FEDERAL UNIVERSITY OF SÃO CARLOS
CENTER OF EXACT AND TECHNOLOGY SCIENCES
DEPARTMENT OF INDUSTRIAL ENGINEERING
POSTGRADUATE PROGRAM IN PRODUCTION ENGINEERING

FOREIGN DIRECT INVESTMENT, REGIONAL INNOVATION AND ABSORPTIVE CAPACITY IN BRAZIL

VITOR MELÃO CASSÂNEGO

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Dissertation for the Master’s Degree presented to fulfill the requirements of the Production Engineering Postgraduation Program of the Federal University of São Carlos (UFSCar).

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CHAPTER 1: INTRODUCTION

1.1. DISSERTATION STRUCTURE

This thesis is presented in 4 main parts. In summary, Chapter 1 presents the main subjects (i.e., Multinational Enterprises – MNEs, foreign investment, innovation, and regional indexes) and their implications for the research problem (i.e., concentration in emerging economies). Chapter 2 presents an empirical article discussing the subject-specific literature review, methods, results, and discussion. Thus, it presents the research development process. Chapter 3 concludes the research and presents its implications, along with suggestions for future academic investigations. The last part, post-chapter 3, presents the annexes relevant to complement the information obtained when processing the data and the bibliographic references used as a basis throughout the research.

1.2. THEME PRESENTATION

1.2.1. Contextualization

Amongst the innovative scenario, the production of Intellectual Property (more specifically Industrial Property) is fundamental as a concrete data source to evaluate the development of any country in terms of the production of inventions, which are possible innovations (HAO et al., 2020; MOURA et al., 2019). The World Intellectual Property Organization (WIPO) is an International Public Law entity and one of the United Nations (UN) institutions. This entity is responsible to map, compare and report every year the production of intellectual property around the world among all the countries, with information regarding the total amount of innovation and also dividing it into detailed categories of knowledge and industrial segments (WIPO, 2020).

Intellectual property, by definition, is a term applied very broadly, as it refers to the property of whatever results from the inventive ability or creative capacity of the human being in every conceivable way possible, including all the modalities, subjects, areas of knowledge, skills, and technologies of material or immaterial creations (PEIXOTO; BUAINAIN, 2021). Still, according to Peixoto and Buainain, these elements that compose the result of inventions can be divided into three main categories: author and related rights; industrial property; *sui generis*. The first category consists of rights given to the authors of intellectual works expressed through any means of communication or attached to several supports. This very generic definition encompasses all the literary and artistic works, artistic interpretations, transmissions via radio or television, phonograms, and computer programs.

The second category, which is more important to this research since it will be the source of indexes used during the investigation, contains the rights granted to patent owners, industrial sketches/blueprints, brands, and geographical indications since it is fundamental to promoting creativity by protection, dissemination, and industrial application of the research results in the aforementioned segments. Here it is worth outlining that the goal of this research is to evaluate innovation, but this is an extremely complex phenomenon and therefore it is still impossible to measure accurately innovation outputs and their effects on the surrounding communities directly. The most common approach used in the specific literature nowadays is the number of patents deposited or granted because they measure the intensity of inventions that can become innovations if they reach the market (MOURA et al., 2019; MUELLER; PERUCCHI, 2014; SALAMA; BENOLIEL, 2008; VIANA et al., 2018).

Last but not least, there is the category that embraces all the elements not contained inside the other two described before. The elements included here are still considered important assets of human intellectual property, for example, traditional knowledge, folkloric manifestations, and protection of new vegetal species, among other situations. To concede these rights to individuals, companies, or educational institutions responsible for the research and creation of knowledge, every country has its intellectual property system (WIPO, 2020). In Brazil, the recognized office to hold a monopoly on these processes is called Instituto Nacional da Propriedade Industrial (INPI) and can be described as a federal autarchy associated with the Economy Ministry (INPI, 2018). This institution was founded on December 11th, 1970, with the responsibility of "executing, in all the national territory, the norms that regulate the industrial property, taking into account their social, economic, juridic and technical function, as well as mediate signatures, ratifications, and accusations regarding conventions, treaties, agreements, and arrangements about industrial property in general" (BRAZIL, 1970).

INPI's operation is driven by a series of backbones and policies that guide the goals and functions that the day-to-day processes need to fulfill. The first one expatiates on the concession of monopolies and intangible assets in the private property's scope for all the categories listed before in this segment of intellectual property. The second pillar is about the dissemination of information when it comes to the state of the art and state of the practice in every area of knowledge encompassed by the definition of industrial property. The third and last pillar deals with the hiring or acquisition of new technologies through contracts of technology transference or private property assets licensing (INPI, 2021b).

However, society needs to receive a counterpart in exchange for the concession of temporary private property over the knowledge produced. The elements composing the aforementioned equivalent, detailed by INPI itself, are to make available the know-how generated throughout the process of technological and scientific development, as a way to abbreviate other research routes and possible conceptions in Research and Development (R&D). Consequently, time and resources from other parts of the society interested in the technology are spared and the creation of incremental or related inventions is accelerated. Besides all that, the institution (INPI) collects a monthly fee for every deposit of possible innovations during the entire process of approval and the concession of property.

The production of intellectual property is usually associated with investments in R&D in a percentage of the national GDP during the 2000-2020 period for some developed and emerging countries. There, one can see that Brazil, despite having a percentage of the GDP destined for R&D activities much higher than the rest of Latin America and the Caribbean region, is still far from some developed countries, and the average of the participating members of the OECD (OECD, 2021). It can be compared to the amount Russia spends on the development of this sector. Nevertheless, Brazil is not among the most innovative country in the region, since according to the Global Innovation Index 2021, the three first economies in innovation in Latin America and the Caribbean are Chile, Mexico, and Costa Rica, respectively occupying the first, second and third places (WIPO, 2021).

Table 1 – R&D spending as a percentage of GDP for emerging and advanced economies

Year	OECD	Brazil	China	USA	Russia	Argentina	Mexico
2000	2.085	1.048	0.893	2.629	0.978	0.392	0.306
2001	2.121	1.062	0.940	2.648	1.097	0.380	0.324
2002	2.098	1.010	1.058	2.561	1.162	0.348	0.354
2003	2.103	0.999	1.120	2.565	1.197	0.367	0.393
2004	2.075	0.963	1.215	2.502	1.072	0.404	0.388
2005	2.104	1.002	1.308	2.516	0.994	0.421	0.398
2006	2.131	0.988	1.369	2.557	0.999	0.452	0.369
2007	2.174	1.081	1.374	2.628	1.039	0.460	0.398
2008	2.240	1.129	1.446	2.757	0.972	0.471	0.444
2009	2.285	1.119	1.665	2.807	1.166	0.587	0.480
2010	2.245	1.160	1.714	2.725	1.052	0.564	0.495
2011	2.274	1.140	1.780	2.755	1.015	0.569	0.471
2012	2.267	1.127	1.912	2.672	1.028	0.639	0.421
2013	2.293	1.196	1.998	2.702	1.027	0.622	0.425
2014	2.315	1.270	2.022	2.718	1.072	0.592	0.435
2015	2.328	1.371	2.057	2.787	1.101	0.619	0.429
2016	2.327	1.286	2.100	2.853	1.102	0.530	0.388

2017	2.367	1.117	2.116	2.905	1.110	0.556	0.328
2018	2.438	1.168	2.141	3.013	0.990	0.501	0.307
2019	2.515	1.208	2.235	3.175	1.039	0.465	0.284
2020	2.681	1.051	2.401	3.450	1.098	0.478	0.297

Source: Adapted World Development Indicators (OECD, 2021)

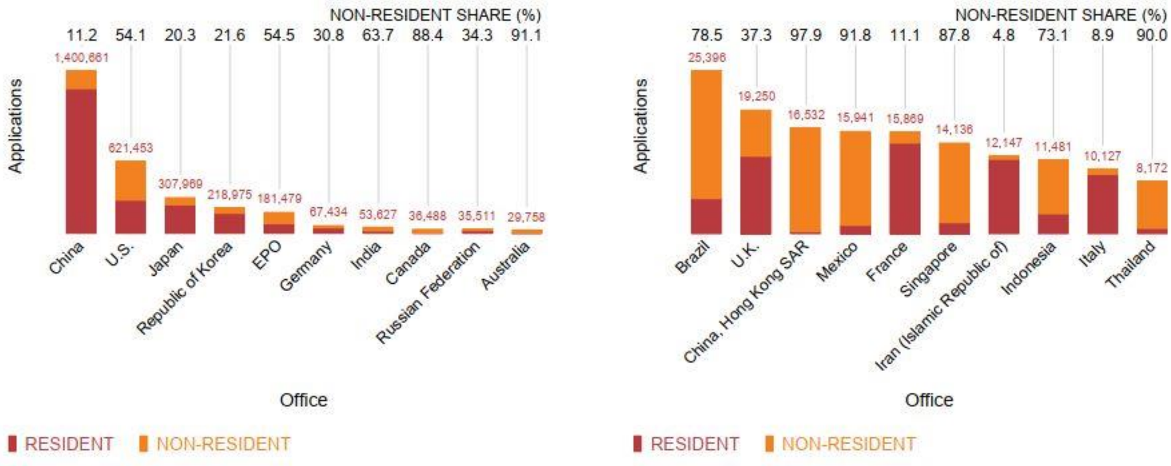
Despite the importance and relations between the constant flow of Foreign Direct Investment (FDI), innovation, and expenditure in R&D, the majority of the Multinational Enterprises' (MNEs) R&D is still performed in the home country, for example, in 2016, only 43% of MNEs planned to spend more than one-fifth of their R&D budget abroad (UNCTAD, 2021). Only a few developing countries manage to receive a significant portion of investments, the BRICS economies being the most notorious examples, as they have succeeded in attracting a growing share of innovation investments (WIPO, 2019, 2020).

It is also important to look at the data regarding one of the fundamental innovation and invention indexes, the ones related to patent deposits and granting around the world. The annual report from the World Intellectual Property Organization affirms that globally, in the year 2019, around 3.2 million patent application requests were deposited and this represents a 3% decrease in the total amount when compared to the year before (3.3 million deposits). It is the first observed reduction in volume since the financial crisis between 2008 and 2009, when the decrease reached almost 3.8% (WIPO, 2019, 2020).

The largest office that receives requisitions and makes concessions of patent ownerships around the globe is the China National Intellectual Property Administration (CNIPA), with numbers as high as 1.400.651 deposits in 2019, representing approximately 43.8% of the world total (WIPO, 2020). In second place overall, but far in absolute terms, lies USA's office called the United States Patent and Trademark Office (USPTO), with 621.453 requests in the same year being discussed, in other terms, 19.4% of the world total. To complete the five more relevant offices, it is worth mentioning the Japanese Patent Office (JPO), the Korean Intellectual Property Office (KIPO), and the European Patent Office (EPO), which occupy the third, fourth, and fifth places, respectively.

Although these five top offices represent together around 84.7% of all the requests globally, it is important to emphasize that the Brazilian office still holds a prominent position in world terms, since historically it always is at the tenth or eleventh position overall in the volume of requests, alternating with the Australian office (WIPO, 2020). Specifically in the year 2019, Brazil received 25.396 deposits, which represents 0.8% of the global total, just as one can see in Figure 1.

Figure 1 – Patent deposits of the 20 largest offices in 2019

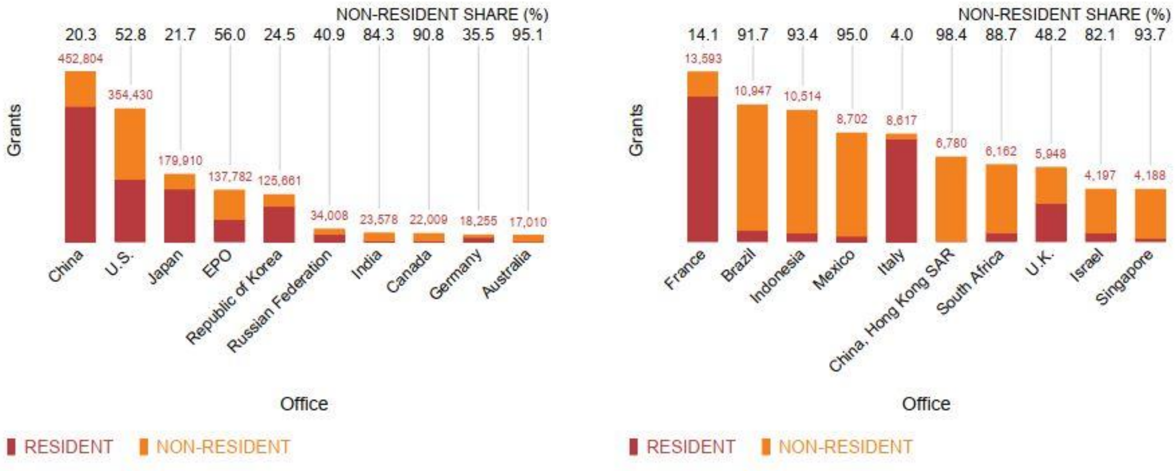


Source: (WIPO, 2020)

When the focus of the analysis is on the concession of patents, the order of relevance of the agencies responsible remains practically the same, as one can see from the top five: SIPO, USPTO, JPO, EPO, and KIPO (WIPO, 2020). The only change that is worth mentioning is the inversion of fourth and fifth places between the South Korean and the European offices. During the years 2018 and 2019, Brazil remained in a solid twelfth position in the number of patent concessions, with absolute numbers of 9.986 and 10.947, respectively. A broader panorama of the 20 larger patent offices in 2019 can be observed in Figure 2. Notwithstanding, it is necessary to mention that the national panorama suffers from a lack of resident deposits, as one can see in the same aforementioned figure since the non-resident share represents an incredible 91.7% of the total deposits.

Nevertheless, patents, in general, can be divided mainly into two fundamental groups, each with its specific characteristics, denominated “invention patents” and “utility models” (INPI, 2018). The Industrial Property Regulation (BRAZIL, 1996) establishes prerequisites and different monopoly protections for these two distinct subcategories, as well as different values of monthly fees to be paid by the proponents during the analysis process to grant the industrial property status to the innovation. So, this research needs to understand the primary distinctions between invention patents and utility models (INPI, 2021c).

Figure 2 – Patent concessions of the 20 largest offices in 2019



Source: (WIPO, 2020)

According to INPI's Economic Business Council (Assessoria de Assuntos Econômicos – AECON), an invention can be described as a new solution to a specific technical issue, circumscribed in a given technological field (INPI, 2021c). Still, in compliance with the same institution, these inventions can be protected by Invention Patents (IP) if they fulfill three basic requisites, which are: novelty, inventive activity, and industrial application. Nonetheless, as the protocol posited by the autarchy, the patent request remains under secrecy for eighteen months, after being submitted and approved in the preliminary formal exam (MCTIC, 2019).

After that entire time, the request is published in the weekly Industrial Property Magazine (Revista da Propriedade Industrial – RPI) and the depositor needs to request the patent analysis. The final decision about the exam itself can be acceptance or refusal and, if the outcome is positive, the patent rights remain active for 20 years, counted from the deposit date on. It also cannot be inferior to 10 years as of the concession date (INPI, 2021b). The Utility Models (UM), on the other hand, are used to outline an item, or a part of it, of practical use and that presents a new disposition, shape, function, or general form. This definition also requires that the invention entails an inventive act, which is less complex than the element "inventive activity". Lastly, a utility model also needs to result in a practical betterment of the application to which it was originally designed (INPI, 2021b).

The concessions of UM are also different from the IP for a series of other facts, for example, the former refers only to products, not processes, and the exam and yearly fees to be paid by the requestor for the deposit are inferior to the ones attached to the latter (INPI, 2021a). One last distinction is the UMs have 15 years of value, counted from the deposit date, and they remain active for more than 7 years from the concession time, that is to say, less than the IPs (INPI, 2018). There is also the case of the Certificates of Addition, which by definition are increments to invention patents, to improve or further develop them (INPI, 2021c). By the differences described above, this research defines Invention Patents as high-intensity inventions, as well as Utility Models and Certificates of Addition as low-intensity inventions.

1.2.2. Intellectual property in Brazil

In general, intellectual property is a theme of rising importance to Brazil inside its territory and also in terms of globalization, since a vast majority of the assets of the most valued companies nowadays in the world are intangible, such as technologies and patents (PEIXOTO; BUAINAIN, 2021). Besides that, the country remains a signatory of mainly two of the international treaties about patents, which favors its insertion in several technology-transfer bilateral or multilateral agreements, or other relevant innovation discussions at an international level (MCTIC, 2019).

The first quotable one is called the Patent Cooperation Treaty (PCT), in which Brazil is a participant since 1978. This multilateral agreement allows an interested party to require patent protection in several different countries simultaneously. In addition, it's worth stressing that, since 2009, Brazil has been acting through INPI on this treaty as an International Authority of Inquiry and also as an International Authority of Preliminary Exams.

The second international treaty is the Strasbourg Agreement, created in 1975, through which all the technological areas to classify the new patents were specified. The set of categories consolidated back then is denominated International Patent Classification (IPC) and it is nothing less than a hierarchical symbol system that allows the subdivision of innovations and the organization of industrial properties at an international level.

Patents are not only considered a very important technological innovation index in any context and a good measure of highly relevant scientific production (MORAIS, 2014), but they also represent a significant percentage of all intellectual property deposits and requests nationally. This data refers to residents and non-residents of the country, in other words, the former means requests that stem from other nations. Just for the sake of comparison, in the year 2019, the number of deposits registered by INPI were 25.396 invention patents, 2.823 utility models, 6.432 industrial designs, 245.154 commercial brands, 577 technology contracts, 16 geographic indications, 3.049 computer programs, and only three integrated circuit topographies (INPI, 2021a).

