WHICH SCENARIOS REFLECT INNOVATION AT THE BRAZILIAN UNIVERSITY?

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Abstract

Innovation is the result of complex, dynamic relationships. As Science and Technology Institutions in universities are part of the National Innovation System, generating knowledge through Teaching, Research, and Extension and Innovation, our aim is to present the current innovation scenarios in the Brazilian university. Therefore, a qualitative/descriptive study is conducted after a literature review and analysis of documents of public domain. Considering the university hybridism and a timid emergence of new helices contemplating community and environmental sustainability, the findings show that there is a need for increasing approximation between university, companies, governments, communities and environmental issues in order to transfer research, development, innovation and technology to the productive sector and to a sustainable life.

Keywords: Innovation; University; Quintuple helix; Scenarios.

1. Introduction

Governments, firms and universities have been investing efforts to encourage, articulate and adopt the innovation for continuous performance improvements (Asiedu et al., 2020; Wegner et al., 2019). In Latin America, the universities have experienced a large and rapid expansion since the early 2000s, increasing the supply of universities and their programs as well as the students access rate (Ferreyra et al., 2017). However, risks or trends that may impact future generations are neglected. According to Moreno (2016), uncertainties about future scenarios fuel the debate about the future of our economic and social

development. Working with scenarios means anticipating what is proposed regarding the future (Jardim Neto et al., 2016). Examining the relationship between the main actors (Government, Universities, and Firms) while considering the social demands (e.g. renewability of materials, pollution in production and use, local sourcing of resources, health impacts, working labour improvements) leads us to provide successful innovation strategies for socio-economic development based on knowledge (Etzkowitz and Zhou, 2017), on the concern for the society (Mineiro et al., 2018), and global environmental issues (Oliveira et al., 2020).

In the context of innovation, according to Chiarini and Vieira (2012), universities are not equal, because some are more driven to the production of scientific and technological knowledge. The intensity is influenced by the dynamics of cultural, social, political, institutional and historical scenarios of their location. Moreover, there is no guarantee that the generation of knowledge in a particular university will derive innovation gains (Chiarini and Vieira, 2012) because not all universities will integrate the five helices in their innovation scenarios. Therefore, it is relevant to understand universities that want to move towards an entrepreneurial model, but deal with environments unfavourable to innovation such as limited interaction with industries or fragile connections in a local ecosystem of innovation (Etzkowitz et al., 2019).

In view of what is outlined above, our problem to be investigated in this study is: What are the current scenarios for innovation in the Brazilian university? Therefore, we must understand how the set of Brazilian universities adds innovation to their primary mission of teaching, research and extension, in their context, in the relationship with the other actors who are part of the disruptive helices, and in the relationship between universities and governments (Mineiro et al., 2018), with firms (Monticelli et al., 2021; Oliveira et al., 2020), with communities (Francis, 2015; Mineiro et al., 2018), and with the environment (Francis, 2015; Oliveira et al., 2020). In this sense, our study aims to reflexively present the current scenarios for innovation in the Brazilian university. It differs from previous research because we present a proposal of a National Innovation System Model that considers the specific context of regional development in an emerging economy. Consequently, universities can develop a central role to develop an ecosystem based on the entrepreneurship and innovation (Thomas et al., 2021). Our study results from a project linked to a graduate program in education from a Brazilian university. The methodology used to develop the study, under the qualitative approach, is descriptive with technical, bibliographic and documentary procedures.

2. National Innovation System (NIS)

In order to understand the scenario of innovation in Brazilian universities, it is premise to consider the NIS, as it gives rise to guidelines and incentives to accelerate or slow down innovation in different areas of knowledge, not being restricted to industry. The NIS was initially conceptualised by Patel and Pavitt (1994) and Nelson (1993). Innovation derives from dynamic and systemic relationships that occur at different levels of developed economic systems. Interactions in relationships lead to the innovation of ideas, processes and products building the foundations of an NIS (Lundvall, 2016). When expanding the conceptualization, Patel and Pavitt (1994) emphasise that the NIS involves ‘intangible’ investments in

technological learning activities. Nelson (1993) stresses that being technologically competitive means different things in different national contexts in which a particular industry is inserted.

NIS, in addition to the macro-dimension, also involves the development of the capacity of innovation and learning of a region, sector or locality. The Regional Innovation System (RIS) relates to regionally identifiable innovation arrangements and policies (geographical proximity) serving public and private interests in interaction with other formal actors such as providers of knowledge, financing and training (Doloreux and Parto, 2005). A Sectorial System of Innovation and production is directed towards a specific set of products and actors (Malerba, 2002).

