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INNOVATION ECOSYSTEMS OF BRAZILIAN FEDERAL UNIVERSITIES: A MAPPING OF TECHNOLOGICAL INNOVATION CENTERS, INCUBATORS OF TECHNOLOGY-BASED COMPANIES AND TECHNOLOGICAL PARKS

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ABSTRACT

Technological innovation as an engine for development requires a structural apparatus to its consolidation, reinforcing the approach of innovation systems, with emphasis on the role of universities. Therefore, considering that associated with this potential are present several innovative elements, such as the Technological Innovation Centers (NITs), the incubators of technology-based companies (IEBTs) and Technology Parks (ParqTecs), and given the lack of systematization National these instruments, the ultimate goal of this study was to analyze the environment for innovation in Brazilian federal universities, through the mapping of NITs, the IEBTs and ParqTecs associated with these institutions, further outlining the relationship of these instruments with technological variables (technological scholarships and patents). We used a qualitative and quantitative approach, descriptive nature, with collection of secondary data on institutional sites of universities and the adoption of simple linear regression analysis. The results realized all 63 Brazilian federal universities and revealed that the most widespread instrument between universities are the NITs, since its presence in 86% of the analyzed institutions. Have business incubators, idealized to strengthen interaction in innovation systems, are associated with 68% of universities, enabling regional development contexts. In relation to technology parks, it was found that, depending on the expenditure required for its implementation, only 26 universities are integrated into ParqTecs. The contributions of this study are concentrated in addition to the mapping done in highlighting the distinctions between the Brazilian regions in terms of scientific and technological structure and the importance of innovation ecosystems.

Keywords: Mapping, Technological Innovation Centers, Business Incubators, Technology Parks, Brazilian federal universities.

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ECOSSISTEMAS DE INOVAÇÃO DAS UNIVERSIDADES FEDERAIS BRASILEIRAS: UM MAPEAMENTO DOS NÚCLEOS DE INOVAÇÃO TECNOLÓGICA, INCUBADORAS DE EMPRESAS DE BASE TECNOLÓGICA E PARQUES TECNOLÓGICOS

RESUMO

A inovação tecnológica enquanto motor do desenvolvimento requer um aparato estrutural para a sua consolidação, reforçando a abordagem dos sistemas de inovação, com destaque para a atuação das universidades. Portanto, considerando que associados a esse potencial estão presentes diversos elementos de inovação, como os Núcleos de Inovação Tecnológica (NITs), as Incubadoras de Empresas de Base Tecnológica (IEBTs) e os Parques Tecnológicos (ParqTecs), e dada a carência de uma sistematização nacional desses instrumentos, o objetivo final deste artigo foi analisar o ambiente de inovação das universidades federais brasileiras, por meio do mapeamento dos NITs, das IEBTs e dos ParqTecs associados a essas instituições, delineando ainda a relação destes instrumentos com variáveis tecnológicas (bolsas tecnológicas e patentes). Utilizou-se uma abordagem quali-quantitativa, de cunho descritivo, com levantamento de dados secundários nos sites institucionais das universidades e a adoção da análise de Regressão Linear Simples. Os resultados compreenderam todas as 63 universidades federais brasileiras e revelaram que o instrumento mais difundido entre as universidades são os NITs, visto sua presença em 86% das instituições analisadas. Já as incubadoras de empresas, idealizadas para fortalecer a interação nos sistemas de inovação, estão associadas a 68% das universidades, viabilizando os contextos regionais do desenvolvimento. Em relação aos parques tecnológicos, verificou-se que, em função dos dispêndios necessários para a sua implantação, apenas 26 universidades estão integradas a ParqTecs. As contribuições deste estudo se concentram, além do mapeamento realizado, em evidenciar as distinções entre as regiões brasileiras em termos de estrutura científico-tecnológica e a importância dos ecossistemas de inovação.

Palavras-chave: Mapeamento, Núcleos de Inovação Tecnológica, Incubadoras de Empresas, Parques Tecnológicos, Universidades Federais Brasileiras.

ECOSISTEMAS DE INNOVACIÓN DE LAS UNIVERSIDADES FEDERALES BRASILEÑAS: UN MAPA DE LOS NÚCLEOS DE INNOVACIÓN TECNOLÓGICA, INCUBADORAS DE EMPRESAS BASE TECNOLÓGICA Y PARQUES TECNOLÓGICOS

RESUMEN

La innovación tecnológica como motor del desarrollo requiere un aparato estructural para su consolidación, reforzando el abordaje de los sistemas de innovación, con destaque para la actuación de las universidades. Por lo tanto, considerando que asociados a ese potencial están presentes diversos elementos de innovación, como los Núcleos de Innovación Tecnológica (NITs), las Incubadoras de Empresas de Base Tecnológica (IEBTs) y los Parques Tecnológicos (ParqTecs), y dada la carencia de una sistematización en el marco de las políticas de desarrollo de la sociedad civil y de la sociedad civil y de la sociedad civil, patente). Se utilizó un abordaje cuali-cuantitativo, de cuño descriptivo, con levantamiento de datos secundarios en los sitios institucionales de las universidades y la adopción del análisis de Regresión Lineal Simple. Los resultados comprendieron todas las 63 universidades federales brasileñas y revelaron que el instrumento más difundido entre las universidades son los NIT, visto su presencia en el 86% de las instituciones analizadas. Las incubadoras de empresas, ideadas para fortalecer la interacción en los sistemas de innovación, están asociadas al 68% de las universidades, viabilizando los contextos regionales del desarrollo. En cuanto a los parques tecnológicos, se verificó que, en función de los desembolsos necesarios para su implantación, sólo 26 universidades están integradas a ParqTecs. Las contribuciones de este estudio se concentran, además del mapeamiento realizado, en evidenciar las distinciones entre las regiones brasileñas en términos de estructura científico-tecnológica y la importancia de los ecosistemas de innovación.