Within the context of innovation and invention production at a national level, one can observe that the volume of patent requests from the state of São Paulo is very high when compared to the rest of the country. According to INPI's biennial last report, the aforementioned state generated around 29.4% of the Invention Patent requests, that is to say, 1.604 requisitions. This sum places São Paulo at the first spot in terms of patent deposits, followed by Minas Gerais (11.7%) and Rio de Janeiro (9.8%), whose added productions do not ever reach the same as the first place, just as one can see in Table 2.

A similar panorama draws itself on the Utility Model patent concessions in the same year mentioned before since it is shown in Table 3 that the state of São Paulo also featured in first place in this kind of technological production. There were 984 requests, representing 35.7% of resident deposits received by INPI during the entirety of 2017. In this category, the difference between the first and the following places is even larger, as it is necessary to cluster together with the three subsequent states so the number of requests can get close to the percentage reached by São Paulo alone. The states that occupy the second, third, and fourth places are Paraná (12.1%), Rio Grande do Sul (10.8%), and Santa Catarina (9.2%).

Table 2 – Invention patent requests by state of origin in 2019

Position	State	Number of Patents	% Of patents	Δ (2019/2018)
1	São Paulo	1604	29,4	3%
2	Minas Gerais	639	11,7	10%
3	Rio de Janeiro	533	9,8	40%
4	Paraná	443	8,1	6%
5	Rio Grande do Sul	438	8,0	8%
6	Santa Catarina	403	7,4	24%
7	Paraíba	236	4,3	15%
8	Pernambuco	133	2,4	-11%
9	Bahia	128	2,3	29%
10	Goiás	118	2,2	39%
	Other states	790	14,5	2%
The sum of patents requests by Brazilian residents		5.465	100	10%

Source: AECON – (INPI, 2021a)

To the authority of the Statistical Data Bank about Intellectual Property (BADEPI), when the technological innovation production is separated by municipalities, mainly when one analyses patent requisition, there is again a significant edge observed in the data from cities located in the state of São Paulo. In 2017, the last year with an official ranking available, among the ten best places of origin for invention patent requests there is the city of São Paulo, with 631 deposits (11.5%), and also Campinas, with 208 deposits (3.8%), occupying the first and fifth places, respectively. When the topic is utility model requests, the situation is similar, as São Paulo is in the first place, with 380 deposits, and Campinas is in sixth place, with 54 deposits (1.9%).

Table 3 – Utility model requests by state of origin in 2019

Position	State	Number of Patents	% Of patents	Δ (2019/2018)
1	São Paulo	984	35,7	16%
2	Paraná	334	12,1	20%
3	Rio Grande do Sul	297	10,8	13%
4	Santa Catarina	253	9,2	-3%
5	Minas Gerais	247	9,0	-8%
6	Rio de Janeiro	175	6,3	7%
7	Bahia	63	2,3	-3%
8	Goiás	59	2,1	40%
9	Espírito Santo	55	2,0	8%
10	Distrito Federal	38	1,4	-3%
	Other states	251	9,1	17%
The sum of Utility Models requested by Brazilian residents		2.756	100	11%

Source: AECON - (INPI, 2021a)

Besides, it is fundamental to highlight the role of educational institutions, such as universities, faculties, and research centers, in the generation of innovations, since they represent ten out of the eleven biggest requestors of invention patents in the year 2020. Amongst these ten universities, all of them are public, just as seen in Table 4. Three of these centers are from the state of São Paulo, occupying the fifth, seventh, and eighth positions. The total number of patents deposited by these three universities is 156 patents, representing a percentage of almost 3% of the entire sum. The names of these centers are Universidade Estadual Paulista Julio de Mesquita Filho (UNESP), Universidade de São Paulo (USP), and Universidade Estadual de Campinas (Unicamp).

Table 4 – Ranking of the invention patent resident depositors in 2020

Position	Name of the Institution	Number of requests	% Of Patents
1	Universidade Estadual de Campina Grande	96	1,82
2	Petróleo Brasileiro SA Petrobras	79	1,50
3	Universidade Federal da Paraíba	74	1,40
4	Universidade Federal de Minas Gerais	63	1,19
5	Universidade Estadual Paulista Julio de Mesquita Filho	55	1,04
6	Universidade Federal de Pernambuco	55	1,04
7	Universidade de São Paulo	51	0.97
8	Universidade Estadual de Campinas	50	0,95
9	Universidade Federal de Pelotas	38	0,72
9	Universidade Federal de Uberlândia	38	0,72
9	Universidade Federal do Paraná	38	0,72
The sum of innovation patents requested by residents		5.281	100
The sum of innovation patents requested by residents and non-residents		24.339	

Source: AECON - (INPI, 2021a)

All these data presented corroborate the idea of educational institutions' relevance, giving them a well-deserved role in the universe of scientific creations and innovations in Brazil. Moreover, the ranking displayed in Table 4 also demonstrates the public policies and programs important to lever Science and Education for a country as a whole. Furthermore, it can be said that the study of possible correlations between regional capacities, FDI, and level of technological innovation in the state of São Paulo can be very representative of the general relations inside the Brazilian territory since the patent production of that area is very significant of the whole resident production in percentage terms.

Holistically, it is possible to conclude that the potential of an efficient application of public policies to the national development via the concession of industrial properties is immense, as the utilization of the tech information contained inside the patent descriptions can increase the competitiveness of national companies in their industry segments and also accelerate the general process of technological innovation (MORAIS, 2014). To quote one example, one field research made by INPI in 2016 named Tech Radar (Radar Tecnológico) found among the main results that, from almost 36.000 patent documents in total published around the world between 2009 and 2013 about plague control, 76% did not have patent solicitations in the Brazilian office.

This means that approximately 27.000 patent documents of only this specific area of knowledge could have been developed in the national territory without any cost in royalties to the creators of the innovations, in other words, without violating a single property right. This represents a latent capacity not harnessed and has endless possibilities, so it is another reason why this research will direct its efforts to the study of correlations involving the production and application of technological innovations inside the national territory.

1.2.3. Existing knowledge and literature gaps

After a thorough bibliographic review, it was possible to build a panorama of the existing research in the Geography of Innovation field of study. Mainly the data banks used as a reference for the searches were SciELO, Web of Science, and Scopus because together they contain a very significant portion of the relevant academic studies for the area of Geography of Innovation. The aforementioned research was made using terms such as patent, regional capabilities, foreign direct investment (FDI), Brazilian regions, and innovation intensity. The focus of the selection of articles was on studies oriented to the relations inside the national territory or that at least contained Brazil as one of the elements of the comparisons made.

Among the most pertinent papers found, some researchers (VIANA et al., 2018) aimed to understand which is the contemporary dynamic of the technology transfer between the knowledge produced at universities and its respective industrial applications in the companies, since the educational institutions are entities that individually create more technology in Brazil. As a result, the academics concluded that the transference of intellectual property along the university-industry axis is still incipient, and just a small percentage of the patents is effectively used in the Market.

Another relevant study (CHAKRABARTI; BHAUMIK, 2015) had a goal to analyze the technological development process in Brazil as a whole with a point of view stemming from the national patent creation data and comparing it to what is done in the rest of Latin America and the Caribbean, as well as to the ten largest Asian economies. However, that investigation used as a dataset the number of patents deposited by residents of the aforementioned countries in the US-American Office (USPTO). The specific criteria adopted was that at least one of the inventors needed to be from the country considered relevant. That study, nonetheless, does not include the patent requests by Brazilians in the national office (INPI) for evaluation.

Moreover, on the method of comparative analysis, another pertinent paper to be quoted had its center of attention on the results given by the implementation of policies in fields such as innovation, technology, and science for a few countries considered globally as being “in development”: Brazil, India, China, South Korea, South Africa, and Iran. The authors categorized the policies into three main areas, which are the influence of the existing institutional structure, the national competitive advantage, and the international role performed by these countries in the world’s process of technology creation. The elements mentioned vary from country to country and need to be taken into account when new policies are discussed to encourage innovation in general.

Besides all that, another study evaluated the national policies implemented to attract Foreign Direct Investments (FDIs) more specifically to the Research and Development of several market segments (ZANATTA et al., 2008). The strategies implemented in Brazil were analyzed together with the ones in China, India, Israel, Ireland, Singapore, and Taiwan so that the theoretical base of comparison could have successful experiences among them. The research made clear that the most important factor to attract FDI is the selection, continuity, and coordination of national policies.

To counterbalance the possible FDI benefits described so far, some of the studies also affirmed that not all the results in society or companies are necessarily positive (BIRD; CAHOY, 2008; SALAMA; BENOLIEL, 2008). These researchers made a panorama of the patenting impacts of new technologies linked to external investments, mainly centered in the pharmaceutical industry which, given the current pandemic context, made the results even more relevant than when they were conducted. The first research is more focused on the Brazilian case specifically and the second one encompasses a wider panorama of the importance and impact of patent breaking in some countries such as Brazil, Argentina, Mexico, and Chile, among others.

Other academics, on the other hand, conducted research with the finality to study the panorama of the innovation produced available in a single database, to detail what are the characteristics of the patents deposited at INPI and indexed to the Derwent Innovations Index (MOURA et al., 2019). The result obtained by them was that, when comparing resident and non-resident depositors, the multinational enterprises (MNEs) prevail, specifically in creations linked to areas such as Health, Information Technology, and Electronics. This foments the debate in which some academics affirm that resident innovation should be more encouraged by structured projects and policies.

Some of the authors developed research with a single chosen industrial segment as the focus, for example, the sector of ionic liquids in Brazil, which inside a broader panorama serves as an input to several processes of the chemical industry (SPEZIALI; SINISTERRA, 2015). Another author chose to investigate if the pharmaceutical sector contributes to national development through the production of new knowledge. This last research concluded that the current normative patent structure doesn't offer alternatives to the monopoly as a foment to innovation and is more prejudicial than beneficial to the whole panorama, thus suggesting the elaboration of alternative models which would coexist (ROSINA, 2011).

It is still worth mentioning that another part of the studies encompassed, in their objectives, specific elements, such as the analysis of possible impacts that new technologies have on some social segments. A good example is one research in which the repercussions and possible applications of assistive technologies are the focus, using as input patent data (SILVA et al., 2018). Furthermore, some investigations had under scrutiny the role of educational institutions in the production of innovations in Brazil, some of them restricting the evaluation to a geographical region or state (AMADEI; TORKOMIAN, 2009; MUELLER; PERUCCHI, 2014). To conclude, there were researchers worried about the impacts that spillovers from technological innovations have on issues such as inequality and environmental destruction, to evaluate the efficiency these creations have in tackling these problems (DOWBOR, 2009).

More results of specific studies with a focus on different aspects of patents and their interaction with companies and society were found, but none of them had a detailed geographical analysis of the national technological production in terms of innovation, FDI, and regional capacities in a regional level, in other words, states or municipalities. The existing research in the current academic field either involves comparisons between the Brazilian situation on some aspect, optic, or approach and other geopolitically relevant countries, or they are only concerned with the country's situation as a whole, without detailing by region. All these situations highlight even more the relevance of determining this research's objectives as described in the following subsections.

1.3. RESEARCH PROBLEM AND GOALS

1.3.1. Research questions and objectives

Just as demonstrated in the previous subsection, there is an area very relevant, but quite neglected in the academic literature when it comes to the production of technological innovations inside the national Brazilian territory. This occurs more specifically regarding the patent creation at a regional level of detail and its possible correlations with regional development indexes mapped mainly by the Economic Applied Research Institute (Instituto de Pesquisa Econômica Aplicada – Ipea).

The measurement of regional capabilities involves indicators such as tax indexes and the quality of life of the population in general, for example, the level of local employment in all the industrial segments. The general objective of the entire research is to establish if FDI can explain the behavior of high and low-intensity inventions and to determine which socioeconomic indexes are relevant to control the statistical regression, both at a state level (São Paulo) and a national level, in other words, for the entire country.

The main objectives of this investigation are two, the first is to determine if foreign direct investment (FDI) is a catalyst to the innovation factors at a regional level in Brazil, more specifically in the state of São Paulo. The second is to investigate if the regional absorptive capacity is a good moderator within the national context in Brazil to explain variations of innovation indexes.

Therefore, the main research questions to fulfill these objectives must be formulated as follows: "Areas that receive more FDI present a higher incidence of innovation?" and "Areas with higher regional absorptive capacity innovate more?". Those questions will be dismembered among three distinct sets of hypotheses, with pertinent variables chosen to represent each piece of information necessary to answer them satisfactorily. Therefore, in short, the current study aims to understand if the capital flow from MNEs helps to develop more innovation in a region controlling for the relevant socioeconomic indexes, as well as studying which is the role of regional absorptive capacity in this environment.

1.3.2. Restrictions

Some key limitations directed the researcher's choice for the analysis to be restricted to the state of São Paulo. These restrictions invariably encompass the limitations inherent to the database and additional information used in the statistical analyses of Chapter 2. Despite the information being detailed at a regional level, the FDI is only considered for the municipality that directly exports the goods, which does not account for the transportation of these products that eventually occurs internally to the country and goes from one municipality to another.

Besides, due to the availability of all the data needed for the pertinent variables, the period adopted is limited to only seven years (2010-2016). It is worth mentioning the complexity of the research since only the municipalities of São Paulo already sum up to 645 different regions. One more constraint is the focus of the investigation being solely on patents, not considering other types of intellectual property such as trademarks, copyrights, and trade secrets. The last identified restraint is the lack of detailing of the patents in their categories according to the International Patent Classification (IPC – WIPO).

1.3.3. Hypotheses and propositions

With the questions and research objectives all set, it was possible to formulate the initial propositions to orientate the analyses of the pertinent phenomena. There are five sets of hypotheses in this research, each one of them encompassing the null (H_0), which is the natural hypothesis put under statistical scrutiny, and the alternative (H_1), which is built based on the scenario not encompassed by the first supposition (MOTA; NOBRE, 2016).

These hypotheses are explained and justified throughout subsection 2.2, and their respective dependent, independent, and control variables are detailed in subsection 2.3.2, as well as the modeling and estimation strategy relevant to each situation in subsection 2.3.3. Nonetheless, they are summed up as follows:

- H1: MNEs tend to foster the innovation environment at the host.
- H2a: MNEs tend to foster more high-intensity innovation at the host.
- H2b: MNEs tend to foster more low-intensity innovation at the host.
- H3a: The MNEs' high-intensity innovation nexus is moderated by regional AC.
- H3b: The MNEs' low-intensity innovation nexus is moderated by regional AC.

1.4. MOTIVATION

The current research will be pertinent to complement the specialized literature since it will add to the amount of investigation already done in the field of Geography of Innovation through a Production Engineering optic. This area of knowledge is still incipient when it comes to detailed investigations of the Brazilian territory. That is why new research can be done following an equivalent methodology to evaluate the correlations established here in other states in Brazil, or to develop even further consolidated analyses. One example of how this could be done is an investigation focused on determining which technological areas of innovation are more relevant to the concrete development of the regions according to the categories present in the International Patent Classification (IPC).

In addition, the results could be used as valuable data inputs for the elaboration of public policies, since the pretension of the research is to constitute correlations among innovations' production, direct foreign investments, and territorial indexes. Once the kind of interactions and influences these elements have on each other are established, it is possible to determine priorities of action so they can provide directions for politicians, lawmakers, and public institutions in general. That way structural projects and policies can be formulated to boost territorial indexes of specific municipalities, states, or even the entire country so that the population's wellness could be improved and the social inequalities diminished.

Finally, it is worth mentioning that the results and observations provided can also be used as sources for studies by educational institutions and private companies so they reflect and also take action upon their role inside the relations described, as generators of technological innovations. Consequently, goals could be set and managerial or administrative decisions could be taken grounded on facts and statistical conclusions, so these entities would be able to produce even more relevant knowledge at a national and international level.

CHAPTER 2: MNES AND REGIONAL INNOVATION INTENSITY - EVIDENCE FROM BRAZIL

ABSTRACT

Foreign direct investment (FDI) has been seen by the literature as an influential factor in the technological evolution of host-countries innovation ecosystems, with several developing nations such as Brazil aiming to attract FDI as a way to potentialize their development through innovative output. However, the evidence on whether FDI configures a source of positive or negative influence on regional innovation capabilities is definitely mixed. Furthermore, despite the existence of studies regarding emerging economies, there is a gap when it comes to the regional level in Brazil. We intend to contribute to the literature by examining whether regional MNEs are inducing high or low-intensity innovations in this last context. Thus, this study aims to complement academic investigations by analyzing the influence of multinational enterprises (MNEs) on regional innovation intensity in Brazil in the state of São Paulo using a unique regional-level FDI database in a panel ranging from 2010 to 2016. The results indicate that the presence of MNEs boosts the production of high and low-intensity inventions, slightly more for the latter than the former. In other words, FDI is better for the production of inventions in general, which can later become innovation, but even more so for utility models and certificates of addition. These findings corroborate with various regression specifications and alternative estimation methods explored throughout the academic literature while remaining robust to endogeneity issues.

Keywords: MNEs, regional innovation, patents, Brazil.