The main elements that make up the dynamic relationships of the NIS (Lundvall, 2016) are established by government, knowledge sources and firms. The government is responsible for regulation, public support and the legal and structural bases for teaching and research. The sources of knowledge come from universities, research institutes, companies and other similar institutions. However, given the innovation scenarios today, we are questioned by the presence of social and environmental concerns in the dynamic relations of the NIS and its relation with the universities to support innovative scenarios.

A relevant aspect in the innovation process is related to how companies are organised in terms of research, Development, and Innovation (R, D and I) aiming at market potentials. Among the models practiced, many innovative organizations have adopted strategies to be open both inside and outside the organization (Laursen and Salter, 2006). Companies are increasingly acquiring technological knowledge from external sources to improve their innovation performance. Known as open innovation, the model allows firms to achieve and sustain their efforts to innovate (Jackson, 2011). In a collaborative dynamic, government, knowledge agents and companies, in complex relationships of open innovation, are the key characters of the system to meet the market demands for innovation (Jackson, 2011). However, we warn of the incipient concern with community involvement and environmental issues (Oliveira et al., 2020) for an innovation that addresses an increasingly sustainable university-driven scenario, as in the Brazilian case.

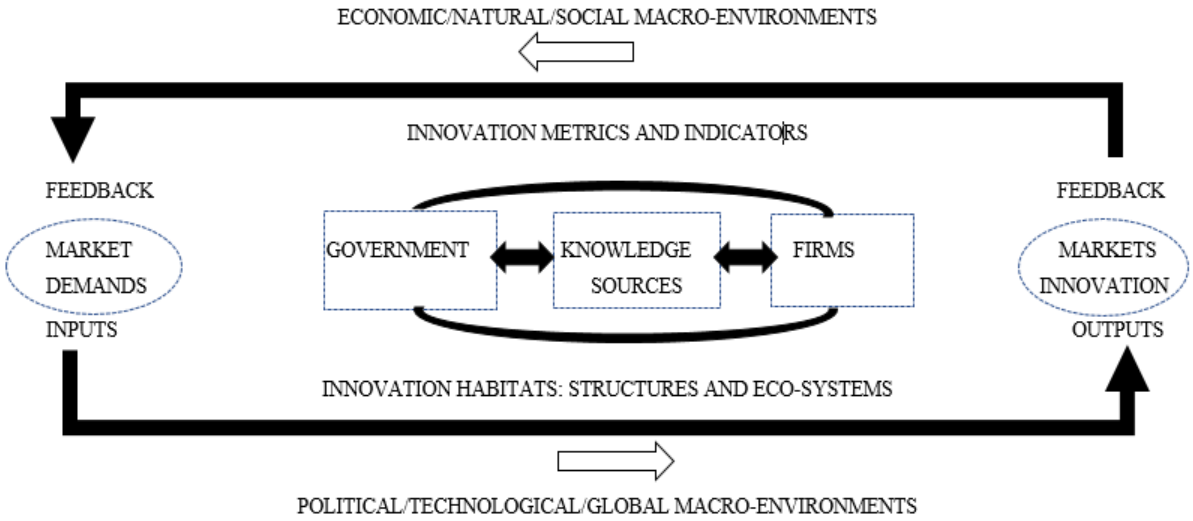
In this context, the university is a space to build the open science triangle, knowledge co-creation, and open innovation, in all its helices, while surpassing the trilogy universities-governments-companies and strengthening its ties with communities and environmental issues. On the one hand, there is a value creation from the interaction between different agents such as government, firms and universities. On the other hand, there is a hazard about which will capture the created value, returning to the society, even partially (Chesbrough et al., 2018; Nambisan et al., 2019).

The NIS also comprises innovation-promoting environments (*Habitats*), that comprise structures for innovation processes and ecosystems. They also include NIS, metrics and innovation indicators. According to Jackson (2011), if, on the one hand, open innovation comprises the energy of complex relationships between NIS actors, in a collaborative and networking dynamic of knowledge. *Habitats* are economic dynamics formed by structures involving human capital and material, technological and financial resources, as well as local arrangements for innovation, such as the Scientific and Technological Poles (STPs) (Jackson, 2011).

The NIS also has its control component that leads us to understand and quantify the capacity of innovation, aiming at improvements and adjustments of bottlenecks (Traitler et al., 2011). Thus, Innovation indicators are one of the components of the NIS that measure the results of an innovation process. A

prominent index in the international economy is the *Global Innovation Index* (GII) that measures innovation levels in 126 countries (McCarthy and Mari, 2019). Thus, NIS is part of different contexts (Nelson, 1993) so that all the gear that drives an innovation system is subject to macro-environmental occurrences. Based on the literature on the topic, the authors propose an NIS model to facilitate the development of this study (see Figure 1).