Palabras clave: Mapeamiento, Núcleos de Innovación Tecnológica, Incubadoras de Empresas, Parques Tecnológicos, Universidades Federales Brasileñas.

1 Introduction

The constant advances in the world economic system have modified the way of thinking and acting on society, a fact that has been corroborated by the intensification of world competition, major technological and communication advances and reduction of geopolitical borders in an economy based on knowledge, information and innovation , digital expansion, and other elements that encourage organizations to seek new alternatives to remain active and competitive in the market (Borges *et al.*, 2004, Morschel *et al.*, 2013, Machado *et al.*, 2014, Marques *et al.*, 2014).

As Efrat (2014) emphasizes, in this current economic scenario, a greater focus on innovation has been observed as a fundamental element in the new economic models. Thus, innovation becomes a key element for the competitive differentiation of organizations (Fossas-Olalla *et al.*, 2015). Therefore, this new context has begun to interfere with various types of players, such as governments, regulatory bodies, companies, investors and other stakeholders, including universities (Paloma Sánchez & Elena, 2006).

Faced with this perspective, the need for new players that strengthened the promotion of innovation, universities saw the opportunities to transform scientific potential into technological capital, since these institutions have the essential requirements for technological promotion, such as trained personnel, laboratories and partnerships with public and private organizations (Marques *et al.*, 2014). Cowan and Zinovyeva (2013) also emphasize that the increase in the development of innovations coincides with the expansion of the university sector and, consequently, one can infer that the innovation performance corresponds to the offer of innovations studies by the universities in a given economy.

Thus, assuming that applied research is a result of efforts initiated in basic research, we can say that according to Löfsten and Lindelöf (2005), higher education institutions are important agents in the production and dissemination of new scientific knowledge. In this context, it emerged that Brazil has excelled worldwide in academic research being responsible for about 53% of this production in Latin America. This puts the country in the 15th place in the volume of world scientific production, just behind the Netherlands (PPG, 2012).

Considering the potential of Brazilian HEIs in the production of basic world research, it is clear that they also stand out in technological production. As demonstrated by Thomson Reuters (2013), of the ten largest patent holders in Brazil from 2003 to 2012, five are public universities, which hold 27% of patents deposited in the country. This result emerges from a process in which HEIs, in addition to maintaining their basic premise of teaching, research and extension, also began to produce applied research.

The rapid increase in university initiatives with a focus on innovative activities has been the emphasis of empirical studies, mainly in first-world countries regions such as the United States (Link & Siegel, 2005). Therefore, considering that associated to this potential are several elements of innovation, such as the Technological Innovation Centers (NITs), the Technological Base Incubators (IEBTs) and the Technological Parks (ParqTecs) and given the lack of a national systematization of these instruments, the objective of this paper was to analyze the innovation environment of Brazilian federal universities through the mapping of the NITs, IEBTs and ParqTecs associated with these institutions and outlining the relationship between these instruments and other technological variables (technological scholarships and patents).

To this end, this article is structured in five more sections besides this introduction. The next section presents the theoretical approaches on innovation, development, innovation system and universities dealing with the innovation process. The methodological procedures used to achieve the proposed objectives

are presented in the third section. Next, the analysis and discussion of the results are presented, including the mapping of innovation instruments and the variables of innovation, technological scholarships and patents. In the final two sections, we present the final considerations as well as the bibliographic references used to develop the study.

2 Innovation, development and innovation system

Given the current market context, based on shorter product life cycles, as well as the constant change in consumer preferences and needs (Martín-de Castro, 2015), technological innovation has become an important factor for organizations. These changes in the environment provide an increase in the competitiveness among organizations as well as the search for excellence of new products and processes that corroborate the development of technological innovations in industries based on knowledge and high technology (Haase *et al.*, 2009, Martín-de Castro, 2015).

In this way, innovation becomes a key element for the competitiveness, survival and growth of organizations (Fossas-Olalla *et al.*, 2015). To that end, since innovation has been a goal for different types of organizations, they must observe the contexts in which they are inserted, as well as their characteristics, as a way to foment and to eliminate the barriers that impede the activities of innovation (Bruno- Faria & Fonseca, 2014).

However, it is necessary to distinguish the concepts of invention and innovation, since the former can be considered a creation of a new process, technique or new product, whereas innovation only occurs with the definitive marketing of an invention generating economic benefits for the organization that owns it (Tigre, 2006, Yeo *et al.*, 2015). In this way, since innovation provides advantages to organizations, according to Deng *et al.* (1999), firms that innovate faster are generally more successful in product development and marketing than companies relying on older technologies.

As Machado *et al.* (2012) clarify, although the concept of innovation is constantly related to an object, such as a microcomputer or a new car model, its definition can assume other forms of conceptualization. According to the OECD (2005), innovation can be interpreted as an implementation of a product, whether it is a new or improved product or service, a new process or a new marketing method, or a new method organizational, applied in the business activities, in the workplace organization or in the company external interactions.

