, the Law of Good consolidated the two legal texts that defined the policy of incentives to current R&D and innovation expenditures (Law 8661/93 and Law 10637/02), which also implied the revocation of both. With its launch, the bureaucratic procedure was simplified, especially by canceling the need for prior authorization to obtain the tax benefit by the interested private firm, or even for the participation of the firm in bidding documents. According to the Law of Good, and Law 5798/06, which regulated the use of tax incentives, firms must send an annual information report on their R&D programs electronically to the Ministry of Science and Technology. The deadline for the transfer of information is July 31 of the year following each fiscal year.

The Law of Good also regulates the main activities that are allowed to receive tax incentives. R&D expenditures are classified as operating costs by the Brazilian Fiscal Authority ("Receita Federal"), which allow firms to exclude R&D expenditures from the calculation base of two basic taxes, which are the Social Contribution on Net Income (CSLL) and income tax (IRPJ). According to the Law of Good (Chapter III, articles 17 to 26), the real gain with R&D expenditures can be summarized as follows (Zucoloto, 2010):

- exclusion of the net profits and of the CSLL calculation base, the amount corresponding to:
- up to 60 percent of the sum of R&D expenditures, classified as operating expenses (or process costing) by the Brazilian Fiscal Authority, in the period
- up to 20 percent, in the case of an increase in the number of researchers dedicated to R&D activities hired in the year of reference
- up to 20 percent, in the case of a patent granted or a registered cultivar
- reduction of 50 percent of the tax on manufactured products (IPI) on machinery, equipment, devices and instruments imported for R&D activities
- depreciation and accelerated amortization of equipment and intangible assets for R&D
- reduction to zero of the rate of income tax on profits for international transfers made for the registration and maintenance of trademarks, patents and cultivars.

C.1.3The Innovation Law

The approval of the Brazilian Technological Innovation Law ("the Innovation Law") took place on 2004, and its regulation was in 2005. The approval of the Innovation Law provides a new instrument to foster innovation and scientific and technological research in private firms, especially in collaboration with universities and public research institutes (PRIs). The main conceptual definitions that lead to an understanding of the normative provisions of the law are in its first chapter. Chapter II deals with stimulating the building of an innovation environment, bringing the main principles that regulate the interaction between academic research institutions, such as universities and PRIs, and private firms. In particular, interaction channels and mechanisms foreseen to foster synergy for the viability of new emerging and technology-based enterprises are highlighted, which includes the regulation of the transfer of scientific and technological knowledge in business incubators. In addition, Chapter III is oriented toward generating incentives for the participation of PRIs in the innovation process. In this sense, it deals with the definition of regulation that allows for and fosters technology transfer and licensing from universities and PRIs to private firms.

The regulation of the Innovation Law implies a set of changes in the behavior of research institutions, aiming to preserve the independence of academic research, to stimulate the generation of new technological knowledge and to foster its transfer to private firms. The Innovation Law recognizes that the scientific and technological knowledge developed within universities and PRIs through research involving their academic researchers is an intellectual property of the university or PRI. In cases where the new technological knowledge generated was created with the financial participation of other entities, whether public or private, the Innovation Law provides instruments for an agreement to be made among the involved partners to define the share of the intellectual property of each. In this way, any research that involves the development of knowledge with the potential for technological application (products, processes and software) can be protected by intellectual property (Bueno *et al.*, 2005; Matias-Pereira & Kruglianskas, 2005).

In 2016, the Brazilian Innovation Law underwent an update, with the approval of the new legal framework for innovation, known as the Code of Science, Technology and Innovation (ST&I), Law 13243/16. The changes undertaken by the new legal framework for innovation in Brazil started with the recognition of the need to change some key points in the Innovation

Law and nine other laws related to the topic. These changes were mainly aimed at reducing legal and bureaucratic barriers and giving greater flexibility to the main institutions of the Brazilian innovation system, especially universities and PRIs (Rauen, 2016).

