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ELEMENTS THAT INFLUENCE THE INNOVATION PROCESS IN A BRAZILIAN PUBLIC UNIVERSITY

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ABSTRACT

The aim of this qualitative study was to analyze the elements that influence the process of innovation management in a public university in southern Brazil. It was conducted semi-structured interviews with 19 questions to three groups: six university managers; six researchers with only scientific production (articles) and seven researchers with also technological production (patents). After transcribing the interviews, the content analysis was performed in MAXQDA 12 software (Verbi GmbH, Berlin, Germany). The lack of understanding of the legal part (17.6%) and bureaucratization in the transfer process (14.7%) were the most frequently reported difficulties in the process of technology transfer. After identifying the main elements of innovation management in a public university, we proposed a new model in which the research projects are developed in conjunction with the productive sector since the beggining of technological development. Public policies and management measures to facilitate the interaction between academia and the productive sector can facilitate technology transfer and, consequently, management of innovation.

Keywords: innovation, science, university, industry, Brazil.

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1 INTRODUCTION

Technological innovation is a key driver of socio-economic development, and companies rely heavily on science as an input to innovation. Such innovation occurs primarily when companies create, through research and development (R & D), new products or processes (DALMARCO et al., 2011). Given the complexity of the development of new technologies, most of the innovations resulting from inter-organizational collaboration that can usually involve universities and industries, and not projects carried out by individual organizations (SALIMI; BEKKERS; FRENKEN, 2015). Moreover, with the important role of governments in the support and funding of scientific research, it is often included in this collaboration. This trend has become known as the "Triple-Helix" of university-government-industry relationship (ETZKOWITZ; LEYDESDORFF, 2000; MEYER; SINILAINEN; UTECHT, 2003; SALIMI; BEKKERS; FRENKEN, 2015).

In this context, universities are organizations that play a key role in our society, helping in education and generation of knowledge that may have important socio-economic impact (ETZKOWITZ; LEYDESDORFF, 2000; PERKMANN et al., 2013). There are some Brazilian universities with a more consolidated innovation management, with the presence of Nucleus of Technological Innovation, constant interaction between universities and industry, and several technologies transferred to the productive sector, as the University of São Paulo (USP) and Federal University of Rio de Janeiro (UFRJ) (ANGELI; DIAS; FILGUEIRAS, 2013; CASTRO; SOUZA, 2012; DIAS; PORTO, 2014; SANT´ANNA; ALENCAR, 2014). However, this scenario is not commonly seen in many Brazilian public universities, and the problem of innovation management is that the motivations of managers, researchers and professors can be very different. The academia tends to encourage the articles published in newspapers and journals, instead of deposits and granting of patents resulting from research (QUERIDO; LAGE A.G, 2011).

Thus, the technological production ends up getting less incentive, as well as the approximation of academic research with the productive sector (HAASE; ARAÚJO; DIAS, 2005). Because of this, the aim of this study was to analyze the elements that influence innovation management at a public university in the south of Brazil. The research question was: "What elements influence the innovation process from the perspective of managers, researchers with only scientific production and researchers with technological production?". We hope that this work contributes to the improvement of innovation management in universities.

This work is divided into five sections, including this introduction. The second section presents a literature review regarding university-industry relationship. The third section shows the methodology adopted. The fourth section provides a descriptive analysis of the results based on interviews with university managers and researchers. Next, we present the discussion of this results and a new model proposed to improve university-industry relationship in development of new technologies. The fifth section brings the final considerations of the work.

2 THEORICAL BACKGROUND

2.1. TRIPLE-HELIX MODEL

The cooperation between the university and industry began to receive attention from academic studies mainly in the 1960s, with studies by Sábato and Botana (1968) in Latin America. The authors evaluated the interaction between university, industry and government as a means of stimulating the growth of developing countries. The studies resulted in the "Triangular Model of Sabato", where the borders are occupied by the government, the productive structure (trade or industry) and the scientific and technological infrastructure of a country. The model indicates that, besides a robust scientific and technological infrastructure, it is necessary to transfer research results to the productive sector.

In the mid-1990s, the Sabato Triangular Model evolved, and the Triple-Helix Model was created by Henry Etzkowitz based on observations of the performance of the Massachusetts Institute of Technology and its relationship with the conglomerate of high-tech companies (ETZKOWITZ; LEYDESDORFF, 2000). The objectives and structure of the Triple-Helix Model are basically the same as those of the Triangular Model of Sabato, but those involved - university, government, and industry - share responsibilities in scientific and technological development without hierarchy. For Henry Etzkowitz, the interaction between these three agents allows the creation of a sustainable and lasting innovation system in modern economies (PHILIPPI; MACCARI; CIRANI, 2015; VALENTE, 2010). In the next section, we will show the historical context of university-industry relationship, especially in Brazil.

2.2. UNIVERSITY-INDUSTRY RELATIONSHIP

The process of approaching the scientific results of the university for the development of technologies in companies is known, among other definitions, as university-industry relationship (MA; LEE, 2008; MENDES; AMORIM-BORHER; LAGE, 2013). Until the 1990s, large companies conducted basic and applied research, developing technological innovations in an autonomous process. In the 1990s a set of structural, legal, financial and human aspects seems to have changed the context surrounding universities, creating a more favorable environment for the protection and commercialization of academic research. There was a change in the behavior of researchers toward intellectual property rights, motivated by the creation of technology transfer offices in universities, and by changes in the general rules that define the researcher's participation in the economic results obtained by the commercialization of research (DALMARCO et al., 2011).