Seen in these terms, it is essential to understand innovation, as well as the processes related to it to understand the social, scientific and economic changes underlying productivity and success of companies, communities and nations (Green *et al.*, 2015). Thus, the term innovation refers to the process in which a new idea, an object or a practice is created, developed or improved (Machado, 2007).

Organizational innovations have the ability to modify processes, decision-making structures, relationships between teams and individuals, as well as several other elements of organizational life (Machado *et al.*, 2014). Thus, as can be observed, innovation affects the entire organizational culture and its management must have a holistic and diversified view of the organization as a whole (Moreira & Stramar, 2014). However, although innovation is considered essential for organizations, often the organizational culture does not change to keep up with the changes that the organization suffers (Morschel *et al.*, 2013).

Considering that in a process of innovation, organizations do not innovate on their own but through interaction with several agents, the fundamental role of an innovation system is highlighted (Lemos, 2003). Palm (2014) conceptualizes a system of innovation as an interaction of several institutions that jointly and individually cooperate for the generation and diffusion of new technologies and innovation and learning are essential

elements of this interaction. Also, according to Leydesdorff (2000), in the collaboration between organizations can occur interactions between clients, suppliers, regulators and knowledge providers.

To this end, within a system of innovation, the main agents that stand out in this interaction are the universities, the companies and the government, constituting what is defined as a triple helix. According to Ivanova and Leydesdorff (2014), this model considers that manufacturing ceases to be the driving force of economic development in the post-industrial phase, focusing on the production and dissemination of knowledge. Etzkowitz (2009) finds that these agents end up assuming the role of each other during their relationships, while continuing with their primary characteristics and their unique identities.

Consequently, universities, in the triple helix relationships, in addition to their primary activities as teaching and research, are increasingly stimulated to develop business-related functions and creation of technology-based companies, assuming an industry role. Industrial corporations, in turn, develop academic activities and set up their own research and training programmes and workforce training centers to generate increasingly high levels of competitiveness. Finally, the government encourages the development of innovative small businesses through university funding and regulation as well as stimulates the industry to develop and implement new technologies (Etzkowitz, 2009, Ivanova & Leydesdorff, 2014).

Therefore, it can be observed that the universities gain notoriety in a system of innovation, being considered by Fujino et al. (1999) as institutions that, in addition to generating scientific knowledge and qualifying qualified workforce for society, are oriented by other system entities to develop activities focused on innovation. Thus, universities are primarily responsible for the discovery of talents, knowledge generation, advancement in scientific and technological research, as well as the transfer of their academic research (Zhao et al., 2014). The universities that have their management focused on innovation will be discussed in the following sections.

3 Universities in the face of the innovation process

The scientific and technological knowledge generated through academic research provides universities with a remarkable recognition as key players in the production of innovation in a given economic context. Thus, as Krabel and Mueller (2009) emphasize, a number of universities have shifted from their traditional premises, such as teaching and basic research, to a more entrepreneurial mission, with industry partnerships and business focus on their academic personnel. This premise emerged along with the expansion of disciplines such as biotechnology, as well as through the growing influence of globalization (Rasmussen *et al.*, 2006).

Although much of the innovation has focused on private firms, there has been a greater interest in expanding these activities to public organizations, such as universities and research centers recently, mainly because their main objectives in the production and dissemination of knowledge. Thus, the modern university needs to face a number of challenges, such as increasing pressures to obtain funding, management reforms, the arrival of new forms of knowledge, the interference of technology in teaching / learning models and the need to introduce new strategies and ways of acting in the current society and economy characterized by knowledge (Eiriz, 2007).

In order to do that, the generation of university knowledge becomes an important element for industrial innovation in the current context (Wu, Chen, & Chen, 2010, Maietta, 2015). Universities need to adapt their academic structures, allowing them to act more efficiently in the technological management, as well as to better enjoy the results of their academic research (Garnica, Oliveira, & Torkomian, 2006).

Thus, the university's role came to be understood as a driver of economic growth, collaborating to the generation of knowledge, and consecutively, of technology, through its innovative context (Guerrero, Cunningham, & Urbano, 2014). As owner of technology, Universities become responsible for their transfer and dissemination, which may occur through various communication channels, such as publications, conferences and academic events, licensing and commercialization of intellectual property, movement of staff through hiring, consultancies, informal communications, among others (Carayannis *et al.*, 1998, Sampat, 2006).

Broadly, universities contribute to economic development either through interaction with existing industry, through the commercialization of generated knowledge or through the creation of new companies (Rasmussen, Moen, & Gulbrandsen, 2006). Thus, in addition to producing marketable knowledge, such as patents and licensing, and trained personnel such as students, universities impact society in a number of other ways, such as through new enterprises, job and talent creation, and cooperation with other local, regional or international organizations (Guerrero, Cunningham, & Urbano, 2014).

Although the main activity carried out by university professors is still considered the generation of academic research and its publication as a way to boost the generation of knowledge, scientists are currently being more driven to the development of applied research, such as patents (Cowan & Zinovyeva, 2013). As Segatto-Mendes and Mendes (2006) emphasize, the capitalization of knowledge is a result of entrepreneurial researchers, who are articulated as intermediary agents in the production and dissemination of innovation.

Thus, scientists are increasingly inserted in a context where they seek to commercialize the results of their research, through channels such as patenting, licensing, consulting and business creation (Krabel & Mueller, 2009). However, this new university mission perspective also provides new challenges for educational institutions, especially in promoting and marketing the results of academic research (Fujino, Stal, & Plonski, 1999, Rasmussen, Moen, & Gulbrandsen, 2006). As Marques et al. (2014) and Kalar and Antoncic (2015) demonstrate through their studies, there is still a separation between the academics and their activities to promote a more innovative university, so that the institution contexts, influences in this process whether an academic will relate to more entrepreneurial activities.