C.1.4The "Inova Empresa" Plan

Finally, in 2013, Brazilian federal government launched the "Inova Empresa" Plan, as part of the federal innovation policy. The main measures of the plan are aimed at fostering private innovation and improving the productivity and competitiveness of domestic firms by fostering technological innovation. The "Inova Empresa" Plan is based on the experiences of two former plans. The first, the Joint Support Plan for Agricultural Technological Innovation in the Sugar-Energy Sector (PAISS), was created to support innovation in agriculture and renewable energy; and the other was devoted to the oil and gas sector (Inova Petro). Inspired by both programs, the "Inova Empresa" Plan aims to expand successful experiences through the integration and coordination of actions from several institutions that support innovation. For example, for funding, both Finep and BNDES sought to coordinate efforts and act in an integrated manner in financing private innovation projects.[11] In this scheme, four R&D expenditure-financing instruments are integrated: economic subsidies; the promotion of agreements with science and technology institutions and cooperative projects; shareholding in technology-based companies (EBT); and special credit conditions (Gordon & Cassiolato, 2019).

The launch of the "Inova Empresa" Plan was surrounded by high expectations and substantial budget resources, both by direct expenditures of federal government and its ministries, as well as by the action of governmental agencies. Sectoral and strategic priorities were defined in the Brasil Maior Plan, using resources from the Investment Support Plan (PSI). It was an important attempt to assign resources to the private firms' innovation projects, and to integrate different initiatives at the governmental level. However, the plan was launched at a time of increasing budgetary constraints in the governmental sphere, which significantly hampered its execution and the possibilities of achieving its goals (Corder *et al*., 2016).

C.1.5Non-reimbursement financing: Finep, BNDES, CNPq, Sebrae

Finally, it is worth mentioning the existence of some funding programs with non-reimbursable financing. The most important programs are presented below (Bueno *et al*., 2005):

- economic subsidy (operated by Finep under the Ministry of Science and Technology): the direct contribution of budgetary resources to firms to carry out R&D activities, aiming to promote a significant increase in innovation
- PAPPE subsidy (operated by Finep): research support program for SME with the purpose of providing financial support through economic subsidy (non-reimbursable resources) to small technology-based firms

[11] The Funding Authority for Studies and Projects (Finep) is an organization of the Brazilian federal government, under the Ministry of Science and Technology, devoted to funding applied science, technology and innovation in Brazil. The National Bank for Economic and Social Development (BNDES) is a development bank structured as a federal public company, under the Ministry of the Economy of Brazil, and is devoted to providing long-term financing for endeavors and investment projects in Brazil.

- PRIME First Innovative Company Program (operated by Finep): aims to create favorable financial conditions to high value-added infant firms, with a focus on their consolidation at the early phase of the development of their ventures
- FUNTEC (operated by BNDES): a technological fund created with the purpose of financially supporting projects that aim to stimulate strategic technological development and innovation, in accordance with the industrial policy programs and other public policies
- RHAE Program (operated by the CNPq[12]): a human resources training program in strategic areas, created to aggregate highly qualified personnel in R&D labs and activities at private firms, in addition to training and qualifying human resources who work in applied research or technological development projects
- Sebraetec Program (operated by Sebrae[13]): created with the aim of encouraging the use of new, both radical or incremental, technology in small and medium-sized enterprises (SMEs).

C.2 Sectoral measures: Federal level

C.2.1The Informatics Law

The Informatics Law (Law 8248/92) is an instrument of industrial policy created in Brazil in the early 1990s to help national hardware manufacturers face the challenges imposed by the opening of the domestic market to international suppliers of computer equipment, as well as to encourage the carrying out of R&D activities in information and communication technologies (ICTs) in Brazil. The initial objective of the Informatics Law was to encourage the local manufacture of ICT equipment, and the internalization of R&D expenditures in the country, by granting tax incentives to the beneficiary firms. To take advantage of these tax benefits, companies had to expend at least 5 percent of their income (excluding software and professional services) on R&D activities, up to 3 percent of which could be in-house activities, with at least 2 percent to be invested in joint projects with universities, PRIs or selected government programs.