Furthermore, with the Law 10,973 (BRASIL, 2004), of December 2, 2004, known as the Technological Innovation Law, Brazil acquired a new incentive to improve innovation in universities. The objective of the law was to allow the university's technological autonomy in order to promote the country's industrial development. According to the Law, a Nucleus of Technological Innovation (NTI) inside a university would be a structure to manage the entire innovation policy of the institution. However, it seems that universities today are still far more concerned with protecting the knowledge they create, rather than looking for partnerships with industry (BARROS, 2015; DALMARCO et al., 2011). Additionally, this Law failed to conclude discussions on the imminent need to increase the efficiency of patenting inventions arising from the academic environment. In addition, there was no incentive to expand the role of the university with an impact on the country's industrial development, assuming an understanding that the patent is essential for the transfer of technology to companies, thus giving rise to market innovations (QUERIDO; LAGE A.G, 2011).

Nevertheless, regarding the innovation process in Brazil in recent years, universities seem to be evolving as knowledge generators. This can be observed by the increase in the number of scientific publications (Brazil was ranked 23rd in articles published in 2015) ("Nature Index tables", 2015). In addition, in order to transfer the knowledge generated to companies, universities are establishing the NTIs, which are responsible for helping researchers to find market opportunities, facilitate the patenting process and manage contracts between industry and universities (DALMARCO et al., 2011).

Between 2000 and 2016 there was a significant increase in the number of patents deposited in the country (DA ROSA et al., 2016; DALMARCO et al., 2011; MENDES; AMORIM-BORHER; LAGE, 2013; OLIVEIRA; VELHO, 2009). In spite of this growth, the participation of Brazilian universities as the users of the intellectual property system was incipient, incomparable to North American universities, for example, that are the users of a system of intellectual property protection much more consolidated (OLIVEIRA; VELHO, 2009). In Brazil, cooperation between the university and industry is still recent and few studies have been done on this subject (PHILIPPI; MACCARI; CIRANI, 2015). Studies have shown that the major emphasis was given to universities in the Southeast region of Brazil (mainly those in the State of São Paulo), responsible for 1699 or 79.5% of patents registered by Brazilian universities between 1979 and 2007. This is explained by the concentration of researchers, public investments and scientific and technological institutions in the region. The southern region (which includes the states of Rio Grande do Sul, Santa Catarina, and Paraná) was the second in the ranking, with 259 (12.3%) patents in the same period (OLIVEIRA; VELHO, 2009).

In recent years, with increasing complexity and cost of technology development, large companies are focusing more on applied research, leaving basic research to institutions such as universities and research centers (HEINONEN, 2015; LAPLUME et al., 2015; MENDES; AMORIM-BORHER; LAGE, 2013). Thus, the increase in published scientific articles should stimulate the creation of new technologies, increasing the activity of innovation in the Brazilian industry. However, instead of providing technologies for companies, universities generally maintained the knowledge internally in the form of patents (DA ROSA et al., 2014; DALMARCO et al., 2011). In addition, despite the increase in the number of articles published, universities still find it difficult to address the needs of the productive sector, especially public institutions (MENDES; AMORIM-BORHER; LAGE, 2013; PRIES; GUILD, 2011; SIEGEL et al., 2003). In Brazil, universities are concerned with the filing of patents related to scientific results without knowing if a industry may be interested in them (AMADEI; TORKOMIAN, 2009; DA ROSA et al., 2016).

In 2016, Law no. 13,243 was approved (BRASIL, 2016) and became known as the Legal Framework of Science and Technology in Brazil. According to this Law, public universities and private industries can work more closely. Among the changes, the Law allows full-time professors to develop research within companies, and university laboratories to use the industry to develop new technologies - in both cases, with remuneration. In addition, it allows companies involved in projects with the university to maintain intellectual property over research results (products). However, changes in the regiment of public institutions themselves are necessary to reduce bureaucracy in the innovation management process after the law has been sanctioned. In this way, the knowledge of university-industry relationship serve as base to structure the interviews and analysis that will be presented in the following chapters.

3 METHODOLOGY

The approach used for the analysis of question-problem was a qualitative approach, and research is characterized as exploratory. The University was chosen as one of the public institutions that has a Technological Innovation Center with more than five years, a business incubator and researchers with patents filed in various areas.

3.1 RESEARCH METHOD

The exploratory study was conducted in a public university in southern Brazil. The methodology was based on semi-structured interviews. The qualitative analysis was used to verify the convergence and divergence patterns perceived regarding the study goals by the following interview groups: Group I: University Managers; Group II: Researchers with scientific and technological production (patents); Group III: Researchers with only scientific production (articles, books or similar). All respondents needed to have a doctoral degree and articles published in international journals. Initially, respondents were identified from NTI. Thus, the method of snow-ball was used, in which researchers interviewed indicated the next, making it easier to obtain contacts.

3.2 INTERVIEW

The interviews included a series of open questions about the views of researchers regarding the elements that influence the publication of articles or patents, university incentives, motivations of researchers, among others. The guide of the interview was adapted and based on previous studies of Maehler (2011) and Siegel (2003, 2004), and two experts validated the interview tool and proposed amendments to the original instrument. One interview was considered "pilot", which allowed improving the script of interviews. The interview questions list for each group is presented in Appendix A.

Each interview was recorded electronically using a digital recorder, with the consent of the interviewee. The recordings were later transcribed to facilitate content analysis. The primary sources of data were obtained from semi-structured interview consisting of 19 questions open for Group I and II, and 10 open questions for Group III. A researcher directly involved in the study design conducted the interviews between March and June 2016, which were held up to 1 hour long. Table 1 described the profile of interviewed. A total of 19 people were interviewed, including 6 managers, 6 researchers with only scientific production, and 7 researchers with scientific and technological production. The researchers were selected from different areas of expertise: engineering, health, biology and agronomy.