Guaranys (2010) reveals that an entrepreneurial university is characterized by several factors, such as the creation and management of research groups, the organization of a structure that allows the transfer of the research carried out in the institution to the market, stimulation of companies creation from the university itself, the establishment of shared research centers with companies and, finally, a most direct action in the socioeconomic development of the region where it is inserted.

Three main elements stand out as important tools for innovation in the current ecosystems developed by the so-called entrepreneurial universities: Technological Innovation Centers (NITs), Technological-based Business Incubators (IEBTs) and Technological Parks (ParqTecs), according to Table 1 (Castells & Hall, 1994, Drummond, 2005). The NITs, or international technology transfer offices (ETTs), were designed to assist in the management of the knowledge generated in the academy, while the IEBTs are focused on supporting, through physical and managerial infrastructure, the first years of life of the nascent companies of technological base, and, finally, the ParqTecs are considered inducers of the regional and local development, since they have as objective the attraction and fixation of new enterprises of technological base (Drummond, 2005).

Table 1

Main Concepts and Characteristics of NITs, IEBTs and ParqTecs.

NITs (ETTs)	Have the purpose to manage the innovation policy of science and technology Institutions (Brasil, 2004).
	Are of strategic importance to universities committed to the commercialization of academic knowledge (O'kanea *et al.*, 2015).
	Must have the ability to assess the technological inventions, to ensure intellectual property rights, identify business partners and establish new ventures for commercial exploitation of academic inventions (Weckowska, 2015).
	They have important objectives are to encourage the disclosure of potentially marketable inventions, managing the University's intellectual property, ensure the resources for the development of research and brokering relations between researchers companies and University managers (Weckowska, 2015).
	They promote guidance for research and development (P&D) and technology transfer, assist in the preparation of offers (management, dissemination and exploitation), support the drafting and negotiation of contracts with companies and manage contacts (Porcel *et al.*, 2012).
	Are fundamental to the development of relations with industry (Macho-Stadler, Pérez-Castrillo & Veugelers, 2007).
IEBTs	They are one of the possible solutions considered in economic literature to support the low economic growth of regions and have been actually deployed in several countries in order to develop new business with strong components of innovation (Tola & Contini, 2015).
	They provide services to micro and small enterprises, such as access to low-cost facilities, access to networks of interaction, assistance in developing business and marketing plans and assistance in management activities, both how much financial administrative (Tzameret, Aas & Stead, 2015).
	They seek to boost regional development through the promotion of business and employment generation, having as main objectives, therefore, creating and development companies, as well as subsidizing these companies without successful (Mas-Verdú, Ribeiro-Soriano & Roig-Tierno, 2015).
	They present themselves as economic benefits highlighted the enhancement of competitiveness of businesses supported income generation, an increase in the tax burden generated and activation of local economies (Fonseca & Jabbour, 2012).

ParqTecs	They are dedicated to the research, development and production of products with high technological content (Drummond, 2005).
	They present as objective, the socio-economic development of the region, from increasing the competitiveness of enterprises and the generation of jobs (Castells & Hall, 1994).
	They exert the function of connection between suppliers and users of technologies, and in environments conducive to the exchange of knowledge and other forms of interaction. Are considered as undertakings responsible for promoting the culture of innovation and competitiveness of enterprises, based on the production and transfer of technology (Soly *et al.*, 2012).
	They are instruments deployed in developed and developing countries to boost regional and national economies, adding to content knowledge. With that these economies become more competitive on the international stage and generate quality jobs, social welfare, plus taxes (Steiner, Cassim & Robazzi, 2008).
	They are at a concentration of innovative companies and other organizations in a given region, to create a culture of innovation, generates a continuous flow of information and knowledge sharing, both between enterprises and between enterprises and institutions academics, often through informal channels (Hu, 2007).

Source: Authors.

It is through related activities that the knowledge and technologies that take place in teaching and research institutions are transferred to companies. It can be done in a variety of ways, including patents, licenses, joint venture participation, and company formation by university researchers (Link & Siegel, 2005). Sampat (2006) evidences the licensing through patents because, from it, the universities will be able to collaborate with the technological change in the industry and, consecutively for the economic growth. Universities need to take care to protect their inventions, especially through patenting, since they can license their inventions, allowing academic research to reach the market and provide financial returns (Cowan & Zinovyeva, 2013, Marques, *et al.*, 2014, Shane, 2004). In summary, the total number of patents deposited is at the forefront of the proxies of indicators that measure technological production (Archibugi & Coco, 2004, Albuquerque *et al.*, 2002, Filippetti & Peyrache, 2011, Khayyat & Lee, 2015).

On the other hand, to obtain the results of the innovation ecosystems of universities it is necessary to establish different stimuli, whose main agent is the public player. In this perspective, Link and Siegel (2005) elucidate that, in many countries, governments (national, regional and state levels) have supported innovation activities through legislation to facilitate the technological diffusion of universities to enterprises, indirect incentives to the establishment of collaborative research, direct subsidies for research to facilitate the diffusion of universities technological production to companies, encouragement for shared use of laboratory facilities as well as the training of qualified staff.