RESUMO

O investimento estrangeiro direto (IED) é tratado na literatura como um fator influente na evolução tecnológica dos ecossistemas de inovação dos países receptores do fluxo de capital. Várias nações emergentes, tal como o Brasil, buscam atrair IED como uma forma de potencializar os seus respectivos desenvolvimentos nacionais por meio da produção de inovações. Contudo, a evidência científica se esse aporte de verbas por meio de suas avenidas configuram uma fonte positiva ou negativa de catálise para as capacidades de inovação regional definitivamente é ambígua. Ademais, apesar de existirem estudos sobre economias emergentes, são escassos aqueles que estudam o caso brasileiro, principalmente com detalhamento regional. Por isso, o presente trabalho busca avaliar se o IED regional induz a produção de inovações de alta ou baixa intensidade, por meio da análise da influência de empresas multinacionais (EMNs) na intensidade de inovação regional no Brasil, mais especificamente no estado de São Paulo. Faz isso utilizando uma base de dados única a nível regional com um painel que vai de 2010 a 2016. Os resultados indicam que a presença de EMNs impulsionam a produção de inovações de alta e baixa intensidade, com um pouco mais de relevância no segundo caso. Em outras palavras, o fluxo de IED é melhor para a produção de invenção no geral, que pode posteriormente tornar-se inovação, especialmente para modelos de utilidade e certificados de adição. Esses resultados corroboram várias especificações de regressão e modelos de estimação alternativos existentes na literatura, ao mesmo tempo que permanecem robustos à questões de endogeneidade.

Palavras-chave: EMNs, inovação regional, patentes, Brasil.

2.1. INTRODUCTION

The literature presents Foreign Direct Investment (FDI) as a catalyst for national economic development since it's able to stimulate native investment, facilitate technology transfers, and increase human capital development (HAQ, 2022). Accordingly, the interplay between FDI inflows and the absorptive capacity of native firms tends to configure an essential element for the development of national innovation ecosystems (KHACHOO; SHARMA; DHANORA, 2018; ZHENG et al., 2020).

Multinational companies' (MNEs) potential impact within the host country regarding technology transference, are the objects of investigation with mixed results throughout the academic literature concerning both developed and developing economies (SARKER; SERIEUX, 2022; ZIA et al., 2021). All in all, according to the 2005 World Investment Report, elaborated by the United Nations Conference on Trade and Development, at least 2156 regulatory changes were carried out in investment regimes (UNCTAD, 2005), being almost the entire sum (93%) favorable to FDI inflows, indicating that governments are recognizing the presence of MNEs in a given sector a factor able to boost the productivity of domestic firms through the transfer of knowledge or new technical and managerial know-how (WOOSTER; DIEBEL, 2010).

In this context, Foreign Direct Investment (FDI) is increasingly seen as an important source for achieving greater and faster economic growth and technology accumulation in many developing countries (BASKARAN; MUCHIE, 2008). There have been studies regarding the impact on economic growth, its contribution to technology diffusion and human capital formation in the local economy, the factors that determine different levels of the flow of FDI to different emerging economies, trade and technology development, and its costs and benefits (GROSSE, 2019a).

The application of FDI in emerging countries, especially BRICS countries, is an important factor in the forming of the further strong, steady, and balanced rise of the national economies based on innovations, as well as their better integration into the world economy (ALI et al., 2022; GUSAROVA, 2013). The development of scientific and technical potential is promoted by the increasing investment's role as the catalyst of scientific research. However, the literature regarding the presence of MNEs and their respective influence on regional innovation output at the subnational scale is still underinvestigated. This area is mostly neglected for emerging economies because of the difficulty to obtain official data, which is fundamental to the establishment of a reliable database and, therefore, grounding subsequent investigations.

Nonetheless, emerging economies are currently a force to be recognized on a global market scale, both in terms of the volume of goods exported and the attraction of MNEs in general (ARBIX; MIRANDA, 2017). Brazil still occupies a position of relevance worldwide as one of the fifteen largest economies, with a GDP of USD 1.608 trillion and an FDI inflow of approximately USD 46.8 million. The sum of these investments represents a significant increase when compared to the GDP of 37.8 million from the previous year (2020) which, in its turn, characterizes an abrupt fall of 45% in comparison to the value of USD 69.2 million received in 2019 (DE NEGRI, 2021).

Thus, considering the aforementioned framework, this study argues that MNEs will have an impact on the invention and consequently innovation intensity in the host region. That doesn't mean just the host country, since this investigation scrutinizes the data for Brazilian municipalities. More broadly, this should answer the following inquiry: "Do MNEs generate regional innovation in Brazil? If yes, then how?". It is important to stress that MNEs influence on local innovation may not be spontaneous, as we state that this phenomenon tends to occur mainly through three avenues according to the innovation management literature: the internationalization of R&D, reverse knowledge transfer (RKT), and horizontal or vertical spillovers (BRUHN; CALEGARIO, 2014; FIGUEIREDO; LARSEN; HANSEN, 2020).

The first avenue is the internationalization of R&D. The relation between this phenomenon and innovation by multinational enterprises (MNEs) has undergone a gradual and comprehensive change in perspective over the past 50 years. Nowadays, scholarly research pays increasing attention to the network-like characteristics of international R&D activities and different streams of literature have emphasized the role of location-specific factors in R&D internationalization (PAPANASTASSIOU; PEARCE; ZANFEI, 2019). It is also important to state that both economic and business literature have paid ample attention to the location factors which affect R&D internationalization.

The second avenue is the RKT. With knowledge recognized as a key source of competitive advantage for organizations, especially in the context of global organizations, its importance has been recognized in multiple theoretical frameworks that have been proposed to explain the functioning of modern MNEs (GRANT, 1996). Large-sized corporations tend to be more fragmented, in the way that foreign subsidiaries are not simply recipients of knowledge from the headquarters, but are active participants in knowledge creation (SCALERA et al., 2014). This also generated the concept of reverse knowledge transfer (RKT), with conclusions such as that subsidiary age is an important determinant of the parent company benefits from RKT, with older subsidiaries being more important due to the cultural and processual nuances absorbed by them from the host country (RABBIOSI; SANTANGELO, 2013).

The final avenue relates to the occurrence of horizontal and vertical spillovers (MARCIN NAPIÓRKOWSKI; WERESA, 2018; QU; WEI, 2017). Despite being rare, in some cases, MNEs presence produces horizontal spillovers by pressuring native companies to innovate since the former tend to be technologically and managerial superior. Thus, local businesses will need to catch up to avoid losing market share because of their productivity gap (KHACHOO; SHARMA, 2016; LI; SUTHERLAND; NING, 2017).

Similarly, vertical spillovers can occur backward within supply chains through a deliberate transfer of knowledge, therefore catalyzing a positive effect throughout the supply chain linked related to the MNE's capital flow, but sometimes these spillovers tend to fade after a certain amount of time (NGUYEN; LUU; DO, 2021; RAHIM; MALEK; PALIL, 2014; ROJEC; KNELL, 2018; WANG; ZHAO, 2008).

Positive vertical spillovers are relatively common because greenfield or acquired affiliates normally demand certain procedural standards from suppliers and buyers. In other words, product and process innovations tend to spread throughout the supply chain when a multinational enterprise (MNE) installs itself in the host country (BETIM et al., 2018; BRUHN; CALEGARIO, 2014). These results were true also for studies with a focus on Brazilian industries only, with evidence of both positive and negative effects from FDI on national industries' productivity coexisting (BRUHN; CALEGARIO, 2014).

Likewise, we follow some studies that highlight the importance of geographical proximity regarding the process of technology transfer that triggers productivity spillover from the presence of MNEs (HAMIDA, 2013; WANG; WU, 2016; XU; SHENG, 2012b). Indeed, in the scope of proximity, some studies have focused on an industrial niche, such as the processing industry (BRUHN; CALEGARIO, 2014) or biotechnology (FIGUEIREDO; LARSEN; HANSEN, 2020). Others have investigated the effects of public-private partnerships as mechanisms to encourage MNEs to boost regional innovation while the geography of corporate innovation or the strategies of knowledge transfer among the headquarters, subsidiaries, and their surroundings are research topics as well (ERVITS, 2018; GROSSE, 2019a; LOPEZ-VEGA; TELL, 2021; PALADINI; GEORGE, 2019).

In this context of technological transference, the amount of importance regarding the concept of absorptive capacity (AC) of local firms is a relevant topic of investigation in the specific literature as well. Thus, native firms with high AC would be able to exploit knowledge coming from the multinational subsidiaries. Generally, high levels of AC will speed up productivity spillovers from multinationals in the region in which the MNE takes place. (GIRMA, 2005).

Because of the contradictions posited by dissonant investigations (KHACHOO; SHARMA, 2016; LI; SUTHERLAND; NING, 2017; MARCIN NAPIÓRKOWSKI; WERESA, 2018; QU; WEI, 2017), it is relevant to adopt a proxy for an innovation panorama of the country's situation when it comes to industrial innovation, using deposited patents in the case of this study to follow other examples from the specialized literature (HAO et al., 2020; HAQ, 2022; KHACHOO; SHARMA, 2016; LEE; LIU; YANG, 2021; WANG; WU, 2016). However, we claim that within the scope of an emerging economy such as Brazil, MNEs may seek location-specific advantages in the host country such as infrastructure, cheap labor, market size, or a tax heaven (DRIFFIELD et al., 2021; DZIEMIANOWICZ; ŁUKOMSKA; AMBROZIAK, 2019; LI et al., 2018a; VILLAVERDE; MAZA, 2015), hence undertaking the bulk of its innovative activities at his home-country, therefore relegating only low complexity R&D at the host. Accordingly, it is necessary to distinguish the R&D activities between two groups, the first one being invention patents (high-intensity inventions) and the other one comprising utility models and certificates of addition (low-intensity inventions).

Hence, such dynamics lead us to formulate the following question: Do MNEs provide more innovation of high or low technological intensity in the receiving region? In this sense, our study seeks to contribute to the literature in two ways. First, is investigates the aforementioned relation between MNEs' presence and regional innovation in an important developing economy. Second, to the best of our knowledge, the issue of technology intensity within the MNEs and regional innovation nexus has not been addressed.

Our study employs a unique FDI database to account for the regional MNEs presence in Brazilian municipalities that were employed in recent studies (ALI et al., 2022; MORALLES; MORENO, 2020; ONODY et al., 2022; POLLONI-SILVA et al., 2021, 2022; ZONTA; AMAL, 2018). Implications for policymakers, and practitioners overall, as well as contributions to the academic literature, are displayed in the conclusion section.

2.2. THEORETICAL BACKGROUND AND HYPOTHESES DEVELOPMENT

Innovation is one of the most important competitive advantages of the 21st century (CHATZOGLOU; CHATZOUDES, 2018; KIRCA, 2012; NADER, 2015). Countries, as well as companies, are interested in stimulating more innovative activity and benefitting from the outcomes, such as income, jobs, profits, and prestige, among others. In this context, the FDI is one of the most important tools to foment innovation in host countries, a practice made possible mainly by MNEs from emerging or advanced countries.

Many academic investigators or people responsible for the elaboration of policies (policymakers) identify this capital flow from MNEs as one of the main economic growth instruments, with the effect of transferring technologies and other benefits to the economy of its host countries (DINH et al., 2019; OLOROGUN; SALAMI; BEKUN, 2020; SIVALOGATHASAN; WU, 2014; SOHAIL; MIRZA, 2020). They claim that the production processes are enhanced directly or indirectly by the presence of multinational enterprises, but another set of researchers posits evidence that there is a decay of environmental conditions in the surrounding communities that could be even higher than the financial earnings (DEMENA; VAN BERGEIJK, 2019; HU et al., 2021).

Nonetheless, there is also a sector of environmentally friendly inventions or innovations, the so-called green innovation, that tries to improve the quality of the environment in host countries through the implementation of clean technologies (AL-MULALI; TANG; OZTURK, 2015; GUO et al., 2021). Besides, MNEs are on several occasions comparatively cleaner than national firms when it comes to *green* management practices and more efficient in dealing with environmental challenges, which also depends on which country they come from (ABDOULI; HAMMAMI, 2017; RIVERA; OH, 2013). Not only that, but MNEs can direct their FDI specifically to renewable practices, such as energy, and the United Nations' 2030 agenda of Sustainable Development Goals encourages the capital flow in renewable energies (ALI et al., 2022).

In this context, FDI is determined mostly by three sets of advantages; (i) ownership advantages (trademark, production technique, entrepreneurial skills, returns to scale), (ii) locational advantages (existence of raw materials, low wages, special taxes or tariffs), and (iii) internalization advantages, in other words, advantages by own production rather than producing through a partnership arrangement such as licensing or a joint venture. The large market size is one of the necessary conditions to reach efficient utilization of resources and take advantage of economies of scale (SCAPERLANDA; MAUER, 1969; WANG; WANG, 2021). The consequence of MNEs to economic growth rests on the stability of the economy and its capacity to absorb new skills, managerial practices, know-how, and technologies in general (KOTRAJARAS; TUBTIMTONG; WIBOONCHUTIKULA, 2011).

Other elements which are also important to attract MNEs and motivate them to invest in a determined country, according to the specialized literature, involve higher grades of real per capita gross domestic product (GDP), an increasing volume of GDP, higher levels of educational achievements, decreasing population growth rates, broader government size, increasing levels of international commerce, lower inflation rates, higher levels of stock and financial market development and eventually lower country risk (DINÇ; GÖKMEN, 2019). Labor cost is another independent factor in the FDI function. Throughout discussions of the effects of labor cost on FDI, one may claim that relatively higher nominal wage, as other things being equal, deters FDI. Foreign investors normally are willing to follow low-cost opportunities in developing countries (GROSSE, 2019). Low costs in developing countries, on the other hand, might refer to other relatively higher costs than the labor cost such as transportation costs and low productivity (JHA; DHANARAJ; KRISHNAN, 2018).

As for the influence of exchange rate on FDI, relatively low prices in the host country might increase FDI inflows since firms can have more endowments and/or equipment through a weak exchange rate in the host country. The tax structure is one of the possible determinants of FDI among others. FDI has less willingness to move to countries with high taxes since tax is a cost factor reducing profitability. Moreover, within the literature on FDI, the country risk variable is another important factor to explain in movements in FDI flows.

A classical work of Schumpeter (SCHUMPETER, 1939) distinguishes between four different basic types of innovation, namely product, process, marketing, and organizational innovations. Recent evidence suggests that a sub-sample of firms engage and successfully introduce a combination of these four basic types, in other words, firms are not only innovating but also innovating with ‘complex’ innovation outcomes. This incorporates regional factors as an additional input to the knowledge production function as well. The specialized literature mainly reinforces the idea that location matters for innovation (FELDMAN; KOGLER, 2010; PORTER; STERN, 2001), particularly for the complexity of innovation outcomes.

Regions with higher positive agglomeration externalities, through knowledge spillover and labor matching mechanisms, seem to nurture firms’ ability to engage and successfully introduce a highly complex innovation outcome. Certain regional factors significantly affect the choice of firms to be complex innovators, such as (i) labor market thickness, (ii) specialized supplier thickness, and (iii) the extent of intra-regional knowledge spillover occurring in the region (KHAN et al., 2022; RYAN et al., 2021). For firms with less complex innovation outcomes, regional factors seem not to play a pivotal role. For these innovators, the 'usual suspects' factors such as internal resources and investment as well as formal collaboration with external partners have a significant role.

All studies that investigate correlations among innovation elements, ecosystems, indexes, and similar examples with geographical analyses are circumscribed in a relatively new area of knowledge, called the Geography of Innovation, which is around for approximately 30 years (ERVITS, 2018). Nowadays, there is some consensus surrounding affirmations propounded by the academic studies conducted, such as that innovation is spatially concentrated, as well as knowledge spillovers. The latter also are nuanced, pervasive, and not easily amenable to measurement (CLARK et al., 2018). Besides, according to the same authors, local universities are fundamental, but not sufficient for innovation, and geography analyses for different places often provide an efficient basis to organize economic activity.

2.2.1. The three avenues of knowledge transfer

MNEs generate a stable form of capital inflow to the host country, increasing the volume of capital stock and, by that, growth in the economy of the host country by financing capital formation equivalent to the results of domestic investment (DINÇ; GÖKMEN, 2019). It is important to stress that MNEs influence on local innovation may not be spontaneous, since this phenomenon tends to occur mainly through three avenues according to the innovation management literature: the internationalization of R&D, reverse knowledge transfer (RKT), and horizontal or vertical spillovers (BRUHN; CALEGARIO, 2014; FIGUEIREDO; LARSEN; HANSEN, 2020).

MNEs create technological improvements at the host trough intra and inter-industry spillovers. The former indicates that horizontal FDI influences active firms in the same sector through competition, demonstration, and labor circulation. The latter, on the other hand, has a profound impact on the innovative activities of supplying firms in the upstream sector of the industries through backward linkages (KHACHOO; SHARMA, 2016; LI; SUTHERLAND; NING, 2017). Another important aspect to take into consideration is if the MNEs are really innovating in the host countries or only doing R&D in their respective countries of origin, or even just implementing secondary or peripheral technologies through FDI.

In this context, there is also relevance in investigating negative horizontal spillovers since critical voices affirm that FDI may be a channel for technology transfer but it does not necessarily lead to innovation, or that the investment is a source of brain drain, hoarding most of the qualified labor force (MARCIN NAPIÓRKOWSKI; WERESA, 2018; QU; WEI, 2017). Because of these contradictions posited by the dissonant investigations, it is relevant to adopt a proxy for an innovation panorama of the country's situation when it comes to industrial innovation, using deposited patents in the case of this study to follow other examples from the specialized literature (HAO et al., 2020; HAQ, 2022; KHACHOO; SHARMA, 2016; LEE; LIU; YANG, 2021; WANG; WU, 2016).