Table 1. Profile of the interviewees from each group

Groups	Position (Area of Practice)	Time at University	Production Summary
Group I: Managers	Rector (Humanities and Social Sciences)	31 years	16 articles
	Coordinator of Nucleus of Technological Innovation (Health Sciences)	6 years	67 articles and 3 deposited patents
	Coordinator of the Incubator (Agrarian Sciences)	18 years	20 articles
	Coordinator of the Pro-Rectory of Extension (Health Sciences)	12 years	123 articles, 18 deposited patents, 1 granted patent* and 1 licensed patent
	Coordinator of Postgraduate Program (Health Sciences)	7 years	117 articles, 1 deposited patent
	Coordinator of Postgraduate Program (Biological Sciences)	18 years	170 articles and 21 deposited patents

Group II: Researchers with scientific and technological production	Associate Professor (Biological Sciences)	8 years	57 articles and 16 deposited patents
	Associate Professor (Engineering)	7 years	42 articles and 18 deposited patents
	Associate Professor (Engineering)	10 years	74 articles and 5 deposited patents
	Associate Professor (Health Sciences)	8 years	84 articles and 1 deposited patents
	Associate Professor (Agrarian Sciences)	3 years	29 articles and 9 deposited patents
	Associate Professor (Health Sciences)	6 years	74 artigos, 14 deposited patents, 1 granted patent* e 1 licensed patent
	Associate Professor (Biological Sciences)	8 years	71 articles and 7 deposited patents
Group III: Researchers with only scientific production	Professor (Health Sciences)	24 years	281 articles
	Associate Professor (Engineering)	2 years	15 articles
	Associate Professor (Health Sciences)	3 years	52 articles
	Associate Professor (Biological Sciences)	8 years	21 articles
	Associate Professor (Engineering)	2 years	10 articles
	Associate Professor (Health Sciences)	8 years	40 articles

*Patent granted in the United States

Source: Research data

3.3 DATA ANALYSIS

Data were collected and analyzed from multiple sources, such as interviews with managers and researchers, file data of the NTI (number of patents deposited and transferred by the university, employees, incubated companies), the surveyed university (number of professors, students, research projects, published articles, etc.) and information from the internet. The content analysis was performed on the MAXQDA software 12 (Verbi GmbH, Berlin, Germany) as described by Bardin (2006), which should be an objective description, systematic and quantitative content of the interviews. The procedure was discussed by two researchers to increase the accuracy of the analytical generalization of empirical data. The recurring themes in the responses were grouped into specific categories defined a priori. In a similar approach to that used by other qualitative studies regarding innovation and technology transfer (MAEHLER et al., 2011; SIEGEL et al., 2003, 2004), the occurrence of each subject was counted and converted to a percentage of the total to facilitate the synthesis and analysis of data.

4 RESULTS AND DISCUSSION

In this section the results of the interviews will be presented, as well as the discussion of the main elements identified. Next, we will propose a new model for university-industry relationship to improve the development of new technologies.

4.1 UNIVERSITY

The researched public university is in southern Brazil and has 98 undergraduate courses, 23 doctoral programs, 44 master's degree courses, 21 specialization courses, 9 residency programs, 4 multidisciplinary residences. In numbers of human resources the university currently has 15,127 undergraduate students, 1,315 master students, 855 doctoral students, 1,351 technical and administrative staff and 1,286 teachers (of these, 78% doctors). Besides, the university has 1,279 ongoing projects in 2015. Of these, 112 are funded. In addition, the university has 210 research groups certified by CNPq and 123 teacher with productivity grants. Regarding scientific production, it has 2,507 articles published in journals, 550 books, 3,421 work in annals (reference year: 2014). And regarding technological production (base year: 2015), it has 67 patents deposited, 1 patent granted, 8 registered softwares and 2 technologies under negotiation (Source: interviews and analyzed university file).

In this university, the Technological Innovation Coordination manages the innovation policy and is divided into two parts: "Entrepreneurship and Business Incubation Center", and the "Intellectual Property and Patents Center". The Entrepreneurship and Business Incubation Center consists of incubation section that aims to implement and develop the incubation policy of technology-based industry; and the section of partnerships and projects that is responsible for the development and control of relationship actions between industry and public agencies. This incubator was established in 2015 and currently has 7 incubated companies in the areas of information and communication technology, biotechnology, agricultural science, creative and cultural industry. Meanwhile, the Intellectual Property and Patents Center is responsible for opening and tracking of patent applications processes, licensing and other issues related to intellectual property. It has 6 employees and was created in 2005 (Source: interviews and analyzed university file).

4.2 CONTENT ANALYSIS

From 19 interviews with managers and researchers, it was analyzed the elements that influence the management of innovation in the university. Four dimensions were identified and will be discussed in the next topics: university role, scientific production, technological production and knowledge transfer. Thus, it was possible to analyze what influence the innovation process from the point of view of managers, researchers with only scientific production and researchers with scientific and technological production.

4.2.1 UNIVERSITY ROLE

The role of the university has expanded from traditional teaching and research to more actively seeking opportunities with development of technologies applied to the productive sector (HEINONEN, 2015; JUANOLA-FELIU et al., 2002). In Table 2 are described the analysis of content for the dimension university role by the interviewees of each group. In the case analysis, for all groups (34.4%) the main role of university reported was to assist in the technological development of the productive sector, with a higher predominance of answer for both researchers group. These results suggest that there is an agreement between the researchers of the potential role of the university to assist the productive sector, which could result in economic and social development. While for managers the training of human resources was the most reported role (36.4%), and probably the university management are more geared for this purpose. One of the managers reported that "the university must provide answers to the society challenges". In addition, it has been reported that "through research, teaching and extension actions by the university can be an important agent in facilitating the lives of those working with research and technological development" (University manager).

Table 2. Frequency (number of answers) and percentage (%) in the text for the dimension university role by the interviewees of each group.