Figure 1. Proposal of a National Innovation System Model



Source: created by the authors based on Nelson (1993).

Specifically in Brazil, it has not defined objective and clear indicators regarding the goals and results of the processes in the documents that are part of the Brazilian innovation policy, such as the National Science, Technology and Innovation Strategy (NSTIS). Likewise, in the alliance between government, universities and firms, there is a need to strengthen the relationship and partnership between these helices for an effective and solid policy of Brazilian innovation.. Thus, the government works along with a group to fill this gap, following the practices of the European Union (Brazil, 2019). However, studies such as Formictc and Innovation Research (Pintec) corroborate with data collection and the creation of some indicators. Pintec is an evaluation study of innovation focused on industry and is carried out by the Brazilian Institute of Geography and Statistics (IBGE) (2017). The relevance of this study is also manifested in the effective participation of universities in the production of knowledge. Table 1 summarises the components of the Brazilian NIS:

Table 1. Components of the Brazilian National Innovation System

Actors Main	Government	Regulation: regulatory mark; legal systems; intellectual innovation; tax breaks.
		Promotion Agencies: FINEP; BNDES.
		Industrial Property: INPI
		Higher education: CAPES; CNPq.
	Sources of Knowledge	STIs; Universities; Non-university HEI; IPTE; RI; Business R, D and I.
	Firms	Industries; Medium and small satellite firms; Service organizations; Agribusiness; Startups.
Habitats of innovation	Structures	CTI; Marketplace; Coworking; Pre-Incubators; Incubators; Accelerators; Mr. Fablab.
	Ecosystems	Networks and connections between actors: individuals; communities; organizations; financial markets; service providers; suppliers; associations; economic bodies; investors; entrepreneurs; researchers; small and large enterprises; material resources; technology transfer offices.
		Locations: STPs; Innovation districts; Smart Cities; Technological Poles.
Indicators	Metrics and Performance Indicators of STIs; NSTIS; Formictc; Pintec.	

Source: created by the authors.

3. Innovation scenarios in the Brazilian University

Universities are centres of basic research and scientific experiences (Lundvall, 2016), which are essential to the dynamics of science through knowledge, technology, and innovation. To increase the university/firm relationship is necessary to improve the Brazilian NIS, through collaborative networks and the development of STPs (Carvalho, 2017). The Innovation Law establishes a wide range of actions for technological development, including the legal conditions for the formation of partnerships between universities, private science and technology (S and T) institutions that are not-for-profit and firms (Morais, 2008). In this context, we emphasise that private institutions that are dedicated to scientific research in Brazil are rare exceptions. Not even public higher education institutions can be generalised. The main locus of knowledge production is placed in more traditional federal universities (Chiarini and Vieira, 2012). In this sense, we present as a challenge for the set of Brazilian universities, to combine teaching and research in order to transfer the knowledge generated to society (Arbix and Consoni, 2011)

Paradigm shifts in the economic and social scenarios in Brazil (Campanário et al., 2005) require a new vision for mutual purposes. This reverberates at the university while questioning a reform of the traditional teaching-learning system. It aims at greater student participation in projects, industry involvement with the university, social responsibility, as well as academic researchers with empirical cases supervising joint studies within the firms, thus becoming members of an industrial team, among other joint initiatives (Traitler et al., 2011).

Open innovation has been consolidated being focused on the consumer and includes for its development: universities, RIs and *startups* (West et al., 2014). Thus, the university must be rethought,

endowed with collaborative management models and structures given an adherence culture with the productive means, in search of an efficient NIS. Following this line, the need for technological development and innovation has presented significant spaces for Brazilian universities imbued as actors of innovation, but with results that can be improved in the university-company relationship (Arbix and Consoni, 2011).

Collaboration in open innovation in the university/firm relationship is the starting point for innovation projects. However, the university also needs to have absorption capacity. For Oliveira and Balestrin (2018), the university's absorptive capacity requires a knowledge base, qualified researchers, scientific-technological infrastructure, and inter-organizational relationships. The knowledge base is founded on scientific production practiced in teaching and research. The relationships include firms, governments, innovation environments, and collaboration in science and technologies with organizations from Brazil and abroad (Oliveira and Balestrin, 2018).