This way of granting incentives was used until 2000, when it was slightly modified by Law 10176/01. The basic principles were maintained and the percentages applied to internal (2.7 percent) and external R&D activities (2.3 percent) were changed. This modification also created mandatory application shares to north, northeast and midwest regions of the country. Subsequently, new changes were introduced by Law 11077/04, which extended the benefit periods until 2019, but with a gradual reduction in tax exemptions. New changes occurred in 2019 (Law 13969/19), when the incentive of the tax exemption was changed to financial credits (Garcia & Roselino, 2004; Prochnik *et al.*, 2015; Salles Filho *et al.*, 2012).

C.2.2The Inovar-Auto Program

Since 2009, the Brazilian government has started to use more intensive policy measures that demand local content for manufacturing. In fact, in 2015, there were at least 17 policy programs in Brazil aimed at fostering local content in domestic manufacturing (Stone *et al.*,

[12] CNPq is the National Council for Scientific and Technological Development, under the Ministry of Science and Technology, devoted to financing academic basic and applied research, with some programs aimed at transfering academic knowledge to private firms.
[13] Sebrae is the Brazilian Micro and Small Business Support Service, an organism that offers several programs to support SMEs in Brazil.

2015). In this context, in 2012 the Brazilian government created the Incentive Program for Technological Innovation and Densification of the Automotive Vehicle Production Chain (the Inovar-Auto Program). The main objective of the Inovar-Auto Program is to promote the strengthening of the automotive supply chain for auto parts and components.

The program consists of up to 30 percent of granting tax on manufacturing (through the Industrialized Products Tax; IPI) to automotive firms that can satisfy the requirements of local content: at least 80 percent of the vehicles should be locally manufactured; and at least 85 percent of the value of the parts and components should be domestically manufactured (Laws 563/2012 and 7716/2012).

The program defined a set of automobile manufacturing activities that should be carried out in Brazil in order for the tax benefits to be granted. Even though it is difficult to measure the capacity of these activities to generate domestic value, it can be mentioned that the Inovar-Auto Program involves strong requirements in terms of the share of domestically produced value-added automotive vehicle manufacturing. Automakers, however, may choose not to meet these requirements and, in return, not be entitled to the envisaged exemption (Messa, 2017).

C.2.3The renewable energy program: PROINFA

In the area of renewable energy, the Incentive Program for Alternative Sources of Electric Energy (PROINFA) was established in 2002 (Law 10438/2002). It is the first program designed to actively promote “alternative” sources of electricity generation in Brazil – wind, biomass and small hydroelectric plants, specifically (Aquila *et al*., 2017). On the whole, the creation of PROINFRA was a response to the severe energy crisis that Brazil went through in the early 2000s. PROINFA was an attempt to reduce the share of energy provided by huge hydroelectric power plants in Brazil, in the form or large dams, by fostering the development of alternative sources of energy.

PROINFA included a special financing system through the BNDES of up to 70 percent of capital costs, excluding the acquisition of land and imported goods and services (Aquila *et al*., 2017). Initially, the program was operated using standard feed-in tariff models to add 3.3 GW of capacity in the Brazilian electrical system – 1.1 GW each from wind, biomass and small hydropower sources – with contracts for long-term electricity purchase (20 years) from independent energy producers guaranteed by the major state-owned Brazilian electric utilities company (Juárez *et al*., 2014). The second phase of PROINFA, which was foreseen in the law, had the aim of making the alternative sources contemplated in the program reach 10 percent of the national electricity consumption in 2022, but that was not implemented due to changes in the regulations of the Brazilian electricity sector (Melo, 2013). PROINFA also included local content requirements, based on forecasting studies by the Brazilian Ministry of Energy. In the beginning, the exigence of local content was about 50 percent of total value added in the manufacturing of machine and equipment, but this share was increased to 60 percent during the 2000s.