Category	Subcategory	Groups Frequency (%) I	II	III	All Groups Frequency (%)
University role to economic and social development	Production of scientific knowledge	-	2 (18.2)	2 (20.0)	4 (12.5)
	Assist in the technological development of the productive sector	2 (18.2)	5 (45.5)	4 (40.0)	11 (34.4)
	Have a relationship with society through teaching, research and extension	2 (18.2)	-	2 (20.0)	4 (12.5)
	Training of human resources	4 (36.4)	1 (9.1)	1 (10.0)	6 (18.8)
	Be aligned with the economic and social needs of the country	3 (27.3)	3 (27.3)	1 (10.0)	7 (21.9)
Impact of research on society	Presentation of research results to society	-	1 (10.0)	2 (20.0)	3 (9.7)
	Continuing education of professionals	-	1 (10.0)	1 (10.0)	2 (6.5)
	Research on the country's development needs	4 (36.4)	-	2 (20.0)	6 (19.4)
	Approach and support of research to the productive sector	4 (36.4)	6 (60.0)	4 (40.0)	14 (45.2)
	Encouraging researchers to bring research closer to society	3 (27.3)	2 (20.0)	1 (10.0)	6 (19.4)
Research funding	Financing with a counterpart of companies	2 (25.0)	1 (11.1)	-	3 (12.0)
	Donation of materials only by companies	-	1 (11.1)	2 (25.0)	3 (12.0)
	Financing by public agencies	6 (75.)	7 (77.8)	6 (75.0)	19 (76.0)

Source: Research data

The university-company relationship should seek to strengthen the university's role in the country, including teaching, research and support for industrial development; and should not be interpreted as a loss of academic principles as if the university were subject to market pressures (CHANG et al., 2016). The approximation and support of research in the productive sector (45.2%) was the main reported means of research to have an impact on society by all groups. In addition, all groups reported receiving funding by public development agencies (76%). The CNPq (National Council for Scientific and Technological Development) and CAPES (Coordination for Improvement of Higher Education Personnel) are the main research promotion agencies in Brazil, created with the purpose of contributing to the development of scientific research in the country. A great contribution of these bodies is to guarantee the subsistence, in large part, of masters and doctoral students, providing a more favorable condition for the training of students with the aim of encouraging the formation of high level human resources (MIRANDA; CARVALHO; RAMOS, 2015).

In the present study, no researcher with only scientific production reported having produced technologies for the productive sector or had financing with counterpart of companies. Some national government agencies, such as the BNDES, encourage the funding of public-private partnerships that can be exploited by university researchers. Obtaining funding from companies can support scholarships and research laboratories, not just royalties, which can represent a major source of fundraising (PERKMANN; KING; PAVELIN, 2011).

4.2.2 SCIENTIFIC PRODUCTION

Scientific journals represent one of the main communication vehicles of scientific research (BEUREN; SOUZA, 2007). In most countries, such as the United States and Brazil, researchers' survival in universities is determined by their scientific productivity, with emphasis on high-quality periodicals, which is an attempt to reconcile quantity with quality (LUCIANI; CARDOSO; BEUREN, 2007). CAPES is the agency that evaluates the graduate programs, with criteria that include the amount of their scientific production (BEUREN; SOUZA, 2007; MIRANDA; CARVALHO; RAMOS, 2015). Qualis CAPES is a list used by CAPES to classify journals used by graduate programs. Despite this, there is more appreciation in the quantity of published articles than in the quality of them (BEUREN; SOUZA, 2007).

Regarding scientific production (Table 3), academic motivation (related to improvement in academic career) was more prevalent in all groups (48.5%), and was the most reported by managers (57.1%) and researchers with technological production (58.3%). For researchers with scientific production, the personal motivation related to a personal desire for research (35.7%) was as expressive as academic (35.7%). These results suggest that even CAPES's high incentives for scientific production were not the main motivators for scientific production (BEUREN; SOUZA, 2007), probably due to the difficulties of producing science in the country, such as few public funds, few fellows of productivity to professors and lack of time for dedication to research, since the researcher is usually also university teacher in Brazil (BOSI, 2007).

The stimulus with quantitative evaluation of scientific production (40.7%) was the most reported reason for the appreciation of scientific production by all groups, especially for the group of managers (40%) and researchers with technological production (50%). While for the group with only scientific production, the higher value would be because it is traditionally what most researchers do and know how to do (57.1%). One of the consequences of the higher valuation of scientific production is that the quality of academic production began to be measured by the quantity of the production itself. As a result, there was a growth of production academic, but the goal of the same ends in the productive act itself, without the consequent return of academic research to society (BOSI, 2007). One of the researchers with only scientific research reported that this is probably due to the "way of researcher evaluation and the way in which funding is obtained, which are basically related to the quantitative scientific production". The description of the results for all groups in the scientific production dimension is given in Table 3.

Table 3. Frequency (number of answers) and percentage (%) in the text for the dimension scientific production by the interviewees of each group.

Category	Subcategory	Groups Frequency (%)			All Groups Frequency (%)
		I	II	III	
Motivation for scientific production	Personal motivation	3 (42.9)	2 (16.7)	5 (35.7)	10 (30.3)
	Academic motivation	4 (57.1)	7 (58.3)	5 (35.7)	16 (48.5)
	Social motivation	-	2 (16.7)	3 (21.5)	5 (15.2)
	Economic motivation	-	1 (8.3)	1 (7.1)	2 (6.1)
Reasons for appreciation of scientific production	Traditionally is what most do and know how to do	1 (10.0)	4 (40.0)	4 (57.1)	9 (33.3)
	There are more published articles than patents in the area	2 (20.0)	-	-	2 (7.4)
	Faster process to the publication of articles	1 (10.0)	-	-	1 (3.7)
	Stimulus with quantitative evaluation of scientific production	4 (40.0)	5 (50.0)	2 (28.6)	11 (40.7)
	Inadequate qualitative evaluation of scientific production	2 (20.0)	1 (10.0)	1 (14.3)	4 (14.8)