The first avenue is the internationalization of R&D. The relation between this phenomenon and innovation by multinational enterprises (MNEs) has undergone a gradual and comprehensive change in perspective over the past 50 years. Nowadays, scholarly research pays increasing attention to the network-like characteristics of international R&D activities and different streams of literature have emphasized the role of location-specific factors in R&D internationalization (PAPANASTASSIOU; PEARCE; ZANFEI, 2019). It is also important to state that both economic and business literature have paid ample attention to the location factors which affect R&D internationalization.

Some studies have been carried out to understand the behavior of subsidiaries from Italy, Japan, Spain, France, and the U.S. towards less developed host countries, Brazil included (CHIARINI et al., 2019). Another branch of literature has been focusing on the internationalization of R&D by Brazilian multinational companies (BMNCs) towards other nations. One of the main exponents of this area of research had as some of the results that the companies have internationalized their product development encouraged by both market-driven and technology-driven (recruitment of qualified personnel, access to foreign talent, etc) factors. When compared to companies from developed countries, BMNCs perform internationalization of R&D activities presenting very similar trends and characteristics (GALINA; MOURA, 2013). Thus, it is possible to state that the R&D activities carried out within the local subsidiary are pushing innovation output at the host while creating local innovation capabilities in terms of infrastructure and human resources.

The second avenue is the RKT. With knowledge recognized as a key source of competitive advantage for organizations, especially in the context of global organizations, its importance has been recognized in multiple theoretical frameworks that have been proposed to explain the functioning of modern multinational enterprises - MNEs (GRANT, 1996). Large-sized corporations tend to be more fragmented, in the way that foreign subsidiaries are not simply recipients of knowledge from the headquarters, but are active participants in knowledge creation (SCALERA et al., 2014). This also generated the concept of reverse knowledge transfer (RKT), with conclusions such as that subsidiary age is an important determinant of the parent company benefits from RKT, with older subsidiaries being more important due to the cultural and processual nuances absorbed by them from the host country (RABBIOSI; SANTANGELO, 2013).

When it comes to RKT in MNEs and the links to subsidiary innovativeness, it is known that in a significant part of the literature on competence-creating subsidiaries, there is the implicit assumption that subsidiary-specific advantage is translated directly into a competitive advantage for the company (ANAND, 2011). This approach is called “social community” and contrasts with a view of the MNE as a structure in which subsidiaries act as self-interested agents serving a disconnected headquarters (MUDAMBI; NAVARRA, 2004). In reality, both forces are simultaneously at play (MUDAMBI; SWIFT, 2011), since MNEs can be seen as a differentiated network and their subsidiaries differ both in terms of the extent to which they are embedded in the local environment as well as in the corporate network.

Besides, two other relevant elements have an influence on the transference of information, one of them being the nature of the knowledge itself, given that by definition the content of the flow can be very complex. When that is the case, it sometimes is difficult for the recipients to acquire the material and especially to use it for organizational benefits (PÉREZ-NORDTVEDT; MUKHERJEE; KEDIA, 2015). At last, the role of MNE’s strategy in each company also influences a successful flow of knowledge, as not all companies give a fair level of autonomy to subsidiaries (AMBOS et al., 2018).

The final avenue relates to the occurrence of horizontal and vertical spillovers (MARCIN NAPIÓRKOWSKI; WERESA, 2018; QU; WEI, 2017). Despite being rare, in some cases, MNEs presence can pressure native companies to innovate since the former tend to be technologically and managerial superior. Thus, local businesses will need to catch up to avoid losing market share because of their productivity gap. MNEs will also raise the wages for some jobs in the industries, mainly when it comes to the technology sector (KHACHOO; SHARMA, 2016; LI; SUTHERLAND; NING, 2017). They also tend to attract qualified personnel, with an intrasectoral migration of skilled workers, urging national companies to search for new alternatives, which could lead to innovation and patent production (HALE; LONG, 2011; LIU et al., 2000).

Variables such as study design, model specification, data characteristics, and the choice of how to measure foreign presence significantly determine whether these studies fail or succeed in documenting spillover effects (GÖRG; STROBL, 2000). Results in both theoretical and empirical analyses suggest that the greater the size of the technology gap between multinational affiliates and domestic firms, the less beneficial FDI is for the host country

(NAKAMURA, 2002). Evidence of intrasectoral spillovers from FDI in developing countries is weak, at best, and specification error may be a problem in the pertinent literature.

2.2.2. MNEs and innovation in emerging economies

Among the emerging countries, BRICS (Brazil, Russia, India, China, and South Africa) are one of the most prominent exponents. They occupy a place of relevance in the geopolitical and economical arrangements and relations throughout the globe, making a considerable contribution to the entire world's development (ALI et al., 2022). Moreover, this group of countries comprises 41% of the world population, covers more than a quarter of the area of the globe, is responsible for 24% of all the nations' GDP, and comprehends over 16% share in the world trade in 2021 (BRICS, 2021). Not only that, but the flow of capital from MNEs into BRICS countries tends to increase continuously since between 2000 and 2018, the global FDI share increased from 6% to 19% (HAQ, 2022).

Location choice (LC) is core to the managerial decisions of MNEs when engaging in foreign direct investment (FDI). LC decisions in most cases are irreversible, or costly to alter, and hence affect the sustainable development of MNEs (DUANMU, 2012). LC is a complex decision, tightly linked to the decision-maker (individual/ managerial), firm (investing activity, ownership structure, internationalization stages, among others), and environmental context (home, host markets, and regional/supranational/networking environment) where the investment takes place (LI et al., 2018b).

Nevertheless, this context could be roughly simplified into two main reasons why entrepreneurial activities are carried out in emerging economies. Firstly, these countries tend to present a rise in the importance of market orientation and an expanding economy. The other reason involves the level of entrepreneurship being much higher in emerging economies than in developed ones, levered by less complex entry barriers and high levels of demand, particularly when it comes to the informal sector (OMRI, 2020). Furthermore, by the year 2050, it is expected that the economies of Brazil, China, India, and Russia (BRIC) will be more significant than that of France, Germany, Italy, Japan, the U.K., and the United States, which compose the G6 (WILSON; PURUSHOTHAMAN, 2003).

Multinational firms have traditionally carried out their core innovative activities – particularly industrial R&D – in the home country, with occasional extensions to Triad countries (BELDERBOS et al., 2013; REDDY, 2000). In the past few decades, MNEs have established R&D activities in emerging markets as well (EGAN, 2017; UNCTAD, 2021). Initially, these activities were mainly to adapt products and processes to local conditions in emerging markets. In recent years, core R&D itself has sometimes moved to emerging market affiliates, particularly in the very large markets of China and India (GASSMANN; HAN, 2004; YIP; MCKERN, 2014).

Nowadays one could classify overseas R&D by multinational firms as belonging to four categories (EGAN, 2017; JHA; DHANARAJ; KRISHNAN, 2018), i.e. (i) adapting products originally made elsewhere to local market conditions in the foreign country, that is, product development in the definition of the United States National Science Foundation (NSF); (ii) carrying out R&D that could be applied in the home country and elsewhere, because the cost conditions in the host country are favorable in comparison with those of the home country; (iii) carrying out R&D in a location where other firms in the same industry are doing R&D, to learn from the innovation environment; (iv) participating in a global network of R&D activity of the firm, based on costs, market features and the availability of knowledge and/or skills.

However, location-specific externalities, such as (unintentional) intra-regional knowledge spillover, which are associated with a certain regional milieu, are commonly inaccurate to explain the innovation of firms. Accounting for such location-specific factors is pivotal according to the regional innovation system (RIS) and geography of innovation literature because they can foster innovation, via knowledge spillover and labor matching mechanisms, even though in this case there is neither any formal nor deliberate search to acquire external knowledge (KHAN; LEW; MARINOVA, 2019).

A firm with a complex innovation outcome is nurtured better in a knowledge-rich region with higher positive agglomeration externalities, where, for instance, there is a higher supply of qualified labor, a higher extent of intraregional knowledge spillover, and a higher supply of specialized Knowledge-Intensive Services (KIS) in the region (TAVASSOLI; KARLSSON, 2021). There is also important to mention three regional characteristics that may affect the innovation outcomes of firms, i.e. (i) qualified labor market thickness, (ii) knowledge-intensive services thickness, and (iii) knowledge spillovers extent.

The native firms from emerging economies enable and develop in an institutional environment characterized by dynamic and evolving institutions, as well as financial support for innovation provided by the government as a key institutional player (KHAN; LEW; MARINOVA, 2019). This innovation can be exploratory or exploitative, and be of a higher or lower level of technological complexity. Nonetheless, the academic literature already has extensively studied the exploratory and exploitative dichotomy (AOKI; WILHELM, 2017; EBERS; MAURER, 2014; SONG et al., 2018), including in a context of institutional ambidexterity and especially for MNEs from emerging countries (KHAN et al., 2022; KHAN; LEW; MARINOVA, 2019).

The other dichotomy, however, between high and low-intensity innovation, hasn't received the proper attention so far. According to INPI's Economic Business Council (Assessoria de Assuntos Econômicos – AECON), an invention can be described as a new solution to a specific technical issue, circumscribed in a given technological field (INPI, 2021c). Still, in compliance with the same institution, these inventions can be protected by Invention Patents (IP) if they fulfill three basic requisites, which are: novelty, inventive activity, and industrial application. Nonetheless, as the protocol posited by the autarchy, the patent request remains under secrecy for eighteen months, after being submitted and approved in the preliminary formal exam (MCTIC, 2019).

After that entire time, the request is published in the weekly Industrial Property Magazine (Revista da Propriedade Industrial – RPI) and the depositor needs to request the patent analysis. The final decision about the exam itself can be acceptance or refusal and, if the outcome is positive, the patent rights remain active for 20 years, counted from the deposit date on. It also cannot be inferior to 10 years as of the concession date (INPI, 2021b). The Utility Models (UM), on the other hand, are used to outline an item, or a part of it, of practical use and that presents a new disposition, shape, function, or general form. This definition also requires that the invention entails an inventive act, which is less complex than the element "inventive activity". Lastly, a utility model also needs to result in a practical betterment of the application to which it was originally designed (INPI, 2021b).

The concessions of UM are also different from the IP for a series of other facts, for example, the former refers only to products, not processes, and the exam and yearly fees to be paid by the requestor for the deposit are inferior to the ones attached to the latter (INPI, 2021a). One last distinction is the UMs have 15 years of value, counted from the deposit date, and they remain active for more than 7 years from the concession time, that is to say, less than the IPs (INPI, 2018). There is also the case of the Certificates of Addition, which by definition are increments to invention patents, to improve or further develop them (INPI, 2021c). By the differences described above, this research defines Invention Patents as high-intensity inventions, as well as Utility Models and Certificates of Addition as low-intensity inventions.

Therefore, it is latent that the state-of-the-art literature about regional high or low-intensity innovation in emerging host countries still does not receive the proper academic attention and, hence, hasn't got a satisfactory number of studies on the subject. The influence that MNEs have on local innovation ecosystems in emerging economies needs to be addressed with urgency to create reliable outputs that could be used as essential pieces of information to ground the decisions of policymakers, private or public native companies, MNEs’ subsidiaries, and also educational institutions in Brazil. Accordingly, this research will focus on the latter dichotomy presented in this subsection.

Larger host countries' markets might be associated with higher foreign direct investment due to larger potential demand and lower costs due to scale economies. There are several studies in the specialized literature regarding innovation and FDI in Brazil on a country level, but few within regional-level scope. Despite that, there is some interesting information available regarding the behavior in Brazil of the FDI coming from MNEs, since this country attracts a small but growing fraction of the international resources for R&D (COLOMBO, 2019). To strengthen investment, there is a series of laws, norms, and public policies involving technologies, industrial property, and innovation in Brazil (INPI, 2018, 2021a, 2021c).

The general objective of all these measures is to regulate and nurture the development of inventions and innovations inside the national territory, with the most prominent ones being Law 9.279/96 and Law 11.196/05 (INPI, 2021b). The former regulates rights and duties for industrial property as a whole in Brazil and the latter consolidates and expands tax incentives to companies investing in scientific and technological development in Brazilian territory (GALINA; MOURA, 2013; VIANA et al., 2018).

For illustration purposes of the country’s relevance internationally, the share of R&D by U.S. MNEs offshored to Brazil has risen from around 1% in 2001 to more than 2.5% in 2013, doubling the rate of growth observed for other countries. Despite the initiatives to incentive the capital flow from MNEs into the country, the national governments have spent on average only 1.12% of the national GDP in national R&D measures from 1994 until 2018 (JENSEN; FILHO; SBRAGIA, 2004; OECD, 2021). From the year 2019 until nowadays, it is worth stressing that this investment, which was already below the 2% average for all OECD countries, has diminished even more, reaching approximately the negligible sum of 0.5% (OECD, 2021).

Moreover, according to the last available Innovation Research (PINTEC survey) conducted by IBGE in 2017, only 10,4% of the entire sum of expenditures in innovative activities by companies were destined for external R&D (IBGE, 2020). Another important piece of information to be taken into consideration is that Brazil attracts more adaptative and support-focused R&D, which makes market size and potential growth the most important assets to maintain and increase investment levels, leaving a secondary role for technological capabilities and other supply-side factors (COLOMBO, 2019).

In this context, some studies identified that the current or potential sectors in which the country has knowledge that may attract FDI are agribusiness, information technology, energy, nanotechnology, biotechnology, chemicals, aeronautics, aerospace, and defense (ARRUDA; BARCELLOS; TUMELERO, 2014). The former studies include comparisons between the patent deposits and concessions in Brazil and other countries in Latin America, the Caribbean, BRICS, other emerging countries, and even globally (CHAKRABARTI; BHAUMIK, 2015; SALAMI; SOLTANZADEH, 2012). Other investigations have their focus on the public policies to attract FDI, foment the production of innovations, or boost science in general, comparing them with the results in other countries (ALI et al., 2022; MOURA et al., 2019; SILVA et al., 2018).

Furthermore, one can find researches that analyze the technological transference along the axis of University-Industry in Brazil or the effect that FDI and patents have on specific national industrial segments (DOHSE; GOEL; GÖKTEPE-HULTÉN, 2021; LIMA et al., 2021; SOARES; TORKOMIAN; NAGANO, 2020). Statistical econometric models normally address the following factors when trying to understand if country features influence the innovation investment of international groups: market size or affiliate's sales levels; agglomeration economies; knowledge externalities; human capital; R&D intensity in the region and academic investigations (BELDERBOS et al., 2014; COLOMBO, 2019; JINDRA; HASSAN; CANTNER, 2016).

The capital movements into Brazil as a whole were studied by scholars to determine the relative importance of the several elements that could influence the flow of these investments, and it was established that the evolution of the consumer market and strength of consumer sales are more important than other normal offered explanations, such as exchange rates and country risk (DINÇ; GÖKMEN, 2019; FELISONI DE ANGELO; EUNNI; MANOEL MARTINS DIAS FOUTO, 2010). Hence, internal market growth represented by aggregate consumer sales was a fundamental factor of attraction for FDI to Brazil.

Positive vertical spillovers are relatively common because greenfield or acquired affiliates normally demand certain procedural standards from suppliers and buyers. In other words, product and process innovations tend to spread throughout the supply chain when a multinational enterprise (MNE) installs itself in the host country (BETIM et al., 2018; BRUHN; CALEGARIO, 2014). Besides, another study affirms that positive spillovers from FDI arise from further linkages where domestic firms purchase high-quality intermediate goods or equipment from foreign firms in the upstream sectors (XU; SHENG, 2012a).

These results were true also for studies with a focus on Brazilian industries only, with evidence of both positive and negative effects from FDI on national industries' productivity coexisting (BRUHN; CALEGARIO, 2014). More specifically, the researchers found that inward FDI leads to positive spillover effects in high-absorption capacity industries and negative effects in labor-intensive industries. There are several challenges concerning knowledge transfer from multinational companies to their local counterparts, which come from different sources. At the country level, the main elements are possible geographic dispersion of economic activities, and national culture, besides distinctions between formal and informal institutions (MINBAEVA et al., 2018).

Nonetheless, just as stated before, there is a lack of regional-level studies, despite the importance of this degree of detail. As one should know, as important as analyzing holistically a national situation may be, there are several institutional, social, and economic disparities throughout the regions that compose a country. This is aggravated in countries that present an extensive geographical territory and emerging economies, such as Brazil. Inequality is an especially serious issue within the national borders of this country before and after the COVID-19 pandemic, since despite the nominal GDP of approximately $1.90 trillion, Brazil has around 20% of its population living in poverty (MALTA et al., 2020).

Given the importance of the capital flow from MNEs, innovation ecosystems, and the socioeconomic relevance of Brazil such as described throughout this literature review, it is fundamental to investigate the correlations amongst these elements in the current context. So, the formulated main research question is "Areas that receive more FDI present a higher incidence of inventions?". Therefore, the first hypothesis posited by this research is:

H1: MNEs tend to foster the innovation environment at the host.

2.2.3. High and low-intensity innovation

The innovation produced by technological advancement throughout all areas of knowledge nowadays is seen as one of the most important factors to magnify economic growth and business success (MARSHALL; PARRA, 2018). Nonetheless, this innovation comes from modifications or creations of new products or processes, or even the recombination of existing elements of one or more parts involved in the functionalities to shape new interactions with positive outcomes (EBERS; MAURER, 2014; FELISONI DE ANGELO; EUNNI; MANOEL MARTINS DIAS FOUTO, 2010; JENSEN; FILHO; SBRAGIA, 2004; OMRI, 2020). These inventions are normally submitted to be patented as industrial properties at an official patent office of the country in which the aforementioned innovation in potential was generated (WIPO, 2020, 2021).