Finally, we highlight the training of qualified personnel - mentioned in several studies (Guaranys, 2010, Guerrero *et al.*, 2014, Marques *et al.*, 2014) as fundamental for the constitution of the innovative university, being the incentives through technological scholarships one of the means used by the financing agencies of the country. For these reasons, the

growth of public and private investment in university technology initiatives has raised important policy issues regarding the impact of these activities on researchers, universities, companies and regions where such investments occur (Link & Siegel, 2005).

4 Methodological procedures

The final objective of this article was to analyze the innovation environment of Brazilian federal universities through the mapping of NITs, IEBTs and ParqTecs associated with these institutions and outlining the relationship between technological scholarships and patents with these mentioned instruments. To do so, the 63 Brazilian federal universities were considered the units of analysis, according to the MEC (2014), as shown in Table 2.

Table 2

Brazilian Federal Universities.

University	Code	University	Code
Fundação Universidade Federal de Rondônia	UNIR	Universidade Federal do ABC	UFABC
Fundação Universidade Federal do Rio Grande	FURG	Universidade Federal do Acre	UFAC
Universidade da Integração Internacional da Lusofonia Afro-Brasileira	UNILAB	Universidade Federal do Amapá	UNIFAP
Universidade de Brasília	UNB	Universidade Federal do Amazonas	UFAM
Universidade Federal da Bahia	UFBA	Universidade Federal do Cariri	UFCA
Universidade Federal da Fronteira Sul	UFFS	Universidade Federal do Ceará	UFC
Universidade Federal da Grande Dourados	UFGD	Universidade Federal do Espírito Santo	UFES
Universidade Federal da Integração Latino-Americana	UNILA	Universidade Federal do Estado do Rio de Janeiro	UNIRIO
Universidade Federal da Paraíba	UFPB	Universidade Federal do Maranhão	UFMA
Universidade Federal de Alagoas	UFAL	Universidade Federal do Oeste da Bahia	UFOB
Universidade Federal de Alfenas	UNIFAL	Universidade Federal do Oeste do Pará	UFOPA
Universidade Federal de Campina Grande	UFCG	Universidade Federal do Pampa	UNIPAMPA
Universidade Federal de Ciências da Saúde de Porto Alegre	UFCSPA	Universidade Federal do Pará	UFPA
Universidade Federal de Goiás	UFG	Universidade Federal do Paraná	UFPR
Universidade Federal de Itajubá	UNIFEI	Universidade Federal do Piauí	UFPI
Universidade Federal de Juiz de Fora	UFJF	Universidade Federal do Recôncavo da Bahia	UFRB
Universidade Federal de Lavras	UFLA	Universidade Federal do Rio de Janeiro	UFRJ
Universidade Federal de Mato Grosso	UFMT	Universidade Federal do Rio Grande do Norte	UFRN

Universidade Federal de Mato Grosso do Sul	UFMS	Universidade Federal do Rio Grande do Sul	UFRGS
Universidade Federal de Minas Gerais	UFMG	Universidade Federal do Sul da Bahia	UFESBA
Universidade Federal de Ouro Preto	UFOP	Universidade Federal do Sul e Sudeste do Pará	UNIFESSPA
Universidade Federal de Pelotas	UFPEL	Universidade Federal do Tocantins	UFT
Universidade Federal de Pernambuco	UFPE	Universidade Federal do Triângulo Mineiro	UFTM
Universidade Federal de Roraima	UFRR	Universidade Federal do Vale do São Francisco	UNIVASF
Universidade Federal de Santa Catarina	UFSC	Universidade Federal dos Vales do Jequitinhonha e Mucuri	UFVJM
Universidade Federal de Santa Maria	UFSM	Universidade Federal Fluminense	UFF
Universidade Federal de São Carlos	UFSCAR	Universidade Federal Rural da Amazônia	UFRA
Universidade Federal de São João Del Rei	UFSJ	Universidade Federal Rural de Pernambuco	UFRPE
Universidade Federal de São Paulo	UNIFESP	Universidade Federal Rural do Rio de Janeiro	UFRRJ
Universidade Federal de Sergipe	UFS	Universidade Federal Rural do Semi-Árido	UFERSA
Universidade Federal de Uberlândia	UFU	Universidade Tecnológica Federal do Paraná	UTFPR
Universidade Federal de Viçosa	UFV		

Source: MEC, 2014.

We adopted a qualitative and quantitative approach based on the association of the most profound and descriptive precepts of the qualitative perspective with the systematizing power of the quantitative approach. In the development of the quantitative analysis, Stata® Statistics / Data Analysis 11.2 was used to estimate the equations of the proposed models. The variables selected for the study were the total technological scholarships (BTEC) and total patents (PAT) of all federal universities made available by the National Council for Scientific and Technological Development (CNPq) and the National Institute of Property (INPI), respectively, in the year 2014.

In addition, considering their institutional sites, the total number of Technological Innovation Centers (TNITs), Technological Base Incubators (IEBTs) and Technological Parks (ParqTecs) associated with each university were identified, as well as the variables described above, grouped in the five regions of Brazil (Center-West, Northeast, North, Southeast and South) for analytical purposes.

The method of analysis used was Simple Linear Regression (RLS), with the estimation of six equations, adopting as independent variables the total number of technological scholarships of the federal universities (BTEC) and the total patents of the federal universities of each region of the country (PAT) and as dependent variables the total of Technological Innovation Centers (TNITs), the total of Technological Base Incubators (TIEBTs) and the total of Technological Parks (TParqTecs) of the universities of each region of the country.