Source: Research data

4.2.3 TECHNOLOGICAL PRODUCTION

In Table 4 is described the results for the dimension technological production by the interviewees of each group. For the development of technologies and patent deposits, the general analysis shows that academic motivation was the most prevalent (48%). While for managers it was observed that personal (30%) and academic motivation (30%) would be the main ones for the deposit of patents, the group that presented the highest academic motivation for this purpose was researchers with only scientific production (66.7%). In addition, for researchers with technological production there was also a predominance of academic motivation for patent production (55.6%). One of the researchers with only scientific production reported that "the stimulus for filing patents still mainly involves the academic issue." According to him, "a lot of people have been filing a patent as a tool to grow their curriculum rather than transforming it into products". The results suggest that the greatest motivation of the researchers with the deposit of patents is with the improvement of the curriculum by the quantitative evaluation of the production. One of the researchers stated:

> A few years ago we needed to encourage people to publish articles and file patents at any cost, because there was no culture of patent deposit. It was a great myth! There was a moment at our university with a great encouragement for people to write patents. However, in my view there was a deviation in this way, since not everything should be patented. In my view, the patent is not an article, it's a market-oriented tool! At the time the deposit is made, a financial obligation is generated for the institution. The patent has market purposes. In the same way that I am a little critical of how the production of articles have been conducted, in patents I am also. Placing a patent without the next day trying to license it is an empty job. Because that patent after a few years is going to expire and will not be worth anything, and generated a burden for university (Researcher with scientific and technological production).

Table 4. Frequency (number of answers) and percentage (%) in the text for the dimension technological production by the interviewees of each group.

Category	Subcategory	Groups Frequency (%) I	II	III	All Groups Frequency (%)
Motivation for technological production	Personal motivation	3 (30.0)	-	1 (16.7)	4 (16.0)
	Academic motivation	3 (30.0)	5 (55.6)	4 (66.7)	12 (48.0)
	Social motivation	2 (20.0)	3 (33.3)	1 (16.7)	6 (24.0)
	Economic motivation	2 (20.0)	1 (11.1)	-	3 (12.0)
Reasons for lower appreciation of technological production	Patents are not peer reviewed	2 (20.0)	-	-	2 (8.7)
	Only quantitative evaluation of technological production	2 (20.0)	2 (40.0)	3 (37.5)	7 (30.4)
	Difficulty evaluating due to the different stages of the patent	1 (10.0)	-	2 (25.0)	3 (13.0)
	Difficulty in turning market innovation	2 (20.0)	1 (20.0)	2 (25.0)	5 (21.7)
	In certain areas patents are not representative	2 (20.0)	1 (20.0)	-	3 (13.0)
	Difficulty in assessing the delay in granting the patent	1 (10.0)	1 (20.0)	1 (12.5)	3 (13.0)
Stimulus of the university to technological production	With technology initiation grants	1 (11.1)	-	2 (25.0)	3 (12.0)
	With the creation of a stimulus environment for innovation	2 (22.2)	-	-	2 (8.0)
	With events promoted by the NTI	5 (55.6)	2 (25.0)	3 (37.5)	10 (40.0)
	The university does not stimulate	1 (11.1)	6 (75.0)	3 (37.5)	10 (40.0)
Difficulties in the patenting process	Lack of university advisory	2 (11.8)	2 (11.8)	N.A.	4 (11.8)
	Difficulties in searching for patent anteriority	-	1 (5.9)	N.A.	1 (2.9)
	Unfamiliarity with the deposit process is made	1 (5.9)	-	N.A.	1 (2.9)
	University Bureaucracy	1 (5.9)	2 (11.8)	N.A.	3 (8.8)
	Problems in the use of resources of the Supporting Foundations	1 (5.9)	-	N.A.	1 (2.9)
	Anxiety of the researcher to publish before patenting	1 (5.9)	-	N.A.	1 (2.9)
	Delays in the patenting process	2 (11.8)	3 (17.6)	N.A.	5 (14.7)
	Few resources available for patenting	1 (5.9)	2 (11.8)	N.A.	3 (8.8)
	Cultural barriers to patenting at the institution	2 (11.8)	-	N.A.	2 (5.9)
	Low qualification of researchers to write patents	2 (11.8)	4 (23.5)	N.A.	6 (17.6)
	Lack of professionalism of NTI	1 (5.9)	2 (11.8)	N.A.	3 (8.8)
	Lack of negotiation	1 (5.9)	-	N.A.	1 (2.9)
	Difficulties in the confidentiality of projects and defenses	2 (11.8)	1 (5.9)	N.A.	3 (8.8)
Contribution of the Nucleus of Technological Innovation (NTI) in the patenting	With evaluation of the patent applications in Institutional Commission	1 (10.0)	3 (27.3)	N.A.	4 (19.0)
	Promotion of intellectual protection events	1 (10.0)	-	N.A.	1 (4.8)
	Support in the administrative part of patenting	3 (30.0)	3 (27.3)	N.A.	6 (28.6)
	Assistance with basic information for patent deposit	4 (40.0)	3 (27.3)	N.A.	7 (33.3)
	Awareness raising for intellectual protection	1 (10.0)	-	N.A.	1 (4.8)
	No or little contribution	-	2 (18.2)	N.A.	2 (9.5)

Suggestions for improvements in NTI	Do more training and workshops on intellectual protection	1 (7.7)	2 (18.2)	N.A.	3 (12.5)
	Improve patenting and transfer protocols	-	1 (9.1)	N.A.	1 (4.2)
	Aid in the search of potential companies for transfer	-	2 (18.2)	N.A.	2 (8.3)
	Streamline patent filing processes	1 (7.7)	-	N.A.	1 (4.2)
	Training of research groups to interact with companies	1 (7.7)	2 (18.2)	N.A.	3 (12.5)
	Creation of Office for Technology Transfer	1 (7.7)	-	N.A.	1 (4.2)
	Help from another office to better qualify patents	1 (7.7)	-	N.A.	1 (4.2)
	More qualified human resources to work at NTI	2 (15.4)	3 (27.3)	N.A.	5 (20.8)
	Stimulate entrepreneurial students to incubate companies	2 (15.4)	-	N.A.	2 (8.3)
	Assistance in the market analysis of technology	1 (7.7)	-	N.A.	1 (4.2)
	Aid in the search of patent anteriority	2 (15.4)	1 (9.1)	N.A.	3 (12.5)
	Careful examination of patent applications	1 (7.7)	-	N.A.	1 (4.2)