Furthermore, given the variety of possibilities when it comes to innovation in all industrial segments, normally they vary in several aspects and characteristics, including the level of invention intensity (BELLO-PINTADO; BIANCHI, 2020; DAI et al., 2021; LIN et al., 2021; ZHANG; CHENG; YU, 2020). To illustrate this vast range of options, one can consider the great number of categories instituted by the International Patent Classification (IPC), which in its eighth edition comprises eight sections, 129 classes, 639 subclasses, 7314 main groups, and 61397 subgroups (INPI, 2018, 2021a; WIPO, 2019).

Nevertheless, patents, in general, can be divided mainly into two fundamental groups, each with its specific characteristics, denominated "invention patents" and "utility models" (INPI, 2018). The Industrial Property Regulation (BRAZIL, 1996) establishes prerequisites and different monopoly protections for these two distinct subcategories, as well as different values of monthly fees to be paid by the proponents during the analysis process to grant the industrial property status to the innovation. So, this research needs to understand the primary distinctions between invention patents and utility models (INPI, 2021c).

According to INPI's Economic Business Council (Assessoria de Assuntos Econômicos – AECON), an invention can be described as a new solution to a specific technical issue, circumscribed in a given technological field (INPI, 2021c). Still, in compliance with the same institution, these inventions can be protected by Invention Patents (IP) if they fulfill three basic requisites, which are: novelty, inventive activity, and industrial application. Nonetheless, as the protocol posited by the autarchy, the patent request remains under secrecy for eighteen months, after being submitted and approved in the preliminary formal exam (MCTIC, 2019).

After that entire time, the request is published in the weekly Industrial Property Magazine (Revista da Propriedade Industrial – RPI) and the depositor needs to request the patent analysis. The final decision about the exam itself can be acceptance or refusal and, if the outcome is positive, the patent rights remain active for 20 years, counted from the deposit date on. It also cannot be inferior to 10 years as of the concession date (INPI, 2021b). The Utility Models (UM), on the other hand, are used to outline an item, or a part of it, of practical use and that presents a new disposition, shape, function, or general form. This definition also requires that the invention entails an inventive act, which is less complex than the element "inventive activity". Lastly, a utility model also needs to result in a practical betterment of the application to which it was originally designed (INPI, 2021b).

The concessions of UM are also different from the IP for a series of other facts, for example, the former refers only to products, not processes, and the exam and yearly fees to be paid by the requestor for the deposit are inferior to the ones attached to the latter (INPI, 2021a). One last distinction is the UMs have 15 years of value, counted from the deposit date, and they remain active for more than 7 years from the concession time, that is to say, less than the IPs (INPI, 2018). There is also the case of the Certificates of Addition, which by definition are increments to invention patents, to improve or further develop them (INPI, 2021c). By the differences described above, this research defines Invention Patents as high-intensity inventions, as well as Utility Models and Certificates of Addition as low-intensity inventions.

Some articles in Geography of Innovation have already studied a part of the aspects involving innovation intensity in some countries, but only a restricted amount is conducted in Brazil. One good example is an investigation that used the annual governmental survey of industry (Pesquisa Industrial Annual – PIA) and the survey of innovation (Pesquisa de Inovação – PINTEC), as well as the classification of technology intensity suggested by the Organization for Economic Co-operation and Development (CAPPELLESSO; RAIMUNDO; THOMÉ, 2020). They discovered that the food sector in the national firms within the food sector could be classified as having low-intensity of innovation, but only analyzed an isolated segment of the Brazilian industry.

Other contributions to the academic literature with a non-national scope include an investigation aiming to characterize the small-scale, low technological, and low-intensity R&D in OECD and European Union countries (GAMITO; MADUREIRA, 2019). Moreover, a group of researchers used fuzzy-set Qualitative Comparative Analysis to differentiate between the distinct pathways to high-level and low-level innovation based on the sources of knowledge and the degree of internalization of the product market (YORUK et al., 2021). They discovered that internationalization boosts the level of product innovation and, with knowledge sources, becomes a critical differentiator between high and low-level innovation products.

Thus, it is imperative to analyze the dichotomy between high-intensity inventions and low-intensity inventions, which have a good chance of becoming innovations. The theoretical basis to distinguish between the two posited categories of technologies was already explained before. Consequently, these next hypotheses need to cover high and low-intensity inventions and the socioeconomic indexes involved as control variables.

The first null hypothesis created in this subsection states that "the volume of FDI tends to generate high-intensity inventions in the region", thus the alternative hypothesis, in this case, says that "there is not a production of high-intensity inventions in regions which receive large amounts of FDI". The second null hypothesis asserts that "the volume of FDI tends to generate low-intensity inventions in the region", hence the alternative hypothesis is that "there is not a production of low-intensity inventions in regions which receive large amounts of FDI". In sum, the next two hypotheses investigated by this study are:

H2a: MNEs tend to foster more high-intensity innovation at the host.

H2b: MNEs tend to foster more low-intensity innovation at the host.

2.2.4. Importance of absorptive capacity for native firms

Despite the importance of the capital flow from multinational enterprises (MNEs) for the promotion of technological development of native firms, many academic studies identified negative horizontal and/or vertical spillovers (BLOMSTRR; KOKKO, 1998; GÖRG; GREENAWAY, 2003; HIEN, 2020; KHACHOO; SHARMA, 2016), which means that in some cases the presence of FDI per se is prejudicial for the host country's economic ecosystem. This causes a diminishment of the amount of money native companies invest and, consequently, leads to a "crowding-out" effect observed in several investigations (AMEER et al., 2021; GHEBRIHIWET; MOTCHENKOVA, 2017; GONDIM; OGASAVARA; MASIERO, 2018; KURTOVIĆ et al., 2022).

In this context of technological transference, the amount of importance regarding the concept of absorptive capacity (AC) of local firms is a relevant topic of investigation in the specific literature as well. According to the most classical definition, AC refers to the ability of an organization or region to identify, assimilate and exploit knowledge from the environment (COHEN; LEVINTHAL, 1989, 1990). This concept represents the link between firms' capabilities to implement new products and the external stock of technological opportunities, such as the ones presented by knowledge spillovers from MNEs (IMBRIANI et al., 2014).

It is still worth commenting that a usual proxy for absorptive capacity is the technology gap between the foreign and domestic firms, the R&D intensity of the native enterprises, or the human capital embodied in native companies (FU, 2007). Moreover, there is also a need for innovation-complementary assets and institutions in the host region, forming a propitious and beneficial technology ecosystem (RYAN et al., 2021).

Thus, native firms with high AC would be able to exploit knowledge coming from the multinational subsidiaries. Generally, high levels of AC will speed up productivity spillovers from multinationals in the region in which the MNE takes place. (GIRMA, 2005). Another important study found that absorptive capacity has a significantly robust moderating effect on innovation so that host country firms' gains from FDI knowledge spillovers depend on whether their AC offsets the negative impact of the foreign capital flow (LEW; LIU, 2016). The same authors suggest that incremental innovation has a higher probability to have come from technological elements of AC, however radical innovation depends more on the human capital aspect of the absorptive capacity.

MNEs assign more responsibility for R&D and innovation to affiliates in emerging markets that have larger markets, lower human resource costs, greater overall R&D activity, and to some extent greater activity of the company in question. China and India are huge exceptions to the rule that MNEs tend to assign only development work to emerging market affiliates: they are increasingly assigning core R&D to these two large countries (GROSSE, 2019). Researchers have distinct views on the mechanisms that generate innovation in host countries, divided between the firm's capabilities being the primary catalysts of innovation, mainly absorptive capacity (APRILIYANTI; ALON, 2017; SONG et al., 2018), and the creation through external partnerships that lead to knowledge acquisition (KHAN; LEW; MARINOVA, 2019; KIM; SONG; NERKAR, 2012).

Furthermore, for national innovation systems to benefit from the attraction of the mobile capital flow that comes from multinational enterprises, it is critical for public policies to ensure that appropriate linkages are established with local actors that hold AC (FU, 2007). Nevertheless, one can find equal importance for emerging economies to prioritize strategic technology niches where the country can realistically attain product and process improvements and knowledge (GUIMÓN et al., 2018).

In European countries, such as Italy (FERRAGINA; MAZZOTTA, 2014; IMBRIANI et al., 2014), and Poland (CIEŚLIK; HAGEMEJER, 2014), the influence of native companies' AC has already been extensively studied, as well as in emerging economies such as China or India, but mainly the former (DUAN et al., 2021). But some significant nations with economies in blatant development and future potential are still mostly neglected by the specialized academic literature, and this is the case of Brazil.

Whereas some studies have already begun to investigate the role of absorptive capacity for regional innovation intensity in Brazil with positive results (GARCIA et al., 2022), there is still a lot of potential for several other academic studies in this field of expertise. As a consequence of that, the last two hypotheses of this research will investigate the role AC has at a regional level with a unique combination of proxies and socioeconomic control variables. Thus, this study posits the following:

H3a: The MNEs' high-intensity innovation nexus is moderated by regional AC.

H3b: The MNEs' low-intensity innovation nexus is moderated by regional AC.

2.3. METHODS

2.3.1. Data sources

The data employed for this investigation configure an integration among regional patent data and the unique foreign direct investment database elaborated by members of the ERMES - Economia Regional e Mudança Estrutural Sustentável (Regional Economy and Sustainable Structural Change) research group. This stems from the Department of Production Engineering located within the Federal University of São Carlos. The specific method developed to calculate regional level FDI is detailed in the following subsections and uses data such as the number of national and foreign enterprises, as well as the volume of exported goods both national and internationally. These last pieces of information, in turn, were obtained from an official governmental administrative instrument named Siscomex (Sistema Integrado de Comércio Exterior), which integrates all the activities of registration, monitoring, and control of the external commerce operations in Brazil.

The most relevant socio-economic regional indexes for each of the municipalities were obtained and compiled to complement the database and provide a broader panorama to characterize each region. This relevant data was attained from a series of governmental official autarchies, institutes, or periodic investigations. Therefore, one of the most relevant sources was the Brazilian Institute of Geography and Statistics (IBGE), which produces several relevant studies, such as the Industrial Annual Research (PIA) and the Innovation Research (PINTEC). Other relevant data come from FIRJAN indexes, which are produced based on the conjunct efforts of a collaborative group of different entities, namely SENAI, SESC, IEL, and CIRJ. Another entity worth of being mentioned here is the State System of Data Analyses (SEADE), which provided some of the control variables employed in the subsequent modeling.

Nonetheless, the most important variables for this study are the indexes related to innovation. Specifically, the regional technological innovation production is represented by patent data, with discretization among invention patents, utility models, and certificates of addition (CA). The indexes were the number of deposits registered by residents of each region during a specific year, since a patent deposit indicates invention, which is, in turn, a proxy for potential innovation once they are implemented. These pieces of information were obtained from the official patent office in Brazil, that is to say, the National Institute of Industrial Property (INPI).

The geographical choice was the set of all the municipalities located in the state of São Paulo (645), over the years 2010 to 2016. This period was chosen because it is the most recent timespan in which there is an availability of all the information necessary to conduct the research's investigation. The restricted geographical region is justified by the complexity of the analyses conducted within a limited timespan and the national relevance of the region as already described in subsection 1.2.2.

2.3.2. Variables description

Dependent Variables

The dependent variables considered to analyze all the hypotheses posited throughout the "Theoretical Background and Hypotheses Development" section of this research are three. One to verify hypothesis H1 and the other two to investigate subsets H2a/H2b and H3a/H3b. Therefore, the dependent variables are the total number of patents deposited in each territory and the discretization between the number of patent deposits of invention patents and the sum of deposits for utility models and certificates of addition. The former represents an index for high-intensity inventions and the latter was chosen to be a proxy for low-intensity inventions for each municipality during the period studied.

These variables were chosen to take into consideration the hypotheses themselves since the first one posits the entire innovative panorama, it is fair to use as an index the total number of patent deposits, without distinction between complexity levels. The other two variables discuss and evaluate the influence of FDI and the importance of absorptive capacity, both for high-intensity innovation and low-intensity innovation, for that reason the variables HII (high-intensity innovation) and LII (low-intensity innovation) were adopted.

As already justified, invention patents have to comply with the criteria of novelty, inventive activity, and industrial application, whereas utility models only need to comply with the "inventive act", which represents a lower level of complexity and innovation. Last but not least, certificates of addition only represent incremental implementations of innovation already deposited, in other words, small improvements to inventions already going through the patenting process.

Core Independent Variables

The first core independent variable within this study is the regional-level FDI. Thus, to accurately evaluate the objective and the hypotheses described throughout section 2.2, the independent variable present in every statistical regression must be the FDI index for each region studied, calculated just as in the correspondence described in (Eq.1). Nevertheless, it is important to highlight that the *lagged version* in one year of this variable was used since according to the pertinent academic literature, this method allows the investigation to better capture the continued effects and spillovers of the capital flow.

$$FDI = \left(\frac{MNC_{jt}}{TC_{jt}}\right) \times \sum_{i=1}^{k} W_{ijt} \quad \text{(Eq.1)}$$

Where (ranging from 0 to infinity):

- j = municipality
- t = year
- MNCjt = number of MNCs
- TCjt = number of companies (total)
- k = number of foreign countries
- W = weight (foreign exports; sum of exports)

The second core variable is the absorptive capacity since in this context of technological transference, the amount of importance regarding the concept of absorptive capacity (AC) of local firms is a relevant topic of investigation in the specific literature as well. According to the most classical definition, AC refers to the ability of an organization or region to identify, assimilate and exploit knowledge from the environment. This concept represents the link between firms' capabilities to implement new products and the external stock of technological opportunities, such as the ones presented by knowledge spillovers from MNEs. Furthermore, for national innovation systems to benefit from the attraction of the mobile capital flow that comes from multinational enterprises, it is critical for public policies to ensure that appropriate linkages are established with local actors that hold absorptive capacity.

A usual proxy for absorptive capacity is the technology gap between the foreign and domestic firms (GIRMA, 2005), the R&D intensity of the native enterprises, or the human capital embodied in native companies. Thus, native firms with high AC would be able to exploit knowledge coming from the multinational subsidiaries. Generally, high levels of AC will speed up productivity spillovers from multinationals in the region in which the MNE takes place. This core independent variable was also used in its *lagged* form, with the same justificative used to FDI, to capture sustained effects of the local AC.

In this research the absorptive capacity was calculated as a regional index using based on a relative labor productivity ratio, as in (Eq.2). This is justified by several studies as plausible because this version of absorptive capacity is positively correlated to the productivity of native companies, in other words, a high value of AC usually indicates a significant level of productivity. This indicates that regions with high AC will tend to better acquire the knowledge stemming from the international capital flow.

$$AC = \frac{LaborProductivity}{max(\,LaborProductivity)} \quad \text{(Eq.2)}$$

Moreover, one can find equal importance for emerging economies to prioritize strategic technology niches where the country can realistically attain product and process improvements and knowledge. Whereas some studies have already begun to investigate the role of absorptive capacity for regional innovation intensity in Brazil with positive results, there is still a lot of potential for several other academic studies in this field of expertise. As a consequence of that, the last two hypotheses of this research will investigate the role AC has at a regional level with a unique combination of proxies and socioeconomic control variables.

Also, a combined form of both variables was explored in the present research (FDIAC), just as shown in (Eq.3), to verify and compare which is more suitable to explain the conduct of the innovation indexes adopted. Therefore, the only remaining variables still need to be explained are the control variables, in other words, the territorial and socioeconomic indexes that may individually influence the dependent variable.

$$FDIAC = FDI * AC \quad \text{(Eq.3)}$$

Control Variables and External Instrument

This study also employs a set of controls. The economic complexity index would be a great choice, because it ought to represent and explain the level of complexity of the productive capabilities of large economic systems, more specifically for this study, of the municipalities. In particular, it would account for the knowledge accumulated in a given population that is expressed in economic activities. Nevertheless, the data available for the timespan and regions here analyzed is very scarce and inconstant, so it could not be considered.

On the other hand, regional GDP per capita (gdppc) fosters the average value of goods and services produced in the region during the year, hence being a good control variable for the situation researched. Another piece of information that must be taken into account is the populational density (dens) for the area, and the geographical space occupied by the region (area), since they reflect indirectly several life conditions, such as the habitational situation, and levels of air pollution, among others. The third control variable chosen is the number of formal jobs existent in each year of the series (emptotal), because it is a fundamental factor that influences the well-being of the regional community. The ratios of the regional value added by three sectors were also considered, namely the industrial (indratio), agribusiness (agroratio), and services (servratio) segments. These represent a holistic panorama of how the region is economically structured, accounting for the sectoral differences among distinct socioeconomic developments.

The FIRJAN indexes were also included within the control variables since they expose the fiscal responsibility (fjfiscal) and social development (fjdmgeral) of the municipality. The latter includes specific local aspects, such as education, wages, healthcare, and educational performance. Finally, the external instrument chosen to consolidate the statistical outputs was the number of jobs provided by multinational companies in the region (empmne). The reason is quite direct since a higher number of jobs from MNEs indicates a more prominent presence of these enterprises overall in the given municipality. Adopting this tool improves the reliability and robustness of the results obtained and allows the regression to consider an external element with influence on the behavior of the innovation indexes.