The local content was calculated on the total investment, considering services and equipment. However, the low private investment in renewable energy led the government to promote changes in the regulatory framework, and it started to adopt the auction system. The Ministry of Energy introduced its competitive bidding program in the form of the so-called Reserve Energy Auction (“LER”) (Law 6353/08) and other types of auctions. Renewable energy auctions in Brazil take place through regular auctions or reserve auctions, the latter since 2009, oriented to bid for non-conventional sources of energy, especially wind energy (Aquila *et al*., 2017).

Local content requirements were formally abolished, remaining mandatory only for developers who resorted to financial support from BNDES, which could finance up to 80 percent of renewable energy projects. The BNDES financial support mechanisms created a clear incentive for the use of wind energy, despite the obligation to meet local content requirements. In practice, local content requirements remained, as all wind farm projects were developed with the support of the development bank (Aquila *et al.*, 2017).

C.2.4Oil and gas

In the oil and gas industry, since 1999 the Brazilian government has defined a Local Content Policy with the objective of stimulating domestic manufacturing of capital goods and services for investments. The definition of the Local Content Policy involved federal government, through the National Council for Energy Policy (CNPE), and the Brazilian regulatory agency for oil, gas and biofuels (ANP), as well as entities from business representatives. It is important to mention that the major Brazilian oil and gas company is the state-owned enterprise Petrobrás. Since the establishment Local Content Policy in 1999, the ANP has decided to award points, in percentages, for firms' commitment to acquire local content. The scoring rules on the local content commitment during the bidding rounds have been in force ever since, which has proved successful in terms of increasing the local content commitment assumed by the oil companies (Xavier Junior, 2012).

In addition to the Local Content Policy, the concession contracts signed between the concessionaires and the ANP require that they contract from Brazilian suppliers whenever they offer price, quality and term conditions equivalent to those of international suppliers. These conditions are similar to those used in Norway and in the United Kingdom before they abandoned local content policies to match EEA legislation. In order to ensure compliance with the agreed local content percentages, the ANP is allowed to apply various penalties to defaulting dealers, such as the payment of fines and the loss of the concession (Xavier Junior, 2012).

Since its establishment, the Local Content Policy has undergone some important changes. These changes were intensified after the discovery of oil deposits in the pre-salt layer and the implementation of the production sharing regime, in which operators are now required to comply with contractual requirements regarding local content (Law 12304/2010) (Piquet *et al.*, 2016).

C.2.5Aeronautics and aerospace

In several countries, the domestic aeronautical industry is characterized by its closeness with the state, which throughout history has acted for its promotion through active industrial policies which are, in large part, directed specifically at this manufacturing sector. In Brazil, the main player in the aeronautics industry is Embraer, a former state-owned enterprise, that coordinates a huge and Global Value Chain in the assembly of airplanes. Despite the presence of Embraer, there are no domestic top-level suppliers in Brazil. The Brazilian aeronautics industry is composed of a small set of firms, most of which provide services that offer low-tech solutions.

Public policy has always played a crucial role in the formation and development of the Brazilian aeronautical industry. During its formation, even before the creation of Embraer in 1969, the state played a fundamental role in providing a set of conditions that allowed for the construction of the necessary capacities for the formation of the production chain and support institutions. Public procurement policies have also always played a vital role in the scope of industrial policy for the aeronautical sector in Brazil.