N.A.: Not applicable
Source: Research data

Unlike the articles, the patent filing at the National Institute of Industrial Property (INPI) does not require peer review, which was one of the elements raised by managers for lower patent valuation. The granting of the registration of a patent in the INPI has taken from 8 to 10 years (GOUVEIA, 2007). These damages the economy and innovation, and the patents granted this year refer to innovations made about a decade ago. In general, the only quantitative evaluation of technological production (30.4%) would be one of the main reasons for the lower valuation of this production, followed by the difficulty of becoming market innovation (21.7%).

Although the analysis of only patent data may be an important method of evaluating technological production, and it is used by several studies and by CAPES, most of the deposited patents did not become products that reach the market (ABRAHAM; MOITRA, 2001; DA ROSA et al., 2015, 2016). Moreover, in some areas (such as the human or social sciences), patents would not be representative of the researcher's production, and the graduate evaluation agencies must consider these different inherent aspects of each area at the time of analyze scientific and technological production.

Among the stimuli of the university for technological production, the most reported was "events promoted by the Nucleus of Technological Innovation" (40%), and still 40% reported that the university does not stimulate this initiative. In addition, 37.5% of the reports from the group of researchers with only scientific production pointed to the university's lack of stimulation. In the group of researchers with technological production, the report of no stimulus was even more prevalent, being in 75% of the reports. Only in the group of managers there was a predominance (55.6%) of reports that the stimulus occurs with events promoted by NTI. Although managers are evaluating that there is a stimulus to technological output, the researchers seem not to be encouraged by what is being done. New measures could be taken to encourage more technological production by researchers, which may include a higher valuation by CAPES or even a higher economic gain with royalties, as already regulated in Law No. 10,973 (BRASIL, 2004). Meanwhile, researchers' low ability to write patents (17.6%) and delay in the patenting process (14.7%) were the most reported difficulties for all groups. One of the researchers reported that "the university does not stimulate technological production, and for groups working with applied science it is always a challenge to try to help the institution to have a movement in favor of this production."

The contribution of NTI, in general, would have been mainly with support with basic information for deposit (33.3%) and in the administrative part of patenting (28.6%). According to Law No. 13,243 (BRASIL, 2016), the role of NTI is to manage innovation institutional policy. In addition, it would be the competencies of the NTI to develop studies of technological prospecting and competitive intelligence in the field of intellectual property in order to guide the innovation actions of the institutions; develop studies and strategies for the transfer of innovation generated by universities; promote and monitor the university-industry relationship, negotiate and manage technology transfer agreements from university.

The main suggestions for NTI were more qualified human resources to work in the nucleus (20.8%), the accomplishment of more training and workshops on intellectual protection (12.5%), the training of research groups to interact with companies (12.5%) and aid in the search for anteriority (12.5%). A recent study pointed out that one of the main management problems of NTIs would be the limited number of human resources trained to operate at the core (RODRIGUES; GAVA, 2016). One of the researchers with technological production reported the group's difficulties in the patenting process:

> The first step we went through was inexperience in the pursuit of patent anteriority. At that moment a bit of demotivation begins, a lack of motivation due to lack of experience. The moment that this difficulty is overcome, the researcher begins to find other barriers. It is necessary to have a team in which everyone understands the innovation. So within this search, the researcher will assess whether what is being done or is intended to develop is innovative or not. When the inexperience of the search for precedence is overcome, the researcher began to encourage the program to stimulate patents (Researcher with scientific and technological production).

4.2.4 KNOWLEDGE TRANSFER

The results for dimension "knowledge transfer" is shown in Table 5. Usually the university does not intend to use the patent to prevent third parties from using the technology, and the main objective is usually to try to carry out the transfer (VEER; JELL, 2012). Regarding technology transfer, in general analysis 63.2% reported that they would consider the development and/or incubation of industry. This was also more predominant in the group of managers (60%) and researchers with technological production (66.7%).

The incubation is a dynamic enterprise development process that helps them survive and grow during the initial period when they are most vulnerable, providing management, financing and technical support services, and also offering shared office services, access to equipment, rents and flexible spaces (RAUPP; BEUREN, 2006). The incubator of the analyzed university presents little more than a year of existence and currently counts on only 7 companies incubated. Recent studies show that universities linked to incubators and technology parks have a positive and effective impact on innovation management, especially in the development of companies from the spin-offs (CHANDRA; CHAO, 2016; CORSI; PRENCIPE, 2016; SOETANTO; JACK, 2016). One researcher stated:

> Considering that students are involved in the development of technologies, incubation and the development of startups would be a good way to take ideas that have been developed in the university and are already protected. And the university would be the partnership

of these companies of academic origin. Soon, there would be a partnership of alumni, graduates of the program, with the university that would help these companies. That would be very socially correct. Because these students would be taking job opportunities, and would continue to do what they learned to do, and the university would be modernizing and participating in companies of academic origin. This for me would be the most beautiful to see happen! Including with the legal participation of researchers and professors with these companies (Researcher with scientific and technological production, 2016).