The university participates in the NIS as a source of knowledge and, consequently, must develop basic research and absorb demands for applied research. For Etzkowitz and Leydesdorff (2000), the university inserted in an innovation ecosystem must relate to the other actors as a participant in the co-creation of sustained value for science and markets (Etzkowitz and Leydesdorff, 2000). Therefore, the creation of value is not only related to technology and products developed in an ecosystem, but also to partnership and collaborative relationships, especially in the recent years aimed at recognizing the participation of society and environmental issues in innovation processes. In this new scenario, such relationships, in addition to those pointed out by Etzkowitz and Leydesdorff (2000) require social participation (Monticelli et al., 2021) and social and environmental responsibility (Mineiro et al., 2018). Thus, the university is an important partner in modelling based on the concept of open innovation.

However, the entire process of innovating also gives rise to intangible elements (Patel and Pavitt, 1994). The University, as a natural environment of creation, has a lot to contribute and can serve as a disseminator of culture (Ortega and Bagnato, 2015). It can interact with the environment and be knowledgeable about the RIS in which it is inserted. Considering the different regional cultures, this aspect is decisive for universities not to adopt the same behaviour in relation to policies and support for innovation (Tosta et al., 2016). However, a common effort identified among the teaching and research universities has been the participation in collaborative networks. A suitable space to form collaborative networks (Carvalho, 2017) in RIS is STPs. In Brazil, this was shown to be an important ecosystem in the relationship between universities, RIs, similar institutions, governments, firms, and society, being all of them concerned with meeting environmental indices. In 2000, 10 parks were fully operating; in 2017, this number increased to 43 while other 23 were in the implementation phase and 37 in the project phase (Brazil, 2019). STPs as complex local innovation arrangements (Jackson, 2011) are instruments of innovation policy that encourage the incubation of *startups* and the integration of regional firms with innovative ventures. Aiming at the development and access to the market of new products and services, it stimulates the flow of knowledge between universities and institutions of R, D and I (Lamperti et al., 2017).

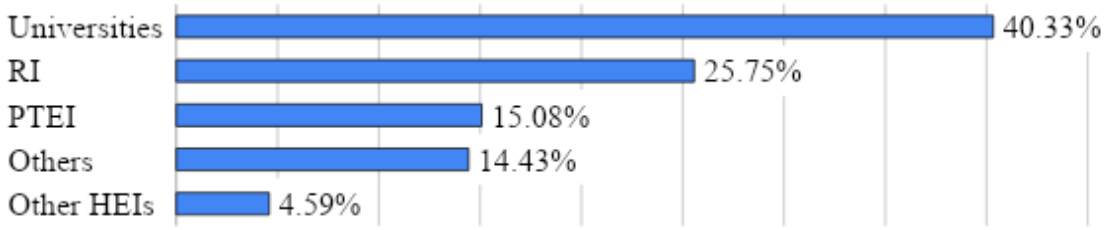
The issue of innovation has proven to be complex. Especially in Brazil and accelerated by the Covid-19 pandemic, there is a favourable environment for dialogue between universities, governments, firms, communities and issues of environmental sustainability. However, barriers such as promotion,

culture of innovation, collaborative management are intervening factors in a complex but possible reality to establish a new stage of approaching different actors participating in this scenario.

4. Contextualization of innovation scenarios in the Brazilian university

According to Formictc 2019, 305 STIs answered the questionnaire, namely: 123 universities, 14 other higher education institutions (HEIs) such as university centres and colleges, 78 RIs, 46 IPTE, and 44 other types of institutions (Brazil, 2019). Figure 2 illustrates the proportional distribution of STIs that responded to Formictc 2019.

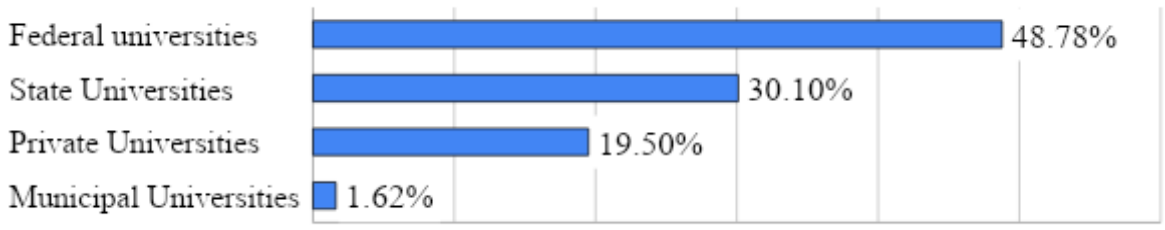
Figure 2. Percentage distribution of STIs



Source: Elaborated based on data from Formictc (2019).