The RLS was used to evaluate how the variables of science and technology, technological scholarships and patents individually influence the total of innovation instruments of the federal universities of a given region. It should be

noted that the RLS model considered the Ordinary Least Squares Method (OLS), which aims to minimize the differences between estimated values and actual values. Regarding the significance of the RLS model, the P-value test was used to evaluate the coefficients estimated alone, and the F-test, to evaluate the explanatory power of the model.

5 Analysis and discussion

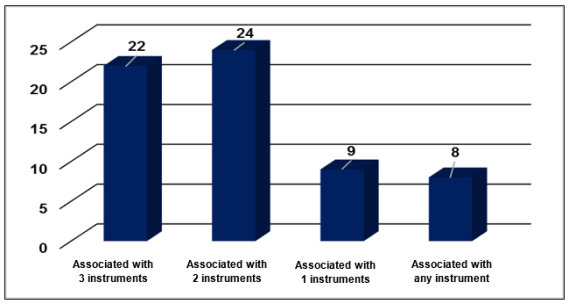
In this section we present the main results obtained with the development of the study in two subsections. The first one, Mapping of Innovation Instruments, outlines the distribution of NITs, IEBTs and ParqTecs in the country by universities and by regions. In the second subsection, entitled Variables of Innovation: Technological Scholarships and Patents, we analyzed the influences of the selected variables, technological scholarships and patents on the instruments analyzed.

Mapping of the innovation instruments

Innovation as an engine of development (Ivanova & Leydesdorff, 2014, Green, Agarwal, & Logue, 2015), the university as an essential actor in the promotion of innovation (Etzkowitz, 2009, Marques *et al.*, 2014) and university expansion notably elucidated (Cowan & Zinovyeva, 2013, Löfsten & Lindelöf, 2005) are precepts that configure the current Brazilian scenario. Given the expansion policy of the higher education, there are 63 federal universities in the country that have a more direct potential for action in the field of innovation, and which, consequently, support development throughout the country, given the distribution in all the geoeconomic regions: North (16%), Northeast (29%), South (17%), Midwest (8%) and Southeast (30%).

The number of innovation ecosystems in universities reveals different initiatives in this context, including a technology transfer office, science and technology parks, business incubators and other institutions, motivated by the perspective that they can generate revenue for universities and spread knowledge (Castells & Hall, 1994, Drummond, 2005, Guaranys, 2010). In this context, Figure 1 below shows the total number of universities associated with the analyzed instruments.

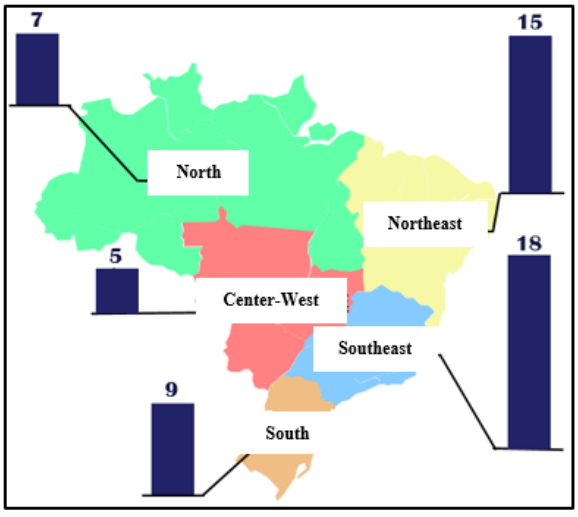
Figure 1 – Total of universities associated with the instruments.



Source: Research data.

With regard to NITs, which aim to articulate the management of innovation and intellectual property policies in universities (Brazil, 2004, Weckowska, 2015), it was verified that only 9 universities do not have it, which confirms that the determination in the Innovation Law on the establishment of these centers has been effective with the adherence of 86% of the institutions. When analyzing geographic distribution, a similar spread to the total number of existing institutions per region is observed, with emphasis on the Southeast and Northeast regions (Figure 2).

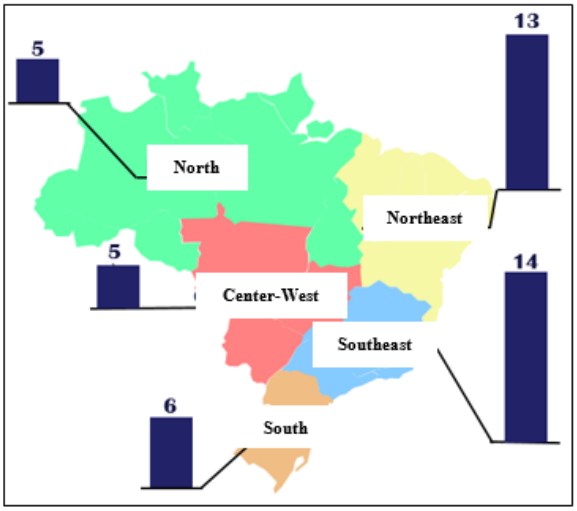
Figure 2 - Number of technological innovation centers (NITs), by region.



Source: Research data.

On the other hand, the IEBTs, designed to strengthen interaction in innovation systems, aim to support small and micro-enterprises with a technological base, through physical and managerial infrastructure (Drummond, 2005, Tzameret, Aas, & Stead, 2015). It was evidenced that 68% of universities are associated to a lesser extent to this instrument in terms of quantity in relation to NITs. On the other hand, the geographic distribution is similar to the previously analyzed instrument, with 63% of IEBTs associated with universities in the Southeast and Northeast regions, together (Figure 3).