The support policy for the Brazilian aeronautical industry has changed over time, adapting to the new needs that have arisen as a result of the advances made by this industry, concentrated in its leading firm. Nowadays, the main instruments to support the aeronautics industry involve public–private partnerships, specially by providing knowledge inputs and public financing (Barbieri Ferreira & Neris Junior, 2020; Caliari & Barbieri Ferreira, 2021; Sturgeon *et al*., 2013). The main policy instruments for the Brazilian aeronautics industry can be summarized as:

- the provision of knowledge inputs to the innovation process, and competence-building for human capital
- demand-side activities, using public procurement for innovation, and the definition of new product quality requirements
- the financing of innovation, productive and commercial activities (Caliari & Barbieri Ferreira, 2021).

C.2.6The economic–industrial complex in health

Another industry that has received public support for innovation is the health industry, through the creation of a framework of public and private institutions known as the health economic–industrial complex. In fact, the pharmaceutical industry was elected one of the priorities of Brazilian industrial policy after its revival in 2003 (Suzigan *et al*., 2020). However, policy measures were at that time very poorly articulated, with the absence of a coordinating institution that could manage the main efforts in both technological and manufacturing areas.

This scenario, however, was modified in 2009, through integrated actions coordinated by the Brazilian Ministry of Health, which involved other federal government bodies, articulations with state governments and, mainly, with domestic private firms. In a typical attempt to create a mission-oriented policy (Mazzucato, 2018), the Brazilian Ministry of Health used its public purchasing power, through the Unified Health System (SUS)[14], to articulate a wide mobilization of public institutions and private firms toward the creation of mechanisms to support innovation and the manufacture of medicines and vaccines (Gadelha *et al*., 2018; Temporão & Gadelha, 2019). The most important instrument is the Partnership for Productive Development (PDP), which incorporated mechanisms of manufacturing development and scale-up. The establishment of the PDP was the result of the creation the Executive Group for the Health Economic–Industrial Complex (GECIS), which exerts the role of the main political coordinator and supervisor of the processes involving local manufacturing and the purchase of medicines by the Ministry of Health, by publishing the first list of strategic products for the SUS. In this way, GECIS was crucial for the building and the execution of initiatives that sought a systemic pattern for public policy, aimed at industrial development, technology and innovation in favor of solving the needs presented by the SUS (Temporão & Gadelha, 2019).

The general architecture of the policy seeks to organize three essential driving forces. The first is represented by the private firms, most of them domestically owned, that master the selected technologies by the Ministry of Health. The second driving force is represented by the Public Pharmaceutical Laboratories (LFOs), both in the form of PRIs, such as Fiocruz and Butantã, and academic laboratories in Brazilian universities. The third driving force is the

[14] SUS is the Brazilian universal public health system.

public purchase policy of the Brazilian Ministry of Health, concentrated in the main health programs of the SUS. In general, the articulation between these three driving forces works as follows. Annually, the Ministry of Health launches a list of strategic products to the SUS. For the realization of the PDP, the public and private institutions involved must develop and send a project, which will (or will not) be approved by the Ministry of Science and Technology. Private firms that are technologically qualified to develop products must commit to the stipulated health standards and to the technological and productive training of public laboratories staff. This guarantees private firms the exclusivity of government purchases during the period in which they must carry out the complete transfer of technological and productive training from partner public laboratories (Temporão & Gadelha, 2019).

C.3 Local policies: The state of Sao Paulo

C.3.1PIPE/Fapesp

The most important program in the financing of small hi-tech firms is the Innovative Research in Small Businesses Program (PIPE), operated by the Sao Paulo State Research Support Foundation (Fapesp). PIPE was created in 1997, with the aim of financially supporting the execution of scientific and technological research in small firms in the state of Sao Paulo. In the program, small firms are defined as those with up to 100 employees, and the program aims to finance, with non-reimbursement funds, business plans with a high return in technological, commercial or social areas (Bueno & Torkomian, 2015; Calligaris & Torkomian, 2003; Cruz, 2009; Fischer *et al*., 2018; Scorsatto *et al*., 2019).