Of the 137 HEIs that attended Formictc 2019, 101 institutions are public, with 99 of them being classified as universities and the other 2 as other types of HEIs. Private institutions add up to 36 HEIs, with 24 being universities and 12 other HEIs (Brazil, 2019). Brazil has 196 universities. As described by the Folha University Ranking (in Portuguese, Ranking Universitário Folha (RUF)) (Folha de S. Paulo, 2019), 78 of them are large, 66 medium and 52 small-sized universities. Of these, 123 universities (99 public and 24 private) are linked through an STI to national innovation policies through monitoring mechanisms of the Brazilian Ministry of Science and Technology. Of the 99 public universities, 60 are federal, 37 state and 02 municipal. Six public and 67 private universities stopped attending Formictc. In the set of private companies, we emphasise that responding to Formictc is only compulsory for non-profit institutions (Brazil, 2019). Figure 3 represents proportionally the distribution of university STIs that responded to Formictc 2019.

Figure 3. Percentage distribution of University STIs



Source: Elaborated based on data obtained from Formictc (2019).

Next, Table 2 was built from the nominate of universities extracted from Formictc 2019 (Brazil, 2019) and assessed considering their grade in RUF 2019, regarding the filing of patents (Folha de S. Paulo, 2019). The levels were defined by the authors as follows: Column 1: distribution of the grades into five levels and the total calculated in columns 2 to 7; Column 2: number of federal universities; Column 3: number of state universities; Column 4: number of municipal universities; Column 5: number of public universities resulting from summing columns 2, 3 and 4; Column 6: number of private universities; and Column 7: total each level, resulting from the sums of columns 5 and 6, as follows:

Table 2. Distribution of University STIs

Grade	Federal	State	Municipal	Public	Private	Total (Public and Private)
1.91 to 2.00	05	03		08		08
1.76 to 1.90	09			09		09
1.51 to 1.75	15	04		19	03	22
1.01 to 1.50	16	08		24	11	35
up to 1.00	15	22	02	39	10	49
Total	60	37	02	99	24	123

Source: Elaborated based on data from Folha de S. Paulo (2019).

In Brazil, there are no centuries-old universities as in Europe, with 78 universities having more than 50 years of existence. Thirty-eight of the institutions are large, of which 28 are public and 10 private non-profit (6 confessional) universities. Of the 8 university STIs in the first level (from top to bottom in Table 1), all of them are public and large-sized, 7 are over 50 years old and 1 (state) is between 30 and 50 years old. In the second level, there are 9 universities, all being federal public universities, 7 of them being large-sized and having 50 years of activity. The third level shows the private (non-profit) universities, with 3 being large institutions with more than 50 years of existence. At the base of the table (4th and 5th levels) we can see the proliferation of different types of universities regarding nature (public or private), amplitude (size), and years of activity. In the fourth level, we noticed that the public universities stand out when compared to the state universities (Folha de S. Paulo, 2019).

From the 305 STIs that were part of Formictc 2019 (Brazil, 2019), 187 of them applied for intellectual property protection in 2018. Of these, 103 were HEIs and 84 were other types of STIs, including public and private RIs and IPTEs. Among the HEIs, 103 were created with requests for intellectual protection, with 79 being public and 24 private (practically all universities). The protection of the intellectual property of STIs is stimulated by the Innovation Law and aims to increase technological production. It aims at greater control and return on intangible assets that can be traded or licensed with interested companies (Brazil, 2019).

Thus, STIs can enter into technology transfer and licensing contracts for granting the right to use or exploiting the creation developed by it. According to Formictc 2019, the vast majority of STIs do not have technology transfer contracts. Only 66 institutions reported having contracts signed in 2018, and of these, half (33 institutions) of them correspond to STIs of HEIs (Brazil, 2019).

5. Research Methodology

The qualitative descriptive study is supported by bibliographic and documentary research techniques and the authors' experience on the topic (Minayo, 1993). According to Fonseca (2002, p. 31): 'Any scientific research begins with a bibliographical research that allows the researcher to know what has already been studied on the subject'. In addition, bibliographic research aims to '[...] organise, integrate and evaluate relevant studies on a given topic' (Koller et al., 2014, p. 41). In this perspective, we rely on the research stages described by Koller et al. (2014): 1st Definition and delimitation of the topic; 2nd Search and organization of materials by reading the titles and abstracts; 3rd Analysis and discussion of data for the final considerations.