The lack of understanding of the legal part (17.6%) and bureaucratization in the transfer process (14.7) were the most reported difficulties in the technology transfer process by the groups. The most reported cause for non-transference was the lack of a culture of university innovation (46.2%), followed by university bureaucracy (30.8%). One of the managers reported there is "difficulty in negotiating and it is difficult to realize technological agreements in the university". In addition, he added that "the bureaucracy has to be diminished! The agreements have been a major barrier, which with the new Legal Framework of Science and Technology can improve innovation policy within the university". Bureaucratic barriers can inhibit the relationship between universities and companies, making the transfer process difficult. Although Law No. 13,243 (BRAZIL, 2016) has made advances regarding university technology transfer policies, further advances are necessary within the university itself in order to facilitate the transfer process and reduce existing bureaucracies.

Table 5. Frequency (number of answers) and percentage (%) in the text for the dimension knowledge transfer by the interviewees of each group.

Category	**Subcategory**	**Groups** Frequency (%)		**All Groups** Frequency (%)
		I	**II**	
Ways to PERFORM technology transfer	It would consider the development and/or incubation of	6 (60.0)	6 (66.7)	12 (63.2)
	It would consider the licensing of technologies	4 (40.0)	3 (33.3)	7 (36.8)
Difficulties in technology transfer	Bureaucratization in the transfer process	4 (18.2)	1 (8.3)	5 (14.7)
	Culture that the private sector wants to take advantage of the university	3 (13.6)	1 (8.3)	4 (11.8)
	Geographical location of the university	-	1 (8.3)	1 (2.9)
	Lack of professionalism of the university	1 (4.5)	-	1 (2.9)
	Lack of university closeness to the productive sector	2 (9.1)	2 (16.7)	4 (11.8)
	University does not want to dilute risks with companies	1 (4.5)	2 (16.7)	3 (8.8)
	Delay in making transfer contracts with productive sector	2 (9.1)	-	3 (8.8)
	Lack of facilitative mechanisms for transfer	1 (4.5)	1 (8.3)	2 (5.9)
	Inadequate conduct of bidding/ electronic auction for patent	1 (4.5)	1 (8.3)	1 (2.9)
	Lack of understanding of the legal part	3 (13.6)	2 (16.7)	6 (17.6)
	Lack of culture of innovation in university	3 (13.6)	1 (8.3)	4 (11.8)

Most common reason of non-transfer of technology	University bureaucracy	2 (33.3)	2 (28.6)	4 (30.8)
	Lack of culture of innovation in university	2 (33.3)	4 (57.1)	6 (46.2)
	Professionalism is lacking for negotiation and transference	1 (16.7)	1 (14.3)	2 (15.4)
	Culture of which the private body wants to take advantage in the process	1 (16.7)	-	1 (7.7)
Partnership with companies in technological development projects	I would consider a prior partnership, and I already	1 (16.7)	1 (14.3)	2 (15.4)
	I would consider a prior partnership, but I never did	5 (83.3)	6 (85.7)	11 (84.6)
Interaction with business researchers	Never interacted with business researchers	2 (33.3)	1 (14.3)	3 (23.1)
	Little interaction, required by courses or some demand of the productive sector	2 (33.3)	4 (57.1)	6 (46.2)
	Interaction with joint development of technologies	2 (33.3)	2 (28.6)	4 (30.8)
Way to get in touch with companies	E-mail	1 (14.3)	1 (14.3)	2 (14.3)
	Conferences or events	4 (57.1)	5 (71.4)	9 (64.3)
	Never got in touch with companies	2 (28.6)	1 (14.3)	3 (21.4)
Technology transfer agreements	Prior to the development of the project	1 (16.7)	-	1 (7.7)
	Without knowledge of how it was done	1 (16.7)	1 (14.3)	2 (15.4)
	There was no transfer of technology	4 (66.7)	6 (85.7)	10 (76.9)

Source: Research data

In addition, 84.6% reported that they would consider prior partnership with companies but never performed. The interaction prior to the development of the project may facilitate the transfer process later, and may also help in raising funds for the development of joint technology, as long as it respects the terms of confidentiality and current legislation. Only 30.8% reported that they interacted with business researchers for the joint development of technologies. It was reported by one of the managers that "the university should be increasingly open to building the partnership". Policies at the university that encourage the transfer process should be empowered so that the technologies produced in the academy reach the market. For all groups, the way to get in touch with companies would be mainly by congresses or events (64.3%), and 76.9% reported that technology transfer never occurred.

From the obtained results, it was possible to analyze the elements involved in the interaction between researchers, academia and productive sector that influence the management of innovation in the university analyzed. In this way, some barriers have been demonstrated, especially in the difficulty found in technology transfer even after the recent advances in the Innovation Law no. 13,243 (BRAZIL, 2016). In the next section we discuss the results found with emphasis on the current model of innovation management in Brazilian public universities, with a proposal of a new model to overcome the obstacles identified.

4.2 PROPOSED MODEL

Innovation studies have underscored a systemic view of the process of interaction between universities and companies. Over the years, at least in some countries, there was some pressure to apply the research carried out in academia in an economic context (MEYER; SINILAINEN; UTECHT, 2003; VALENTE, 2010). Consequently, governments sought to play a facilitating role and actively support the transfer of technology, as initiatives to innovation of Law No 10,973 (BRAZIL, 2004). However, the research and development of new technologies involves several steps to reach the market. Despite many advances in the last decade and based on our study results, the universities seem to find difficulties in performing technology transfer (AMADEI; TORKOMIAN, 2009; DA ROSA et al., 2015, 2016). In Figure 1 is shown the various steps involved so that research is translated into a product that reaches the market.

In addition, intellectual property issues involve confidentiality and rights over publication of results and research. To have a positive interaction between the private sector and universities, it can be necessary to formalize contracts and avoid bureaucratic procedures, providing a greater degree of security for both (QUERIDO; LAGE A.G, 2011). Figure 2 illustrates the model of the traditional process of scientific and technological production in universities. After the elaboration of the project and the development of a new technology, the researcher chooses to realize the scientific production with articles, or deposits the patent for the later submission of articles derived from research (DA ROSA et al., 2014, 2016; PRIES; GUILD, 2011; SALIMI; BEKKERS; FRENKEN, 2015).