PIPE supports joint projects between academic researchers and small firms in a wide range of knowledge areas, but with a focus on applied science and engineering. Joint projects have to be presented in three sequential phases (Cruz, 2009):

- Phase I lasts six months and aims to carry out research that has technical feasibility in the proposed ideas. The results obtained in this phase will be the condition for the qualification of the next phase. At least two-thirds of the research activities must be carried out by the small firm, which can thus subcontract up to one third of the research of other firms, consultants or research institutions. In this phase, in addition to the consumption material and lab machinery necessary for the project, scholarships may be granted to the researchers and support staff
- Phase II can last up to 24 months and is when the main share of the research is developed. At least half of the research activities must be carried out by the proposing small firm, which may thus subcontract up to half of the research to other firms, consultants or research institutions. At this stage, Fapesp will be able to finance the purchase of equipment and material necessary for the project, and grants may also be awarded to researchers and support staff. The equipment acquired with own resources is the property of the Fapesp, and at the end of the project it should be donated to the academic partner
- Phase III sees the development of new commercial products, based on the research results that were obtained in Phases I and II. Fapesp will not provide financial support of any kind to project at this stage, but may collaborate in obtaining support from other sources if the results of the research prove the technical feasibility of the ideas, as well as their potential for commercial or social return

C.3.2PITE/Fapesp

Another important program carried out by Fapesp is the Research Support Program in Partnership for Technological Innovation (PITE) (Bueno & Torkomian, 2015; Cruz, 2009). The aim of PITE is to give financial support for joint research projects between academic researchers and private firms, of any size, if both are located in the state of Sao Paulo. It aims to facilitate the dissemination of scientific and technological knowledge generated in universities and PRIs. PITE supports research projects for the development of new products with high technological content or new production processes. It finances the share of the research projects that is under the responsibility of the research institution. The private partner must offer financial compensation to cover its share of the joint project (Cruz, 2009). Three types of partnership are considered:

- Modality 1: a joint project, proposed by a researcher or group of researchers linked to the university or the PRI in partnership with a company or group of companies, aiming at developing innovation whose exploratory phase is practically completed. This type of project includes those whose exploratory phase has already been completed by the researcher or the research group with its own resources or funding agencies. Additional investments in the development of innovation must be justified by means of a preliminary cost-benefit analysis, which will be considered as a priority element. Fapesp will finance up to 20 percent of the cost of the project, and the company (or companies) involved must supply the rest of the resources
- Modality 2: a joint project, proposed by a researcher or group of researchers linked to a university or Public Research Institutes in partnership with a company or a group of companies aimed at developing innovation associated with low technological and commercial risks. This type of project typically includes incremental innovation projects, forced by the market, involving the stages of exploration and certification. As a priority element, the project should demonstrate the socioeconomic benefits that its success will have on the production or services sector in which it is inserted. Fapesp finances up to 50 percent of the cost of the project, with the company (or companies) involved contributing the rest of the resources
- Modality 3: a joint project, proposed by a researcher or group of researchers linked to a university or IPP in partnership with a company or a group of companies aiming to develop innovation associated with high technological risks and low risks of commercialization, but with high “fertilizer or germinative” power. This type of project typically includes radical innovation projects, the resulting innovation of which can have a significant impact on an entire sector of activity. Incremental innovation projects can also be included in this modality, when the company involved is medium-sized or small and when the innovation results from a significant socioeconomic contribution to the country. Fapesp finances up to 70 percent of the cost of the project, with the company (or companies) involved contributing the rest of the resources.

C.3.3Other programs at local level

Finally, two programs from the state of Sao Paulo government to support industrial and technological development in the state can also be mentioned.