While made by sources such as scientific articles and books, the bibliographic research has a certain similarity to documentary research that works with diverse sources, such as: statistical tables, news, reports, legislation and rankings (Fonseca, 2002). Based on the methodology discussed above, the development of this research comprises three stages:

1st Theoretical approach: Primary or relevant authors in certain aspects of the topic 'innovation and Brazilian university', which are identified by the following descriptors: *Open Innovation* (Laursen and Salter, 2006; West et al., 2014) *Innovation Ecosystem* (Jackson, 2011); *Innovation System* (Doloreux and Parto, 2005; Etzkowitz and Leydesdorff, 2000; Malerba, 2002); *National Innovation System* (Lundvall, 1992; Nelson, 1993; Patel and Pavitt, 1994); Innovation in Brazilian Universities (Albuquerque, 1996; Arbix and Consoni, 2011); Policies of technological innovation (Campanário et al., 2005; Morais, 2008; Salermo and Kubota, 2008); Fourth Helix (Mineiro et al., 2018; Monticelli et al., 2021); Fifth Helix (Francis, 2015; Mineiro et al., 2018; Oliveira et al., 2020). Other journals were added favouring publications in the last five years in Portuguese and English from different databases, with emphasis on SciELO, CAPES and Ebscohost. The following descriptors are used: Innovation; Innovation *Habitats*; Fifth helix; scenarios; *Innovation.*

2nd Documentary approach: The study is contextualised in the report with data related to university and innovation. It is focused on the Formictc 2019, which is an official electronic form of data collection, in order to check the existence of an innovation policy through formal documents that guide the institution in actions related to innovation, intellectual property protection, and technology transfer. The document is not specific to higher education but covers Science and Technology Institutions (STIs) (Brazil, 2019). STIs carry out studies of technological prospecting and competitive intelligence in the field of industrial property and the transfer of the innovation generated, after the Centre for Technological Innovation (CTI) (Brazil, 2016). According to Law No. 13,243 of January 11, 2016, STIs consist of:

> Scientific, Technological, and Innovative Institution (STI): body or entity of the direct or indirect public administration or legal entity of private non-profit law legally constituted under Brazilian laws, with headquarters and venue in the country, which includes scientific or technological, basic or applied research or the development of new products, services or processes in its institutional mission or its social or statutory objective (Brazil, 2016, our translation).

In the list of participants in the Formictc 2019 report, we, therefore, identify the STIs related to universities as university STIs. The RUF (Folha de S. Paulo, 2019) is an assessment of the private sector of higher education in Brazil, carried out by Folha de São Paulo since 2012. The *ranking* assesses Brazilian universities with scores ranging from zero to 100, including five aspects, in a total of 100 points, with different weights distributed as follows: Research (42); Teaching (32); Market (18); Internationalization (4); Innovation (4). The innovation indicator is divided as follows: Articles in collaboration with firms (2) and Patents filed (2) (Folha de S. Paulo, 2019).

Universities can be measured for their performance in innovation in the science and technology relationship by two indicators: Scientific Potential Indicator (SPI) and Technological Innovation Indicator (TII). TII, which includes structures such as the Centre for Technological Innovation (CTI), has the fillings (deposits) of patents as the main measurer of technological development (Pereira et al., 2016). According to the report Formictc 2019, the management of intellectual propriety and technology transfer is one of the most defining activities when analysing the importance of institutions that have an innovation policy (Brazil, 2019). Thus, we chose to use the note obtained in RUF 2019 (from zero to 2) regarding the patent filing to identify the different levels of involvement of university STIs in innovation (Folha de S. Paulo, 2019). The authors built five levels on a scale of zero to 2 to contextualise in the study the differences and contributions of universities in favour of innovation (Chiarini and Vieira, 2012). Such data was added to the reports, legal approaches and quotes from reports (periodicals).

3rd Analysis and discussion of the findings: Our bibliographic study and documentary analysis allowed the analysis and discussion of the findings in dialogue with several authors. We emphasise that no institution was mentioned in this study. The interest is in measuring the participation of the university STI, based on the criterion of patent filing. Although the contextualization is used to quantitative data, they do not alter the essence of the qualitative study.

6. Analysis and Discussion of the Results

The study identified the differences existing between the institutions in terms of their processes and results. We have a heterogeneous university system with public universities in the three government spheres (federal, state and municipal) and private universities of different types (religiously affiliated and lay community universities and paid universities). This system is formed by traditional universities and others with a few years of existence, whether they are large, medium, or small-sized, in addition to those characterised as university centres, institutes and colleges (Folha de S. Paulo, 2019). This context reflects higher education institutions only focused on teaching, called Colleges or University Centres, and few institutions with University status (no more than 200 out of a total of 220 higher education institutions in Brazil) focused on Research responsible for furthering knowledge that generates innovation.