2.3.3. Model Development and Estimation Strategy

Considering all of the variables explained beforehand, we employ the specifiquation describe in (eq 4) to evaluate the hypothesis underlying the present investigation.

$$Regional\ Innovation = \beta_0 + \beta_1 FDI_{t-1} + \beta_2 AC_{t-1} + \beta_3 (FDI_{t-1} * AC_{t-1}) + \beta_4{}' X_{t-1} + \beta_5 empmne_{t-1} + a_i + u_{it} \qquad \text{(Eq.4)}$$

- Regional Innovation (pattotr = sum of deposits for all patent categories, HII = deposits for invention patents, or LII = deposits for utility models and certificates of addition)
- FDIt-1 = lagged FDI index
- ACt-1 = lagged AC index
- X = Matrix of control variables
- Empmne = jobs provided by MNEs
- ai = fixed effects
- u = residual term
- Variables (i = 1 to 645 / t = 1 to 7)

The regional patent existing information shows several zeros, as the smaller cities normally didn't produce any innovation during the timespan of the dataset used. In those cases, the specialized literature (AMEMIYA, 1984; MCDONALD; MOFFITT, 1980; STEWART, 2009) strongly recommends the use of TOBIT methods for panel data. According to the other characteristics of this dataset, in these analyses both Negative Binomial and Poisson regressions were tested, to verify which one is more suitable for each of the cases. Moreover, in hypotheses H1, H2a, and H2b, three alternatives of equations were tested: one with FDI and AC; one with FDI, AC, and FDIAC; one with only FDIAC.

It is also proposed to use the modified Wald for heteroskedasticity (LASKAR; KING, 1997), the Wooldridge test for autocorrelation (WOOLDRIDGE, 2010), J-statistics and C-statistics tests to delineate endogeneity, the Pesaran test for cross-section independence (PESARAN; HSIAO, 2004) and the Variance Inflation Factor (VIF) to measure multicollinearity. In addition, the Hausman test will be used to estimate if the regression using random effects is the best choice since it compares with the fixed effects option.

Robustness analysis will be conducted by traditional random effects through feasible generalized least squares (FGLS), and fixed-effect models with Driscoll-Kraay standard errors to account for heteroskedasticity, autocorrelation, and cross-sectional dependence, since proximity may play a role within innovation ecosystems (FÁVERO, 2013; MORALLES; MORENO, 2020). Finally, endogeneity issues may be treated through the SYS-GMM method while the presence of endogeneity will be tested by using the C-Statistic.

2.4. RESULTS AND DISCUSSION

The data processing within this research was mainly divided into four distinct steps: Data Acquisition, Data Wrangling, Exploratory Data Analysis, and Econometric Regressions. The first one, with the theoretical development as a fundamental basis, had as central activities the identification of which pieces of information were necessary to conduct the investigations, where to find them, in other words, the sources (institutions, entities, databases, research reports, among others), and their obtaining. The specific sources were already extensively discussed in subsection 2.3.1.

The second phase consisted of five distinct steps, namely: discovery, structure, cleaning, enrichment, and validation. The first step was to fully understand the conjuncts of data obtained during the previous phase, comprehending the data blocks holistically and in their details. The second was to structure it into a single database, with caution to not lose any information in the processes developed.

Cleaning the data, in turn, consisted in excluding duplicated data and revising possible absent information, among other minor procedures. In the enrichment step, the number of jobs offered by Multinational Enterprises was added to the database, as an external instrument. Finally, the validation step allowed all the values to be verified and investigated if they made practical sense and if the outliers were just abnormal behavior or corrupted data.

2.4.1. Exploratory Data Analysis

For this research, the innovation indexes considered only the patents deposited by resident sources, this includes MNEs that act through several means and distinct industries in Brazilian territory. Otherwise, it wouldn't be possible to map the inventions per region, since the patents would be discretized correctly.

The aggregated panorama for the invention indexes adopted can be observed in Table 5 – Aggregated Inventions Panorama in São Paulo 2010-2016Table 5, invention patents being the High-Intensity Invention index and representing approximately 58,35% of the total deposits, encompassing a total of almost ten thousand inventions. Utility models are in a solid second place of relevance, with 40% of the deposits, which represent 6850 inventions. Certificates of addition, on the other hand, only managed to reach an amount of 281 deposits and, summed up with the Utility Models they represent the Low-Intensity Invention index with 41.65% of the deposits.

Table 5 – Aggregated Inventions Panorama in São Paulo 2010-2016

	Invention Patent (HII)	**Utility Model**	**Certificate of Addition**	**MU-CA (LII)**	**Total Patents (pattotr)**
Absolute	9992	6850	281	7131	17123
Percentage (%)	58.35	40.00	1.64	41.65	100

Source: Author's archives (2022)

In another aspect of the analysis, the percentage of places with data different from zero in at least one of the years from 2010 to 2016 is the same when one considers the categories of invention patents and utility models. Both distinctions present non-null values in almost 58.3% (376) of the municipalities under the current study. After an adequate verification of the null cases, the absence of data was confirmed as being a reality mainly in small or mainly rural municipalities, according to the criteria established by the Brazilian Institute of Geography and Statistics (IBGE).

The most recent official requirements for a municipality to be classified as small include: having a population inferior to 50 thousand inhabitants, presenting a demographic density superior to 80 inhabitants per square kilometer and the agricultural activity needs to represent less than 15% of the local Gross Domestic Product (GDP). On the other hand, a place can be categorized as relatively rural or rural if the regional GDP composed of agricultural activities surpasses 15% and the demographic density observed is inferior to 80 inhabitants per square kilometer (BRAZIL, 2011).

In any circumstance, when these municipalities present data about any category of innovation, the values are small, with just a few patent deposits each year. Therefore, a valid assumption of the total amount of creations produced in these regions when the data is absent is to consider the number of local deposits equal to the null value. That way, the research can develop better correlations regarding all the municipalities present on the dataset, without the restriction of using only values that appear on the official statistics offered by INPI.

Through another optic, the summarized information for the database, containing the number of observations, and basic statistical characteristics such as mean, standard deviation, and minimum or maximum values for each variable can be found in Table 6. As expected, all of them have the same number of observations and the database ranges from 2010 to 2016. The description of what each variable is specifically and their respective sources can be seen thoroughly in Appendix A.

Table 6 – Summary of the variables

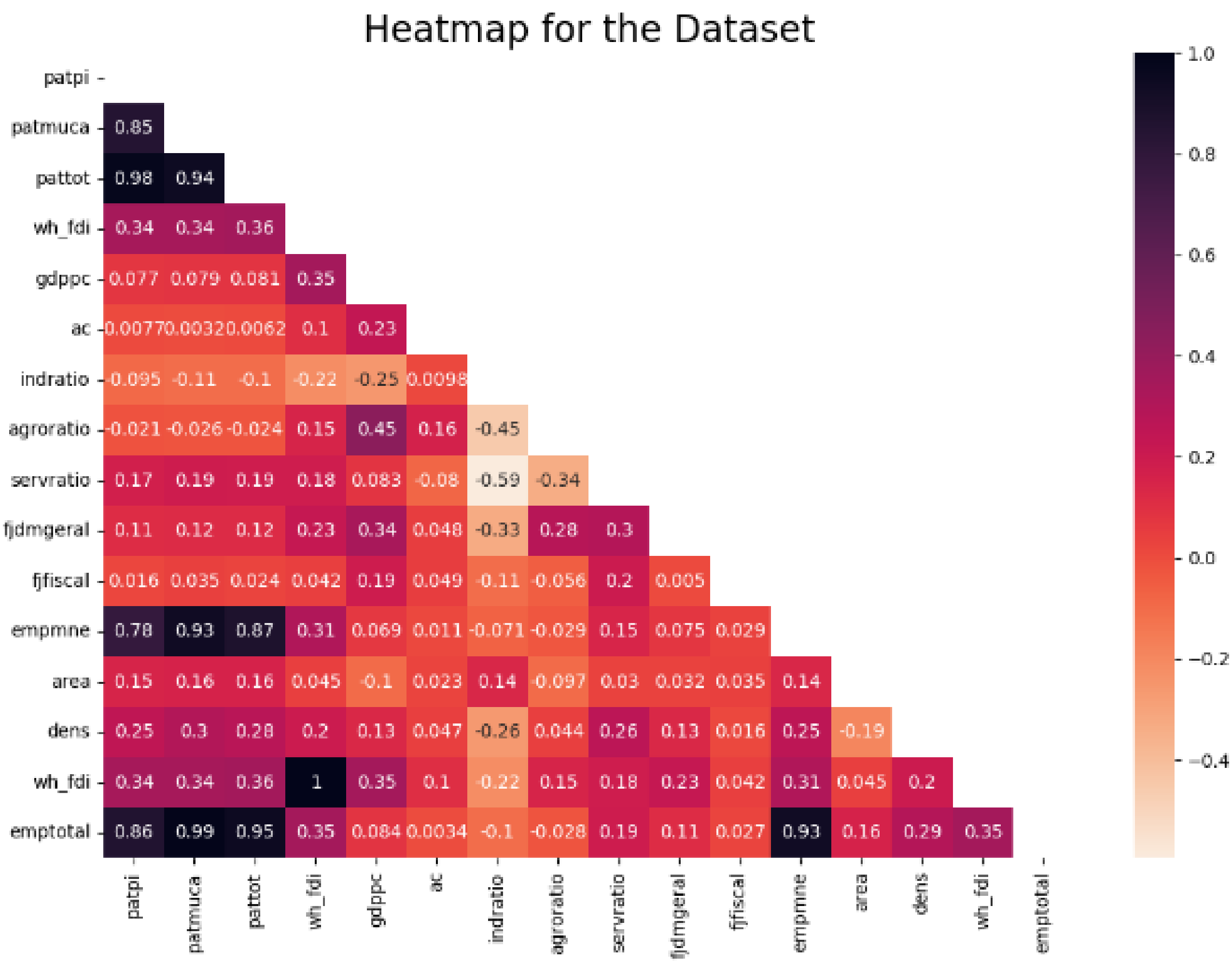
Variable	Mean	Std. Dev.	Min	Max
wh_fdi	26.01	97.30	0	1281
gdp	3806914	28400000	22230.14	683000000
gdppc	29126.72	24637.42	4900.24	364529.30
indratio	11.86	12.15	0	70.80
agroratio	25.63	14.36	3.08	86.74
servratio	45.75	13.07	8.31	89.44
fjdmgeral	0.785	0.0636	0	0.93
fjfiscal	0.329	0.313	0	1
emptotal	30340	247113	0	5308401
empmne	22	303	0	7886
ac	0.0525	0.0429	0	0.7500
area	429.35	348.21	3.61	1978.80
dens	453.56	1499.13	5.24	13534.82
HII	3.27	30.82	0	814
LII	2.33	19.48	0	446
pattot	5.60	48.45	0	1210

Source: Author's archives (2022)

From Table 6, it is possible to compare some information from similar indexes, for example, the mean from the industrial, agribusiness, and services ratio, which excludes the public sector. The fraction of value added by the services segment (45.75%) contributes more than the other two combined since agribusiness and industry provide 25.63% and 11.86%, respectively. In another comparison, one can observe that the number of jobs offered by national companies is far greater on average than the jobs occupied by multinational enterprises. Furthermore, the variance and absolute values of the indexes for municipal fiscal responsibility and social development are different, with the former being lower and having a high standard deviation, and the latter having a higher value and lower standard deviance.

One important aspect of the variables chosen for the econometrical regressions is that they have a low correlation value among each other. This signifies that the control variables chosen are independent of one another, and monitor distinct aspects of the environment related to the phenomena studied. The independent variables and the external instrument in this case will try to explain the behavior of the dependent variable from distinct angles.

Figure 3 – Correlations' Heatmap for the Dataset

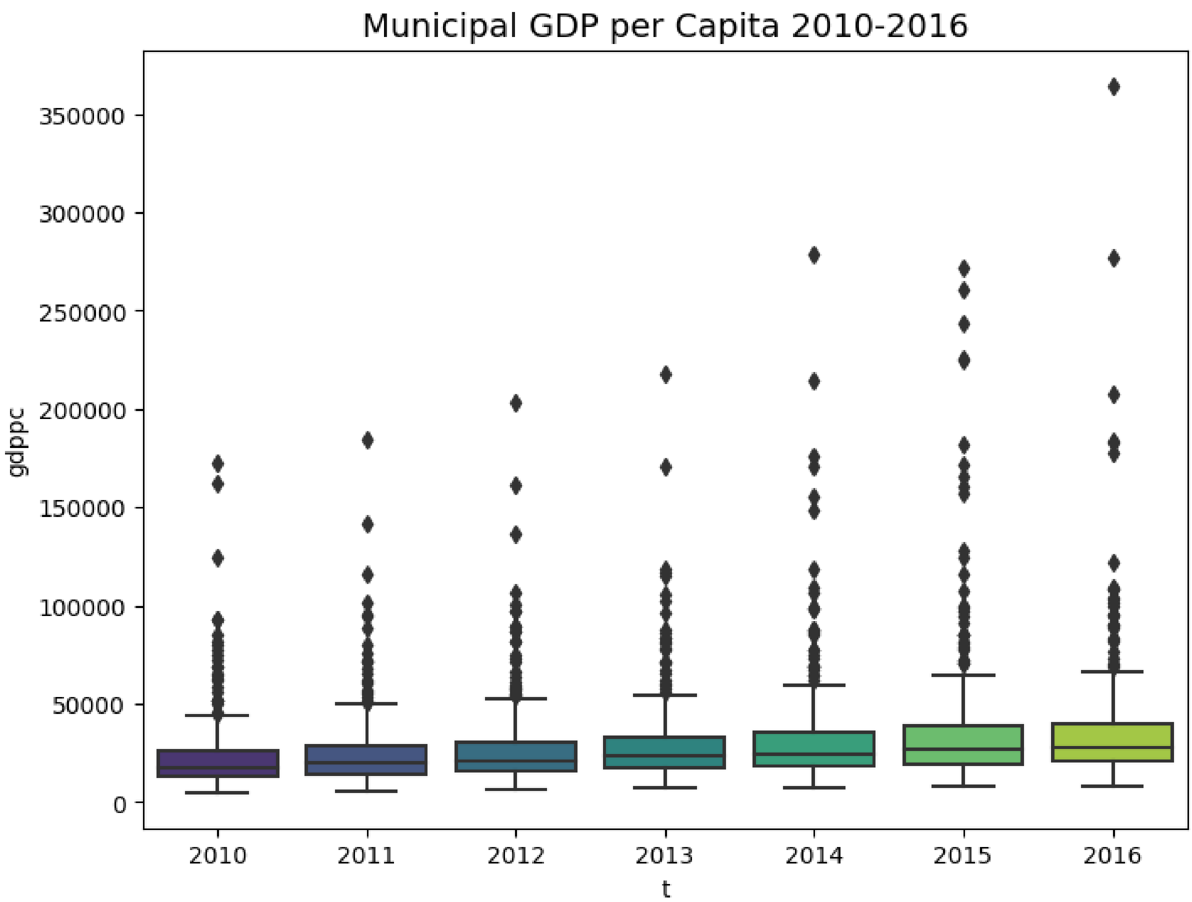


Source: Author's archives (2022)

From Figure 3, it is possible to identify that the mentioned condition regarding the low correlation values among the variables is generally satisfied, and some expected high relational values are observable as well to indicate a corroboration with some of the hypotheses posited.

For example, there is a high correlation between the jobs provided in general, the jobs provided by MNEs, and the invention indexes. This already indicates that the presence of industries, national or international, favors the production of technology and innovation. Another interesting relatively high negative relation between the industry and services ratio of value added to the municipal GDP. That information implies that the industry and services compete for space between themselves, while the ratio occupied by the sum of agribusiness and public sector contributions remains somewhat constant.

Figure 4 – Annual Boxplots for the Municipal GDP per Capita

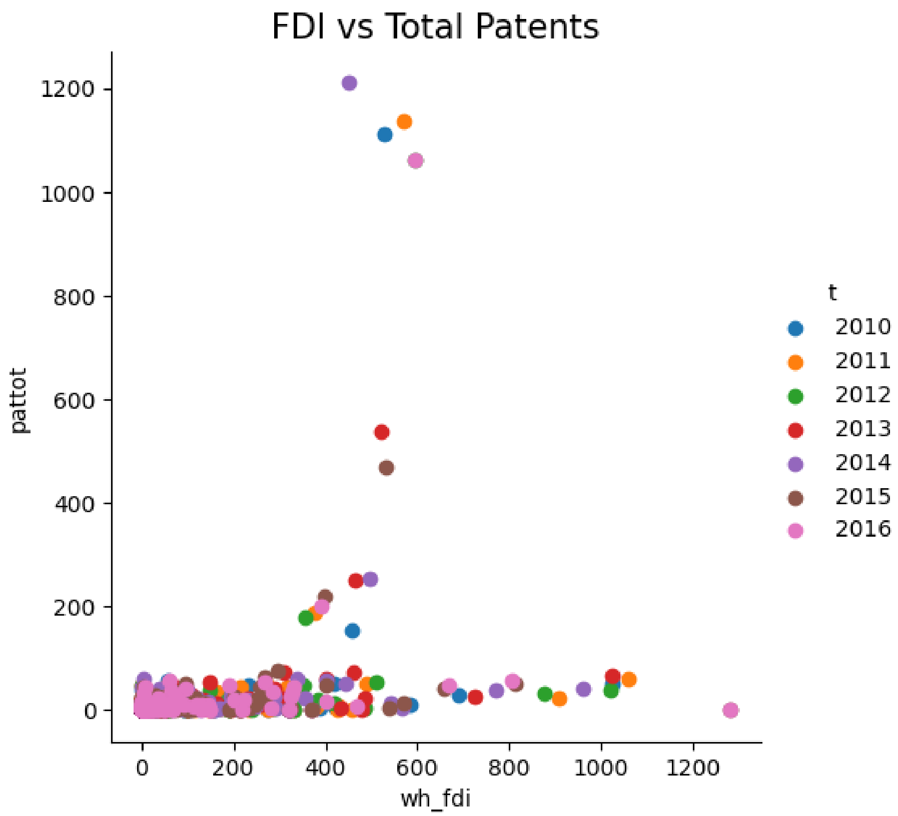


Source: Author’s archives (2022)

Further analysis of the GDP per Capita for the municipalities reveals that the production of value for each region rose on average from 2010 to 2016 and got slightly more evenly distributed among those places. Nonetheless, the general behavior of this index remained the same, which is a high concentration of data in lower values of GDP and some outliers from larger cities occupying the superior portion of the graphic. Furthermore, these outliers are observably rising in absolute values during the investigated timespan.