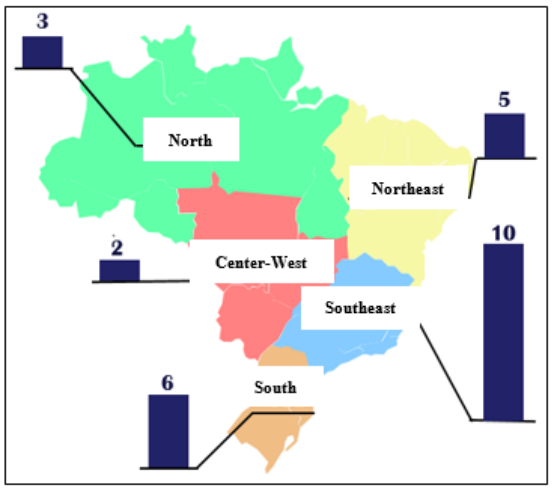
Figure 3 - Number of Incubators of technology-based companies (IEBTs), by region.



Source: Research data.

In the innovation environments, the technological parks (ParqTecs) stand out, characterized mainly by the hybrid character, housing science and technology institutions, technological offices of large companies and small technology-based companies (Drummond, 2005, Hu, 2007). Due to the expenditures required for its implementation, only 26 universities are integrated with ParqTecs, suggesting an open space for expansion of this instrument (Figure 4).

Figure 4 - Number of technology parks (ParqTecs), by region.



Source: Research data.

In the context of the ParqTecs, Soly *et al*. (2012, p.22) point out that "despite its strategic importance in the national innovation system, the planning, implementation and operation of technological parks present several challenges." These authors also affirm that, "for the implementation and management of a park, significant contributions of financial and intellectual resources are necessary" (Soly *et al.*, 2012, page 02). Thus, adding to this difficulty the assumptions that innovation is a fundamental element to generate competitive advantage (Fossas-Olalla *et al.*, 2015), there is a constant need to eliminate other barriers that surround the innovation process (Bruno-Faria & Fonseca, 2014) and that innovation is an interactive phenomenon (Lemos, 2003, Palm, 2014), Link and Siegel´s (2005) concepts are reified in the present study, by elucidating that the role of government in this complex environment of search for development through innovation becomes fundamental.

Variables of innovation: technological scholarships and patents

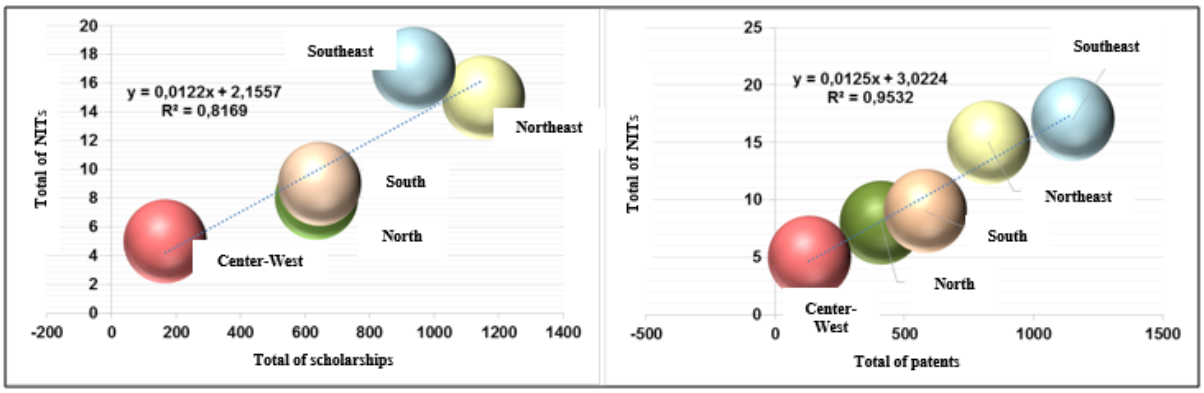
Innovation ecosystems associated with universities are influenced by and influence other variables in the scope of science and technology of these institutions. In this sense, this subsection

analyzes the relationship between the total number of technological scholarships of the universities, a variable for the training of qualified personnel, considered a key factor for the innovative university's performance (Guaranys, 2010, Guerrero *et al.*, 2014, Marques *et al.* and the total of patents of the analyzed universities, the main indicator of innovation activity measurement (Archibugi & Coco, 2004, Filippetti & Peyrache, 2011, Khayyat & Lee, 2015), with the instruments analyzed here. After all, delineating local (and / or regional) innovation contexts presupposes a necessary alignment with factors that are involved in this process, whether they are characteristic of training, such as technology grants, or results-based ones, such as patents.

After these considerations, the equations of the estimated Simple Linear Regressions (with their graphical representations), under which the relationship between the independent variables [the total of technological scholarships by region (BTEC) and the total patents by region (PAT)] and dependent variables [the total NITS (TNITs), the total IEBTs (TIEBTs) and the total ParqTecs (TParqTecs)] were analyzed. However, among the six equations proposed in the methodology, the two related to the ParqTecs were not considered statistically significant after running the P-value test and the F-test. The main argument for this occurrence relies on the fact that the total of ParqTecs is still limited, as discussed in the previous subsection.

As for the equations that showed to be significant, the first one to be discussed is that of the relationship between the BTEC and PAT with TNITs (Figure 5).

Figure 5 – Relationship between technological scholarships and patent and total of NITs, by region.



Source: Research data.