In this scenario, some traditional public universities stand out in innovation, with emphasis on federal universities and 3 state universities from the same state (Folha de S. Paulo, 2019). There are differences in the intensity of scientific and technological knowledge production between universities (Chiarini and Vieira, 2012), which do not adopt the same behaviour in relation to policies and support to

innovation (Tosta et al., 2016). Moreover, intellectual production developed in universities does not necessarily involve the transfer of technology to companies (Chiarini and Vieira, 2012).

We found that in the list of intellectual protection requests made by Brazilian HEIs (practically all universities), which complied with Formictc 2019 (base year 2018), for technology transfer contracts to companies, they were 3 to 1. In other words, the university produced 3 times more knowledge than what it transferred to the productive sector in 2018 (Brazil, 2019). The industry, in turn, spent 3 times more on internal R, D and I, in relation to the spending on external R, D and I. This does not mean that there is a direct relationship between the two facts, but it does indicate that the concept of open innovation (Jackson, 2011; Laursen and Salter, 2006; West et al., 2014) it is still little explored by Brazilian firm when the university is participating.

However, according to Formictc 2019, universities represented 40.3% of Brazilian STIs and, individually, the main source of knowledge among all types of STIs, with RIs in second place, representing 25.6%. Of the technology transfer contracts signed, HEIs (mostly universities) accounted for half of them in relation to all other types of STIs (Brazil, 2019). Seen from this perspective, the university has been the main, non-business source, in contributing to add value in innovation in Brazil. In this context, Pereira et al. (2016) highlight the importance of scientific capital for technological capital. According to Lundvall (2016), universities are essential to the dynamics of science by generating knowledge through basic research and scientific experiments. Tosta et al. (2016) emphasise that the generation of knowledge and scientific publications, objects of research, are critical to promoting innovation.

Being a debate in the current international literature on the advantages and disadvantages of STPs (Lamperti et al., 2017) in Brazil, ecosystems are conducive for universities to integrate into knowledge networks (Brazil, 2016). For Lamperti et al. (2017), open science contributes to collaborative innovations and constructions in democratization of knowledge generated at the university. Thus, the triangle shared science, co-creation of knowledge and open innovation presents itself as an opportunity to generate an original research contribution to open educational theory and practice (Lamperti et al., 2017). Therefore, the paradigms must be changed (Campanário et al., 2005) and in the teaching/learning system, with greater alignment between academia and the business world (Traitler et al., 2011). This approach requires new management structures and models from universities (Arbix and Consoni, 2011) that aim at improving the development of knowledge and innovation in order to develop collaborative networks (Carvalho, 2017).

We observed factors that are still preventing us from having an NIS (Lundvall, 2016) with a higher degree of maturity (Albuquerque, 1996), which is attested by Brazil being an emerging nation with a lower performance in innovation (McCarthy and Mari, 2019) and the strong dependence on imported technology, present in Brazilian innovation processes (IBGE, 2017). We also see a lack of alignment in the relationship of the Triple Helix, a concept that is already outdated, with the merging fourth and fifth helices that demand integration with the community in the search for a solution to real problems with environmental sustainability. This reality shows how much we still have to advance in terms of cooperation and collaborative work to achieve our goals of innovation and entrepreneurship, surpassing the status of an emerging country, as well as the traditional discourse and the imperative practice of the triple helix. In the sequence, we point out ways to establish the other helices claimed here.

According to Monticelli et al. (2021, p. 78) the quadruple helix is '[...] formed from the relationships established between companies, government, universities and organised civil society [...]'. In addition, the authors add that this may be a key to economic growth, by placing '[...] innovation as a practice to be developed not only by companies, but by universities that provide academic support for new research and discoveries'. In this sense, Mineiro et al. (2018) claim that the fourth helix is composed of government, firms, universities and civil society. However, innovation requires the integration of a fifth helix, often disregarded by the others, as we will see below.

This fifth helix is highlighted by Mineiro et al. (2018, 82) as follows: 'Sustainable issues lead to the imminence of the Quintuple Helix, which has the Environment proposal and can be seen as a transdisciplinary structure that analyses sustainable development and social ecology'. Pope Francis (2015) highlighted the importance of caring for the environment and sustainable and integral development in order to take care of our common home, the Earth. That is, the 'natural environment is a collective good, the patrimony of all humanity and the responsibility of everyone' (Francis, 2015, p. 75). Similarly, Oliveira et al. (2020, p. 455, our translation) state that:

> The Fifth Helix highlights problems such as global warming and the growing concern about sustainable issues for the model. It refers to sustainability as the main factor for regional development. The agents representing the helix are still scarce, and the studies approach theoretically the environment and actors related to socio-ecological aspects. It is also worth mentioning the non-association with an actor. The role of these actors is to foster sustainable development.