The first is “Desenvolve-SP,” which is a development agency created in 2009 designed as an institutional instrument to support economic development policies for the state of Sao Paulo. Its programs are marked by three financing axes. The first axis is for government programs, in partnership with other Sao Paulo state government institutions that aim to stimulate social and regional development. The second axis involves projects in partnership with municipalities, in which it offers lines of credit to the public sector, at low interest rates and on long terms, to support the municipal administration in making the necessary investments in the infrastructure of the cities. The third is the business-oriented axis, which finances projects, investments, the acquisition of machinery and financing for working capital for small and medium-sized companies (Gallo, 2017). Its performance, however, is quite modest – until 2015 the agency had disbursed less than 500,000 US dollars since its establishment, and this scenario has not changed in recent years.

The other program is for scientific parks is the Sao Paulo Technology Park System (SPTec). This program aims to support the development of science parks in order to attract investments and generate new knowledge-intensive or technology-based firms. Currently, the state of Sao Paulo has 13 technology parks, and nine more require accreditation by the program.

Conclusions and future research

The report inspected a number of patterns and trends in order to better understand what makes São Paulo different from the rest of Brazil and the continent, and what the main potentialities and drawbacks are.

The guiding question were: is the São Paulo innovation ecosystem the main innovation hotspot in Brazil and Latin America? Which role does the São Paulo ecosystem play in the Global and Brazilian innovation networks? What are the main effects of the geographical decentralization of technology production in Brazil on the role of the São Paulo ecosystem?

We find that São Paulo is rich in scientific activity, but lags behind with respect to patent production. At the same time, São Paulo is a (patent) leader of the country and the region, and presents characteristics that resembles the large innovation hotspots of the world.

Using geolocalized international patent families and scientific publications from Web of Science (WoS), this report has characterized the main patterns and trends of the São Paulo innovation ecosystem, and how it integrates within the regional and global systems of innovation. The report focuses on four main aspects: (1) the role of São Paulo as a national and regional innovation powerhouse, but its distance to more innovative global hotspots; (2) the technological and scientific capabilities of São Paulo that could allow the area to diversify into more complex, high-value technologies; (3) the role of the scientific sector; (4) the role of global innovation and knowledge networks in driving São Paulo's innovative success.

This report also explored the main characteristics of the technological production of the São Paulo innovation hotspot within the Brazilian national innovation system. Using data from Brazilian Office of Intellectual Property (BADEPI/INPI) and some additional Brazilian databases regarding innovation inputs and outputs, the report shows that the São Paulo's innovation hotspot is the most important Brazilian region in patenting. This is a reflection of the strong innovation activity carried out in the local ecosystem, especially by Brazilian standards. Despite the regional decentralization of the production of technological knowledge in Brazil, São Paulo's innovation hotspot has maintained its position of leadership in patenting. In addition, if we take only industrial patenting (that is, excluding academic patenting), the share of the São Paulo innovation hotspot is even higher. In this way, Brazilian technological production is still largely concentrated in São Paulo.

Another important characteristic of the São Paulo innovation hotspot is its technological diversification. Our analysis of the specialization indicators shows that it is hard to find a clear specialization in the São Paulo innovation hotspot, since the indicators are generally low. This means that the São Paulo ecosystem is characterized by important diversification externalities, since the local production of technological knowledge seems to benefit from important cross-fertilization effects.

Regarding technological collaboration, our results also show an increase in the technological collaboration both in the São Paulo innovation hotspot, and the Brazilian innovation system. The growth of technological collaboration occurs mainly with domestic inventors, and when there is a lower level the international technological collaboration. Moreover, we can also see that the São Paulo innovation hotspot has increased its centrality in the Brazilian innovation system, as shown by the growing participation of local actors in the networks of inventors, especially in those that involve private firms, both domestic and MNCs. Therefore, the analysis of the main characteristics of the technological production of the São Paulo innovation hotspot shows that it maintains its key role for the creation and diffusion of new technological knowledge in the Brazilian innovation system and in the domestic networks of innovation.

Part of such success can be connected with the innovation policies reviewed in Part C of the report, especially the local initiatives. However, more research is needed to conclude a direct relation between policies and São Paulo’s success in agglomerating innovation and occupying central positions in the national network.

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