For both variables, a positive relationship with the total NITs was found; the first estimated equation (ratio between BTEC and TNITs), was significant at the 95% confidence level and a high explaining power of the dependent variable (TNITs) as a function of the independent variable of approximately 82%. The second estimated equation (relation between PAT and TNITs) showed a greater level of significance, being statistically significant at the 99% confidence level and a high explaining power of the independent variable (PAT) to explain the dependent variable (TNITs) of approximately 95%.

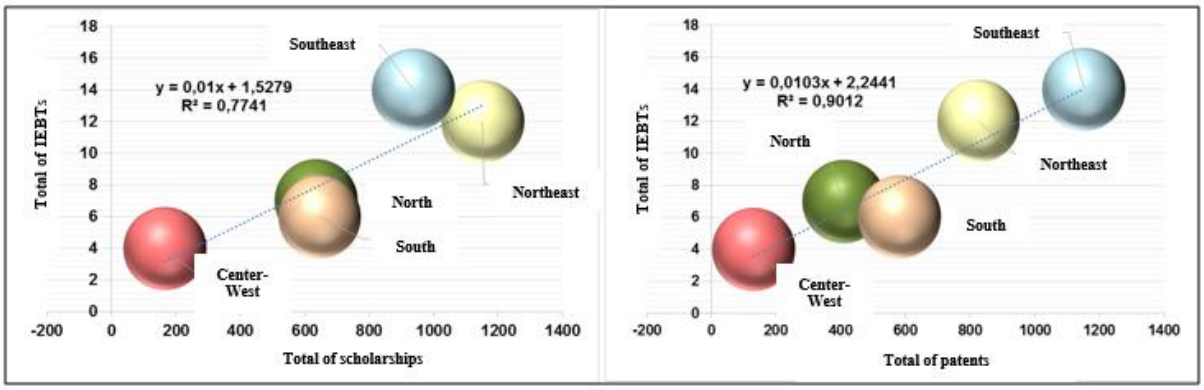
In addition to the explicit linearity, the graphical representations also expose a certain pattern of the order of the relationships verified in the regions which shows the prominence of the Southeast and Northeast regions in the scope, not only of the analyzed instrument (NITs), but also in the other analyzed variables (BTEC and PAT), resulting from a large number of universities compared to other regions.

Therefore, the analysis carried out enabled us to propose a hypothesis of triangulation among the three themes previously considered, in which a greater number of technological scholarships provide a better personnel qualification

(Guaranys, 2010), so this input drives the research - both scientific and technological -, generating the need for the constitution or maintenance of a NIT, aiming at the management of the knowledge produced (Porcel *et al.*, 2012); concomitantly, knowledge that is protected results in patents – a widespread intellectual property (Sampat, 2006) which, in turn, need to be managed, justifying again the institution of the NIT for commercialization and licensing of the protected technology (Macho-Stadler, Pérez-Castrillo, & Veugelers, 2007; O'kanea *et al.*, 2015).

In the second group of equations proposed, the relationships between the BTEC and PAT variables were established with the TIEBTs (Figure 6).

Figure 6 – Relationship between technological scholarships and patent and total of IEBTs, by region.



Source: Research data.

Like in the previous analysis, we found a positive relationship for both variables with the total IEBTs and confirmed the statistical significance of the first estimated equation (ratio between BTEC and TIEBTs) at the confidence level of 95% and an explaining power of the model of approximately 77%. Regarding the relationship between PAT and TIEBTs, a statistical significance was also found at the 95% confidence level, with the power of the independent variable (PAT) to explain the dependent (TIEBTs) of approximately 90%.

The prominence of the Southeast and Northeast regions was once again evidenced, reiterating the role of innovative attitude of the universities located in these regions, considering both the instruments (NITs and IEBTs) and the variables (BTEC and PAT) analyzed in isolation to clarify the relationship between them to the promotion of development. In this way, these regions can provide an example for other regions, which should aim, mainly, to build solid innovation environments in addition to infrastructure and also directed to systematized interactions, as suggested by the systems innovation literature (Leydesdorff, 2000, Lemos, 2003, Palm, 2014) and the triple helix (Etzkowitz, 2009, Ivanova & Leydesdorff, 2014).

6 Final remarks

Technological innovation has become in the current competitive and globalized context *conditio sine qua non* for the development of companies, regions and nations. Within a scenario of multiple actors permeated by diverse interactions, universities have emerged as potential for transforming the socioeconomic environment that they are inserted as they have essential requirements for technological promotion. For this reason, Brazilian federal universities were the empirical focus of this article.

The results of this study unfold as main reflection the institutionalization of NITs and attests the importance of the establishment of the Innovation Law on

the institution of these centers. In addition, the IEBTs, designed to strengthen interaction in innovation systems, are enabling the regional contexts of technological development. Also, we found that there is still a certain lack of resources regarding the implementation and management of the Parqtecs, due to the number of universities associated with these instruments, suggesting an open space for expansion of this instrument, through government support, mainly. In addition to the mapping, we also considered the distinctions between Brazilian regions in terms of scientific and technological structure and the pre-eminence of strengthening interactions among actors and variables in universities' ecosystems of innovation.

The contributions of this study focus on addressing the lack of mapping of the elements of innovation discussed, thus helping to consolidate a national innovation policy. The use of only secondary data, a limitation of the research, was considered due to difficulties in accessing information from the analyzed institutions. However, according to the data collected, the results obtained allowed to reach the proposed objectives and contribute in an innovative way to the studies of this area, since that allow future research to use new qualitative analysis that investigate the perspectives of the various actors in the field of innovation studies, which has been consolidated among Brazilian researchers.

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