Therefore, the high echelons of government must be responsible for the topic of innovation, creating effective policies with universities and companies (Salermo and Kubota, 2008), community and individuals, while establishing and consolidating a culture of innovation and entrepreneurship outside the institutional walls that tracks the entire reality to be explored and cared for, such as the preservation of environmental life. To increase the relationship, government, society, university, company and the environment is to improve the Brazilian NIS (Carvalho, 2017). This involves the conception of shared science that establishes a view of the sharing of knowledge from teaching/learning, bringing theoretical frameworks closer to open practices and co-creation (González-Pérez, Ramírez-Montoya and García-Peñalvo, 2018) of value sustained for science and innovation.

In 2020, we started to live an unexpected event called Covid-19 Pandemic. Despite all the social and economic ills imposed by the pandemic, the opportunity for a new scenario of innovation rises. We are talking about a unique moment in the history of current generations where change has never been faster or more urgent. Therefore, as the production of vaccines, e-commerce, virtual education, artificial intelligence, humanity is taking large and fearless steps in terms of innovating so as not to die. Therefore, a scenario of closer ties between the different helices analysed in our research is an opportunity, considering that the joint work speeds up and qualifies the processes and products required for a world that needs to innovate to continue to exist.

Final Considerations

The present study aims to reflexively present the current scenarios for innovation in the Brazilian university. From this focus, we address our understanding of the importance of those universities that practice teaching, research, extension and innovation through technology transfer, creation of scientific knowledge, and dissemination of creative culture in academic venues and those promoting innovation serving the 5 helices.

The university is one of the sources that generate knowledge and promotes the solution development of large-scale social problems (Thomas et al., 2021). In this sense, it has an academic dynamic that distinguishes it from other public and private research institutes. For Etzkowitz and Zhou (2017), this is due to the flow of 'human capital' found in the research groups, as opposed to the static laboratories of the research institutes. Students are potential inventors and a source of innovation, that is, they are the primacy of the university (Etzkowitz and Zhou, 2017). However, without denying the great contribution of the aforementioned authors, we must expand the helices in our strategic planning and any governance plan. We understand that true innovation and worthy entrepreneurship are solutions when considering the five helices that participate in this new culture that gradually gain discourses and practices. However, it still has to evolve until it consolidates with a degree of scalability.

Based on the analysis and discussion of the data, we highlight four points to be considered. First: The performance of our network of university STIs. We have a set of research universities with outstanding scientific competence and intellectual capital. This certainly enhances contributions to raise the standards of innovation and technological development in an emerging country. However, the realization of the potential of these institutions depends on the way that their innovation policies will be conducted and the behaviour of the economic and social framework of the country.

Second: We have modern legislation and adequate government structures. What we certainly need is an improved performance and efficiency, ensuring, above all, continuity in government actions and processes. This is not a criticism of the public sphere, which is also affected by the prevailing convictions of the government. We understand that the open innovation model should flourish from entrepreneurial ideas and views, in a co-innovation process in dynamic ecosystems, but supported by effective and constant public policies involving community and sustainability.

Third: We do not need more universities. We already have an expressive number of HEIs in Brazil, 2,448 HEIs in total (IBGE, 2017), with a demand on the part of students that is lower than the available places. We must qualify universities that practice teaching, research and extension, encouraging them to develop effective innovation integration policies aimed at the development of their communities while guaranteeing the promotion of a sustainable life.

Fourth: the new pandemic scenario requires closer ties and accelerated innovation to meet the urgent and necessary demands in different areas of knowledge, in addition to immediate primacy in health and artificial intelligence. Such reality dialogues globally, beyond Brazilian borders, building scalable solutions at world levels to common problems in a globalised world.

On the other hand, during the study, we noticed a gap represented by the small number of publications related to good innovation practices in the Brazilian university, focused on the fourth and fifth helices, although the topic of innovation and Brazilian university is extensively addressed. However, we

made progress in contributing to the literature to have more information related to the innovation scenarios in the Brazilian university, enabling new disruptive axes for innovation in the government-firm and university alignment and calling for attention to potentialise the helices community and environmental sustainability. This will be the topic of our next paper, when continuing our research, now in the context of the Covid-19 pandemic.

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