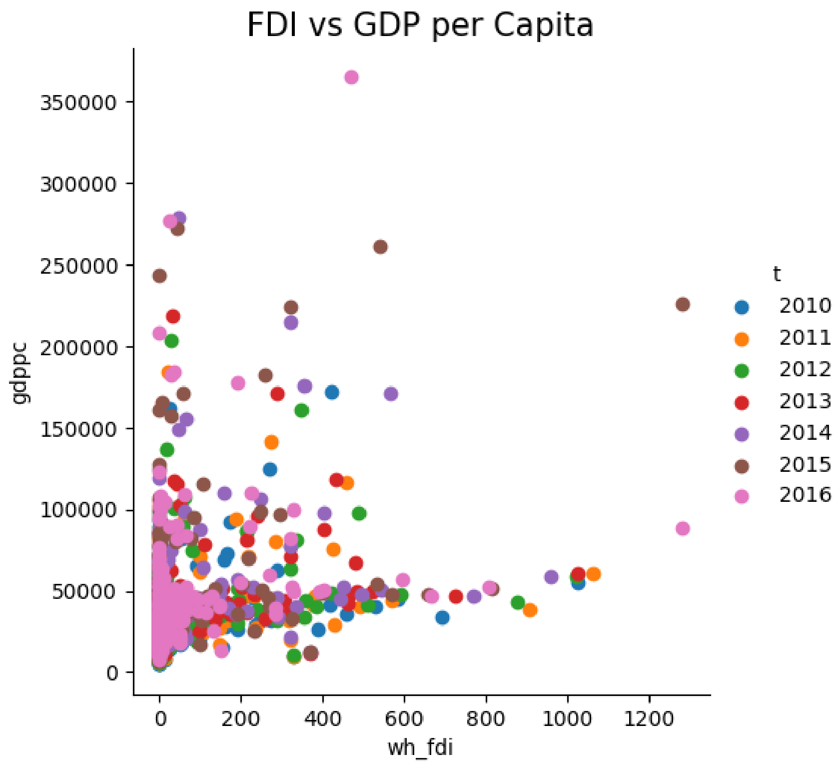
On another angle, the graphs depicted in Figure 5 e Figure 6 help to understand the behavior of the municipal FDI when compared with the total number of patents deposited and the GDP per capita, respectively. The number of patents remains low for most of the municipalities, but a few stand out, and they are not necessarily located in higher FDI areas. When it comes to the GDP per capita, on the other hand, a wider range of values is located in lower values of FDI, with general spread data when the flow of capital increases. Holistically, it is possible to infer that the variables chosen for the present analyses are pertinent, and it is viable to progress to the direct application of the econometric models established beforehand.

Figure 5 – FacetGrid for FDI vs Total Patents



Source: Author’s archives (2022)

Figure 6 – FacetGrid for FDI vs GDP per Capita



Source: Author's archives (2022)

2.4.2. Regression Results and Discussion

The examinations applied to verify the properties of the pertinent variables in Table 6 were the modified Wald test, the Wooldridge test, the Pesaran test, and the Hausman test, just as described in subsection 2.3.3. (LASKAR; KING, 1997; PESARAN, 2015; WOOLDRIDGE, 2010). After that, the statistical regressions were applied according to the information detailed in the same section of this research. First of all, the comparison made by the Hausman test, which is constructed as a function of the difference between the estimators for random effects and fixed effects, resulted in a rejection of the null hypothesis inherent to the test and, therefore, a preference to use fixed effects. This means that the explanatory variable has a constant relationship with the response variable across all observations.

The autocorrelation test (Wooldridge) resulted in a not rejection of the hypothesis of this test when the dependent variable is on the correlations described beforehand. This means that there is not a first-order autocorrelation phenomenon for all of the situations investigated. This situation will be considered in the statistical regression that follows. Furthermore, the null hypotheses for the modified Wald test were both statistically not rejected, revealing the absence of heteroskedasticity throughout the observations, which will also be taken into account.

When the C-statistics test was applied, the null hypotheses as the regressor being exogenous were not rejected, therefore indicating the absence of endogeneity, which indicates the marginal distribution of the independent variable is independent of the conditional distribution of the dependent variable. Finally, the Pesaran test was applied to investigate the existence of cross-section independence, which resulted in the not rejection of the null hypothesis of weak cross-sectional dependence and the residuals are likely to not inhibit cross-section dependence. It is worth mentioning that all the null hypotheses of the tests made so far had a level of significance of 1%.

Nonetheless, despite the positive results from the tests applied to verify the integrity and solidity of the database, as well as the relevance of the variables chosen, still there is a lot of discrepancy among the absolute values of the indexes since they represent completely different aspects of the environment. Given this situation, the solution found in this research was to normalize the data by the min-max method, except for the dependent variables (number of patents), which remained with their original values, given the number of null values present and the fact that they are integers, by the very nature of these proxies.

Besides, it is important to highlight that two distinct regressions were tested with all the hypotheses, namely the Poisson and Negative Binomial alternatives. Even the Zero Inflated Negative Binomial was considered to be one of the options to study the phenomena, but discarded due to the issues inherent to the method. Furthermore, the phenomena observed in hypotheses H1, H2a, and H2b tried to be explained by a series of three combinations of distinct equations. One with the lagged FDI and AC, one with those two and the combination FDIAC, and finally one with only the last aforementioned variable. Hypotheses H3a and H3b, since they consider only the possible moderating role of regional absorptive capacity, didn't allow to test distinct alternatives.

After a preliminary convergence evaluation and also coherence between the coefficient values and the standard deviation, the Poisson regression method was selected to be used in all the hypotheses posited here. Furthermore, regarding the combination of variables for the phenomena of H1, H2a, and H2b, through the same criteria, the best explanation was provided by the use of only the combined version of capital flow and absorptive capacity (FDIAC). Finally, it is worth mentioning that, during this step of evaluation, the variable absorptive capacity on the regressions used for testing hypotheses H3a and H3b was not applied as lagged, since the objective is to analyze specifically the moderating power of this organizational characteristic.

Table 7 – Econometrical regressions' results

VARIABLES	Poisson_PatTot	Poisson_HII_H2a	Poisson_LII_H2b	Poisson_HII_H3a	Poisson_LII_H3b
lfdiac	3.348**	7.333***	-1.208	-	-
	(1.419)	(1.829)	(2.231)	-	-
empmne	-0.231***	-0.595***	0.229**	-	-
	(0.0735)	(0.0961)	(0.114)	-	-
area	161.3***	174.1***	149.6***	209.4***	173.0***
	(34.62)	(38.41)	(36.55)	(38.39)	(35.63)
dens	2.050***	2.059***	3.668***	1.724***	3.994***
	(0.489)	(0.570)	(0.681)	(0.527)	(0.674)
gdppc	1.091*	1.749**	-0.826	2.901***	-1.280
	(0.573)	(0.721)	(0.875)	(0.587)	(0.779)
indratio	0.498	-0.277	1.054	-0.304	0.353
	(1.155)	(1.432)	(1.537)	(1.372)	(1.420)
agroratio	6.197***	5.649***	7.697***	5.973***	7.324***
	(0.927)	(1.135)	(1.228)	(1.079)	(1.121)
servratio	9.127***	9.398***	9.957***	10.34***	9.326***
	(0.971)	(1.194)	(1.307)	(1.125)	(1.196)
fjdmgeral	3.837***	5.119***	3.020***	0.933	2.998***
	(0.509)	(0.663)	(0.719)	(0.678)	(0.735)
fjfiscal	0.00621	-0.104**	0.168***	-0.435***	0.166***
	(0.0360)	(0.0463)	(0.0543)	(0.0447)	(0.0508)
emptotal	0.0394	-0.123	0.338	-0.864*	-0.480
	(0.462)	(0.553)	(0.711)	(0.460)	(0.551)
ac	-	-	-	5.417***	0.344
	-	-	-	(0.636)	(0.724)
Constant pattotr	-10.38***	-	-	-	-
	(0.837)	-	-	-	-
Constant hii	-	-12.05***	-	-9.288***	-
	-	(1.013)	-	(1.019)	-
Constant lii	-	-	-11.41***	-	-10.90***
	-	-	(1.101)	-	(1.058)

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Source: Author's archives (2023)

The econometrical regressions' results can be seen in Table 7 and several conclusions can be interpreted from these coefficients, with the answers for the questions and hypotheses posited being among them. The first interpretation must be regarding the independent variables chosen to investigate each phenomenon. According to the results, hypothesis H1, in other words, the influence of FDI and absorptive capacity in the process of fostering regional innovation within the regions studied cannot be discarded. This indicates that the capital flow originated in MNEs and the absorptive capacity of native industries combined establish a positive and significant relation with the production of patents in general, which in turn means that they catalyze possible innovation throughout the municipalities.

When it comes to the hypotheses H2a and H2b, one cannot be rejected, while the other can, having as basis the coefficients also observed in Table 7. It is possible that both FDI and AC combined do influence the production of high-intensity innovation, but not low-intensity innovation processes. This is interpreted by the positive and statistically relevant coefficient for H2a with a relatively low aggregated standard deviation on one side, and the negative result for H2b with a high associated standard deviation.

So, the influence and technologies brought by all possible avenues of foreign direct investment, together with a relevant AC for native companies, probably increase the production of invention patents. Nonetheless, this study found no evidence that the same occurs for utility models and certificates of addition. One explanation for this dichotomy is that generally technologies implemented by MNEs, and consequently the spillovers propagated to the surrounding environment have a high degree of complexity, while inventions with lower levels of innovation rely on other socio-economic regional factors to be explained.

Last but not least, one can infer from the results for hypotheses H3a and H3b that a similar situation took place. Native industries' absorptive capacity was found to be relevant in moderating the behavior of high-intensity inventions, but not so much of their low-intensity counterparts. Probably because the companies themselves can innovate in low-level technology fields, but benefit from external influences when it comes to high-level technologies. It is worth stressing that all analyses here are done with a 1% level of confidence, which equals to saying that in every 100 studies with the same method, approximately 99 will have the same result.

It is also important to verify the behavior of the external instrument employed and for the control variables chosen within the context of H1, H2a, and H3a, which were the hypotheses with no statistical evidence to reject their veracity. Both the production of patents in general and invention patents specifically maintain a negative correlation with the number of jobs offered regionally by MNEs.

This may happen because generally foreign enterprises tend to have more capital at their disposition to invest in processes and people, which generates a more stable and inclusive work environment, with higher wages and associated benefits. In counterpart, this causes evasion of qualified workforce from native to international companies. Nonetheless, this effect seems to be unable to cause a negative effect overall, when taking into consideration the influences of FDI and AC as well.

For the most part, the control variables chosen were also statistically relevant to encompass several distinct socio-economic and geographical aspects of the municipalities studied, except for the industrial ratio and the total number of jobs existent within the region. So, yet another conclusion possible to be made from this investigation is that elements such as social development (education, healthcare, wage, among others), GDP per capita, populational density, and geographical area are relevant to the proliferation of inventions since technology and societies are by definition complex ecosystems of ever-changing and correlating distinct phenomena.

CHAPTER 3: CONCLUSIONS AND IMPLICATIONS

The Geography of Innovation is a field of knowledge that will only grow in relevance since innovation markedly has a geographic component to its generation and dispersion. Within this context, inventions and their subsequent possible innovation results affect economic growth and technological change, just as explained in the literature review of this study. Innovation is not only spatially concentrated but also has spillovers that are geographically localized and nuanced. Moreover, each municipality is different in terms of urbanization, diversity, population, wages, and several other socioeconomic indexes.

3.1. CONCLUSIONS

The database used for the statistical analyses in this article is quite complex, with variables that present some barriers to the interpretation of the results since they reflect the inequalities existent throughout the Brazilian territory, more specifically in the state of São Paulo. Nonetheless, the database used had consistent results regarding characteristics such as heteroskedasticity, endogeneity, and cross-section dependence. To better interpret complex correlations and distinct indexes with an ample range of absolute values, the independent and control variables went through a process of normalization by the min-max method. The dependent variables are integers by nature and definition, so they remained with their "original" values for the econometrical regressions.

In sum, it was possible to conclude from this research that the influences of foreign direct investment (FDI) and regional absorptive capacity (AC) do foster regional innovation within the area studied. The relevance of the State of São Paulo and representability of the whole in terms of the indexes chosen was attested throughout the first chapter of this research. This catalyst effect was observed when it comes to patents in general and invention patents specifically, in other words, these elements affect more high-intensity innovation, without statistical evidence that they distinctly influence low-intensity innovation, namely utility models and certificates of addition.

Both the production of patents in general and invention patents specifically maintain a negative correlation with the number of jobs offered regionally by MNEs, which may happen because generally, foreign enterprises tend to have more capital at their disposition to invest in processes and people. Besides all that, the control indexes chosen were overall relevant to complement the statistical models.

3.2. LIMITATIONS AND SUGGESTIONS

There are some limitations to this research and, consequently, also opportunities and possibilities for future academic investigations. The first constriction exists because the geographical area studied is restricted to the state of São Paulo, which, despite its prominence in the patent deposit indexes and representativeness of the whole, does not comprise the data for the entire country. Another aspect to be quoted is the period studied, of which the last year the database contains is 2016 and, therefore, a little far from the current year. It was not possible to find all the data for more recent years, mainly the information needed to calculate the foreign direct investment index such as described throughout this investigation.

One more constraint is the focus of the study being solely on patents, not considering other types of intellectual property such as trademarks, copyrights, and trade secrets. Just as analyzed before, using patent deposits or patent grants as indexes for innovation is a common practice in this area of academic literature. Nevertheless, patents are only possible innovations, since to be considered as such they need to be implemented and other indexes can complement this perspective.

The last identified restraint is the lack of detailing of the patents in their categories according to the International Patent Classification (IPC – WIPO), which is made available in the context of Brazil by INPI. There is a lot to explore if one segments the patents produced by categories of technology, the results could highlight the specific industries to have investments fomented in a given region to obtain the best results in terms of the production of innovation.

For future research, one pertinent suggestion is to utilize the methodology here described to analyze the rest of the Brazilian states on a regional level and verify if the relations and conclusions from this study can be extrapolated to the entire country. Furthermore, interested academics could build another database comprising the recent years (2017-2021) and update the study for a different timespan. Other studies could expand to also examine the other aforementioned intellectual property categories, building an even more holistic panorama.

Moreover, it is important to investigate if they foment inventions and if these inventions become innovations that, in turn, improve local socioeconomic indexes, thus generating well-being to some degree in the society that lives there. Another important suggestion is to find more internal and external instruments relevant to the econometric analyses, producing even more reliable and robust results. Last but not least, there could be movement in the other direction, in other words, a discretization and analysis of the distinct patent categories and their respective relations with foreign direct investment and regional indexes.

3.3. DISSERTATION EXECUTION SCHEDULE 2022-2023

During the second half of the Master's degree, this investigation was partially developed during both semesters of 2022 and the beginning of the first semester of 2023, only until the end of January. The first chapter and several exploratory studies to understand the thematic, methodology needed, and fields of knowledge used were done during both semesters of 2021. The development followed approximately the schedule detailed in Table 8.

Table 8 – Execution Schedule

	2022		2023
Phases	**2022/1º**	**2022/2º**	**2023/1º**
Chapter 2: Literature revision	■		
Chapter 2: Method and Results	■		
Chapter 2: Conclusions, Limitations, and Suggestions	■		
Qualification		■	
Chapter 3: Conclusions		■	
Chapter 3: Limitations and Suggestions		■	
Chapter 2 – Article submission			■
Final writings			■
Defense			■

Source: Author's archives

3.4. FINAL CONSIDERATIONS

Some of the suggestions made within subsection 4.2. will be encompassed by the thesis that will be formulated for the present researcher's Ph.D. degree. The analyses will be more thorough since the researcher will use libraries available for programming with Python or R in the context of Data Science. The results obtained will also be presented in a more visual format, with geographical area representations, detailed comparisons, and a broader national panorama. Nonetheless, the aim and motivation will still be similar to the description provided in subsection 1.4. (Motivations).

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APPENDIXES

APPENDIX A – Description of the variables

Variable name	Description	Source
HII (PAT_PI)	Number of invention patents deposited at municipal level	INPI
LII (PAT_MUCA)	Number of utility models and certificates of addition deposited at municipal level	INPI
FDI	FDI intensity at municipal level	Measure created by ERMES Lab using data from SISCOMEX
AREA	Area of the municipality in square kilometers	IBGE
GDPPC	Gross Domestic Product *per capita* in real (R$)	Calculated with data from IBGE
DENS	Populational density at municipal level	Calculated with data from IBGE
INDRATIO	Industry GDP percentage	Calculated with data from IBGE
AGRIRATIO	Agribusiness GDP percentage	Calculated with data from IBGE
FJDMGERAL (health, education, wage, and jobs)	General Regional Development Index for socioeconomic indexes at municipal level	FIRJAN
FJFISCAL	Regional Development Index for educational conditions at municipal level	FIRJAN
EMPTOTAL	Total number of occupied jobs in general at municipal level	SEADE
EMPMNE	Total number of occupied jobs in Multinational Enterprises at municipal level	SEADE
AC	Absorptive capacity at municipal level	Calculated with data from IBGE and MCTI

APPENDIX B – Compiled Econometric Regression Results

VARIABLES	(1) POISSON_H1	(2) POISSON_H2a	(3) POISSON_H2b	(4) POISSON_H3a	(5) POISSON_H3b
lfdiac	3.348**	7.333***	-1.208		
	(1.419)	(1.829)	(2.231)		
empmne	-0.231***	-0.595***	0.229**		
	(0.0735)	(0.0961)	(0.114)		
area	161.3***	174.1***	149.6***	209.4***	173.0***
	(34.62)	(38.41)	(36.55)	(38.39)	(35.63)
dens	2.050***	2.059***	3.668***	1.724***	3.994***
	(0.489)	(0.570)	(0.681)	(0.527)	(0.674)
gdppc	1.091*	1.749**	-0.826	2.901***	-1.280
	(0.573)	(0.721)	(0.875)	(0.587)	(0.779)
indratio	0.498	-0.277	1.054	-0.304	0.353
	(1.155)	(1.432)	(1.537)	(1.372)	(1.420)
agroratio	6.197***	5.649***	7.697***	5.973***	7.324***
	(0.927)	(1.135)	(1.228)	(1.079)	(1.121)
servratio	9.127***	9.398***	9.957***	10.34***	9.326***
	(0.971)	(1.194)	(1.307)	(1.125)	(1.196)
fjdmgeral	3.837***	5.119***	3.020***	0.933	2.998***
	(0.509)	(0.663)	(0.719)	(0.678)	(0.735)
fjfiscal	0.00621	-0.104**	0.168***	-0.435***	0.166***
	(0.0360)	(0.0463)	(0.0543)	(0.0447)	(0.0508)
emptotal	0.0394	-0.123	0.338	-0.864*	-0.480
	(0.462)	(0.553)	(0.711)	(0.460)	(0.551)
Constant pattotr	-10.38***				
	(0.837)				
/lnalpha	0.453***	0.529***	0.346***	0.615***	0.346***
	(0.0876)	(0.0977)	(0.105)	(0.0943)	(0.102)
ac				5.417***	0.344
				(0.636)	(0.724)
Constant hii		-12.05***		-9.288***	
		(1.013)		(1.019)	
Constant lii			-11.41***		-10.90***
			(1.101)		(1.058)
Observations	2,622	2,622	2,622	3,059	3,059
Number of ibge7	437	437	437	437	437

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

APPENDIX C – Compiled SYS-GMM Test Results

VARIABLES	(1) SYS- GMM_H1	(2) SYS- GMM_H2a	(3) SYS- GMM_H2b	(4) SYS- GMM_H3a	(5) SYS- GMM_H3b
L.pattotr	-0.739***				
	(0.0324)				
lfdiac	167.4	136.3	136.3		
	(201.6)	(154.9)	(154.9)		
empmne	-289.9***	-291.8***	-291.8***		
	(73.84)	(86.88)	(86.88)		
area	-74,319	-68,842	-68,842	-72,857	1,903
	(63,318)	(62,549)	(62,549)	(67,152)	(3,263)
dens	-436.6	-1,320	-1,320	-1,341	6.214
	(831.5)	(1,089)	(1,089)	(1,075)	(25.04)
gdppc	-10.49	-7.047	-7.047	-2.821	1.458
	(13.81)	(14.73)	(14.73)	(13.75)	(1.039)
indratio	12.65	5.825	5.825	-2.936	-0.211
	(10.19)	(8.966)	(8.966)	(5.266)	(1.527)
agroratio	18.31	6.742	6.742	-1.400	-1.985
	(18.23)	(17.96)	(17.96)	(13.51)	(2.956)
servratio	28.85	13.62	13.62	7.235	-2.165
	(26.80)	(32.15)	(32.15)	(28.08)	(4.154)
fjdmgeral	13.01	4.709	4.709	-2.800	-2.970
	(16.91)	(19.36)	(19.36)	(16.39)	(2.541)
fjfiscal	-4.779	-2.325	-2.325	-4.226	0.835*
	(6.355)	(5.080)	(5.080)	(6.509)	(0.460)
emptotal	2,437***	2,169**	2,169**	1,999**	572.1***
	(694.7)	(1,003)	(1,003)	(996.7)	(20.23)
L.hii		-0.727***	-0.727***	-0.710***	
		(0.0242)	(0.0242)	(0.0228)	
ac				25.84	1.453
				(24.99)	(1.419)
L.lii					-0.413***
					(0.0753)
Constant	181.2	211.5	211.5	235.8	-1.603
	(145.9)	(177.2)	(177.2)	(198.6)	(8.073)
Observations	2,622	2,622	2,622	2,622	2,622
Number of ibge7	437	437	437	437	437

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX D – EndogeneityTests Results

	ENDOG_LIML						ENDOG_GMM					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
VARIABLES	pattotr_fdi	pattotr_lfdiac	hii_fdi	hii_lfdiac	hii_fdi	hii_lfdiac	pattotr_fdi	pattotr_lfdiac	hii_fdi	hii_lfdiac	lii_fdi	lii_lfdiac
wh_fdi	21.01		23.72		-2.717		21.01		23.72		-2.717	
	(43.10)		(44.16)		(3.621)		(42.99)		(44.05)		(3.612)	
lac	-6.800		-7.014		0.214		-6.800		-7.014		0.214	
	(21.39)		(22.54)		(2.412)		(21.34)		(22.49)		(2.406)	
area	-6,245	-7,779	2,370	-963.1	-8,614	-6,815	-6,245	-7,779	2,370	-963.1	-8,614	-6,815
	(23,584)	(24,720)	(23,449)	(23,972)	(5,918)	(5,881)	(23,524)	(24,649)	(23,390)	(23,903)	(5,903)	(5,864)
dens	-261.8	-111.0	-303.7	-187.4	41.96	76.43	-261.8	-111.0	-303.7	-187.4	41.96	76.43
	(291.8)	(376.2)	(305.0)	(423.9)	(37.97)	(76.17)	(291.1)	(375.1)	(304.2)	(422.7)	(37.88)	(75.95)
gdppc	2.982	-5.399	2.824	-4.543	0.159	-0.856	2.982	-5.399	2.824	-4.543	0.159	-0.856
	(7.762)	(18.21)	(8.366)	(18.70)	(1.238)	(2.329)	(7.743)	(18.16)	(8.345)	(18.64)	(1.235)	(2.323)
indratio	3.067	7.141	1.706	5.691	1.361	1.450	3.067	7.141	1.706	5.691	1.361	1.450
	(4.385)	(9.455)	(4.698)	(9.650)	(0.938)	(1.267)	(4.374)	(9.428)	(4.687)	(9.622)	(0.936)	(1.264)
agroratio	0.548	6.137	0.117	5.024	0.431	1.112	0.548	6.137	0.117	5.024	0.431	1.112
	(4.130)	(12.44)	(4.292)	(12.74)	(0.849)	(1.570)	(4.120)	(12.41)	(4.281)	(12.70)	(0.846)	(1.565)
servratio	5.640	10.39	5.949	9.763	-0.310	0.630	5.640	10.39	5.949	9.763	-0.310	0.630
	(6.700)	(13.87)	(6.891)	(14.15)	(1.053)	(1.560)	(6.683)	(13.83)	(6.873)	(14.11)	(1.051)	(1.555)
fjdmgeral	1.191	0.919	0.240	-0.512	0.951	1.431	1.191	0.919	0.240	-0.512	0.951	1.431
	(4.138)	(5.660)	(4.661)	(5.937)	(0.998)	(1.078)	(4.128)	(5.644)	(4.649)	(5.920)	(0.995)	(1.075)
fjfiscal	0.798	1.085	0.0859	0.314	0.712***	0.771***	0.798	1.085	0.0859	0.314	0.712***	0.771***
	(0.958)	(1.125)	(1.068)	(1.232)	(0.221)	(0.248)	(0.956)	(1.121)	(1.066)	(1.229)	(0.221)	(0.247)
emptotal	-1,000	584.0	-842.9	710.7	-157.2	-126.7	-1,000	584.0	-842.9	710.7	-157.2	-126.7
	(4,086)	(5,288)	(4,260)	(5,379)	(385.8)	(370.1)	(4,076)	(5,273)	(4,249)	(5,363)	(384.8)	(369.1)
lfdiac		555.1		522.8		32.30		555.1		522.8		32.30
		(633.0)		(660.2)		(74.92)		(631.2)		(658.3)		(74.71)

Observations	2,622	2,185	2,622	2,185	2,622	2,185	2,622	2,185	2,622	2,185	2,622	2,185
R-squared	0.010	-0.012	0.008	-0.004	0.025	0.015	0.010	-0.012	0.008	-0.004	0.025	0.015
Number of ibge7	437	437	437	437	437	437	437	437	437	437	437	437

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

APPENDIX E – Hausmann & Wooldridge Tests Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	Haus_H1	Haus_H2a	Haus_H2b	Haus_H3a	Haus_H3b	Woold_H1	Woold_H2a	Woold_H2b	Woold_H3a	Woold_H3b
lfdiac	149.5*	213.7***	-60.23***							
	(78.72)	(76.86)	(11.82)							
empmne	-148.7***	-191.3***	74.61***							
	(21.79)	(21.43)	(3.186)							
area	125.6	114.6	24.37	176.8	3.964					
	(170.7)	(157.8)	(34.34)	(160.8)	(33.47)					
dens	-0.419	-1.993	1.940***	-0.689	1.448**					
	(3.424)	(3.162)	(0.693)	(3.214)	(0.673)					
gdppc	-3.604	-2.121	-0.751	2.806	-2.063*					
	(6.558)	(6.221)	(1.128)	(6.243)	(1.153)					
indratio	2.274	1.460	1.045	1.210	1.029					
	(7.356)	(6.920)	(1.323)	(7.032)	(1.346)					
agroratio	2.535	1.410	1.298	1.726	1.219					
	(6.332)	(5.958)	(1.140)	(6.068)	(1.160)					
servratio	3.820	2.431	1.749	4.134	1.103					
	(7.080)	(6.675)	(1.265)	(6.790)	(1.289)					
fjdmgeral	3.614	0.898	1.964**	2.888	1.409					
	(6.140)	(5.896)	(0.991)	(6.081)	(1.059)					
fjfiscal	0.0893	-0.513	0.502***	-1.082	0.644***					
	(1.067)	(1.076)	(0.146)	(1.120)	(0.166)					
emptotal	1,058***	678.5***	354.4***	535.8***	410.5***					
	(18.39)	(17.89)	(2.907)	(7.395)	(1.551)					
lac				-5.126	-2.400					
				(12.52)	(1.869)					

L.__000006						-0.900***	-0.880***	-0.430***	-0.931***	-0.542***
						(0.0220)	(0.0246)	(0.0448)	(0.0183)	(0.0321)
ac										
Constant	-6.263	-2.762	-3.154***	-5.138	-2.287**					
	(5.955)	(5.595)	(1.086)	(5.757)	(1.108)					
Observations	2,622	2,622	2,622	2,622	2,622	1,748	1,748	1,748	2,185	2,185
R-squared						0.632	0.614	0.176	0.643	0.290
Number of ibge7	437	437	437	437	437					

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

APPENDIX F – Modified Wald and Pesaran Tests Results

(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Wald_H1	Wald_H2a	Wald_H2b	Wald_H3a	Wald_H3b	Pesaran_H1	Pesaran_H2a	Pesaran_H2b	Pesaran_H3a	Pesaran_H3b
30.45	87.20	-56.75***			30.45	87.21	-56.75***		
(103.4)	(107.0)	(11.99)			(103.4)	(107.0)	(11.99)		
-151.5***	-251.6***	100.0***			-151.5***	-251.6***	100.0***		
(26.85)	(27.77)	(3.112)			(26.85)	(27.77)	(3.112)		
-14,898	-7,998	-6,901	-7,786	-3,441	-14,898			-7,786	-3,441
(133,626)	(138,205)	(15,488)	(117,540)	(16,170)	(133,626)			(117,540)	(16,170)
-241.4***	-264.8***	23.40**	-247.0***	44.09***	-241.4***	-264.7***	23.44**	-247.0***	44.09***
(93.24)	(96.43)	(10.81)	(75.80)	(10.43)	(93.24)	(96.41)	(10.80)	(75.80)	(10.43)
4.817	3.607	1.210	8.525	0.294	4.817	3.611	1.214	8.525	0.294
(12.90)	(13.35)	(1.496)	(11.62)	(1.598)	(12.90)	(13.34)	(1.495)	(11.62)	(1.598)
3.716	2.739	0.976	1.506	0.612	3.716	2.775	1.007	1.506	0.612
(18.18)	(18.81)	(2.107)	(15.10)	(2.077)	(18.18)	(18.79)	(2.106)	(15.10)	(2.077)
-0.138	-0.194	0.0556	-1.939	-0.175	-0.138	-0.172	0.0745	-1.939	-0.175
(17.06)	(17.65)	(1.978)	(14.18)	(1.951)	(17.06)	(17.64)	(1.977)	(14.18)	(1.951)
4.059	4.308	-0.249	4.757	-0.587	4.059	4.336	-0.225	4.757	-0.587
(19.54)	(20.21)	(2.264)	(16.30)	(2.242)	(19.54)	(20.20)	(2.263)	(16.30)	(2.242)
2.574	1.823	0.751	1.583	0.101	2.574	1.825	0.753	1.583	0.101
(10.04)	(10.38)	(1.163)	(8.478)	(1.166)	(10.04)	(10.38)	(1.163)	(8.478)	(1.166)
1.202	0.697	0.505***	0.293	0.617***	1.202	0.696	0.504***	0.293	0.617***
(1.264)	(1.308)	(0.147)	(1.173)	(0.161)	(1.264)	(1.307)	(0.147)	(1.173)	(0.161)
-936.0***	-735.9***	-200.2***	-1,830***	-84.50***	-936.0***	-735.8***	-200.1***	-1,830***	-84.50***
(256.6)	(265.4)	(29.75)	(193.5)	(26.62)	(256.6)	(265.4)	(29.74)	(193.5)	(26.62)

			7.371	2.228				7.371	2.228
			(12.87)	(1.770)				(12.87)	(1.770)
54.09	33.97	20.12	38.52	10.48	54.09	12.42	1.528	38.52	10.48
(360.6)	(373.0)	(41.79)	(317.0)	(43.61)	(360.6)	(19.24)	(2.156)	(317.0)	(43.61)
2,622	2,622	2,622	3,059	3,059	2,622	2,622	2,622	3,059	3,059
0.025	0.046	0.345	0.039	0.023	0.025	0.046	0.345	0.039	0.023
437	437	437	437	437	437	437	437	437	437

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

APPENDIX G – Variance Inflation Factor (VIF) and Correlation Tests Results

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	VIF_H1	VIF_H2a	VIF_H2b	VIF_H3a	VIF_H3b	CorrelationTestGeneral
lfdiac	149.5*	213.7***	-60.23***			
	(78.72)	(76.86)	(11.82)			
empmne	-148.7***	-191.3***	74.61***			
	(21.79)	(21.43)	(3.186)			
area	125.6	114.6	24.37	169.2	1.675	1.675
	(170.7)	(157.8)	(34.34)	(148.0)	(32.07)	(32.07)
dens	-0.419	-1.993	1.940***	-1.629	1.178*	1.178*
	(3.424)	(3.162)	(0.693)	(2.995)	(0.653)	(0.653)
gdppc	-3.604	-2.121	-0.751	1.470	-2.435**	-2.435**
	(6.558)	(6.221)	(1.128)	(5.806)	(1.091)	(1.091)
indratio	2.274	1.460	1.045	0.338	0.955	0.955
	(7.356)	(6.920)	(1.323)	(6.350)	(1.231)	(1.231)
agroratio	2.535	1.410	1.298	0.887	1.097	1.097
	(6.332)	(5.958)	(1.140)	(5.505)	(1.067)	(1.067)
servratio	3.820	2.431	1.749	2.838	0.972	0.972
	(7.080)	(6.675)	(1.265)	(6.183)	(1.190)	(1.190)
fjdmgeral	3.614	0.898	1.964**	2.453	1.013	1.013
	(6.140)	(5.896)	(0.991)	(5.282)	(0.927)	(0.927)
fjfiscal	0.0893	-0.513	0.502***	-1.054	0.621***	0.621***
	(1.067)	(1.076)	(0.146)	(0.954)	(0.143)	(0.143)
emptotal	1,058***	678.5***	354.4***	567.6***	413.4***	413.4***
	(18.39)	(17.89)	(2.907)	(6.889)	(1.504)	(1.504)
ac				5.711	0.772	0.772
				(11.37)	(1.719)	(1.719)
Constant	-6.263	-2.762	-3.154***	-4.139	-1.893*	-1.893*
	(5.955)	(5.595)	(1.086)	(5.121)	(1.011)	(1.011)
Observations	2,622	2,622	2,622	3,059	3,059	3,059
Number of ibge7	437	437	437	437	437	437

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

APPENDIX H – Dispersion Tests

(7)	(8)	(9)	(10)	(11)
DispersionTest_H1	DispersionTest_H2a	DispersionTest_H2b	DispersionTest_H3a	DispersionTest_H3b
0.137	0.340	0.0535	0.300	0.0293
(0.296)	(2.373)	(0.0777)	(6.637)	(0.0756)
2,622	2,622	2,622	3,059	3,059

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1