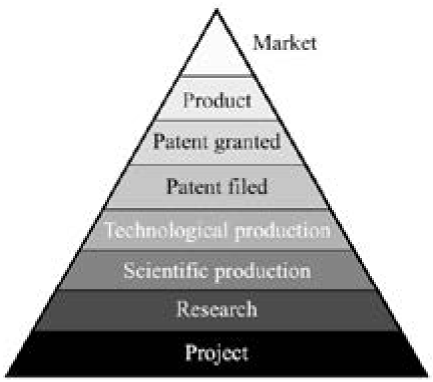

Figure 1. Illustration of the steps necessary for projects and research to turn out products that reach the market.
Source: Prepared by the authors

In the traditional model, only after the patent be filled is made the prospecting of partners (i.e. industry), to license the technology and possibly lead to the market what was developed at the university. As demonstrated in this study, difficulties in prospecting partners after the development and patenting of technologies by universities are diverse. Among the barriers reported, it was highlighted that there are many technologies that can not be of market interest, there is unfamiliarity and bureaucracy related to the legal part of the transfer process, and there are few resources at the university for intellectual protection.

A growing number of companies depends heavily on science as an input to innovation. The electronics industry, the pharmaceutical, biotechnology and nanotechnology are examples of extremely complex technologies to be developed (DA ROSA et al., 2014, 2016; PRIES; GUILD, 2011; SALIMI; BEKKERS; FRENKEN, 2015). Innovations in these areas may involve interaction between universities and companies (SALIMI; BEKKERS; FRENKEN, 2015). In Figure 3 is shown a model proposed for the process of scientific and technological production in the universities. In Table 6 are shown the main features and differences between the current model and the proposed in our study. In this model, it is suggested to prospecting partners at the beginning of the research projects. Thus, some research can be carried out with the demands of the productive sector. Moreover, as potential collaborators in the research, industry may be involved in patent protection process and have priority in licensing and transfer of technologies developed in conjunction with universities, reducing bureaucracy and shortening distances between the productive sector and academia. Additionally, they can invest more heavily in patenting technologies in foreign markets, which requires a high cost very often impractical for public universities (MEYER; SINILAINEN; UTECHT, 2003).

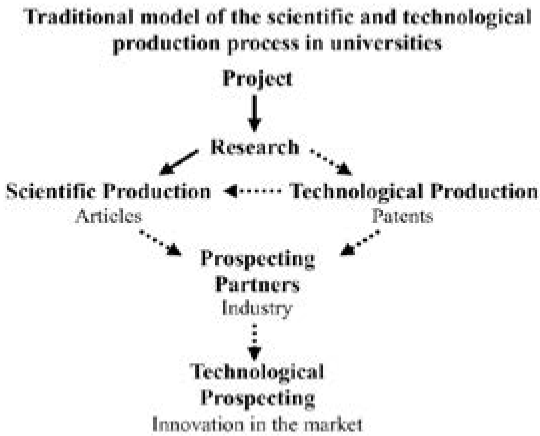

Figura 2. Traditional model of the scientific and technological production process in universities.
Source: Prepared by the authors

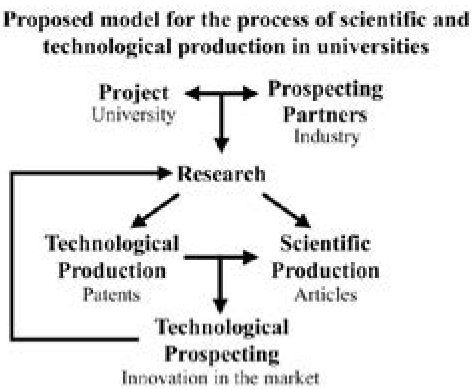

Figura 3. Proposed model of the process of scientific and technological production in universities.
Source: Prepared by the authors

Table 6. Comparison of the characteristics of the traditional model for the scientific and technological production process of the universities with the model proposed by this study.

Traditional model	Proposed model
Research projects developed with researcher autonomy	Research projects developed in conjunction with the productive sector
Research mainly in the interests of the researcher	Research in the interests of the researcher and the productive sector
Researcher/NTI prospects partners for transfer after technology is developed	Researcher/NTI prospects partners prior to the development of technology
Financing mainly of a public development body	Financing of public funding body, with possibility of counterpart of companies
Researcher chooses whether to opt for scientific and technological production, or only scientific	Researcher with the industry decides whether to opt for technological production, or only scientific
University is primarily responsible for filing technology patents	University and industries can be co-holders of technologies developed in partnership
Patent costs only from the university	Patent costs can be divided between university and business
Difficult interaction of academy researchers and business researchers	Possibility of interaction of academy researchers and business researchers
Difficult process of technology transfer	Facilitating the technology transfer process for an existing partner industry
	Facilitation in the recruitment of human resources from the university to the industry, such as students who acted in research with interaction with industries

Source: Prepared by the authors

According to IBGE (2013), only 1.3% of all domestic companies funded innovation projects in partnership with public institutions. Public policies that facilitate the interaction between academia and the productive sector can leverage the model of the Triple-Helix and thus facilitate the transfer of technologies developed at the university (PERKMANN et al., 2013). Thus, the university would have new sources of funds not only from royalties after the licensing of technologies, but also from investments of industry focusing on research and development of technologies with market application.

5. CONCLUSIONS

From this study, it was possible to evaluate the elements that influence the management of innovation of a public university in the south of Brazil. Although researchers and managers report the importance of university contact with the productive sector, the relationship between university-industry is still incipient in the institution. In addition, suggestions were made for the NTI, such as more qualified human resources, training and workshops on intellectual protection. In addition, the report of bureaucracy and lack of culture of innovation in the institution was expressive, as well as the lack of understanding of the legal part.

Although the present study adds important contributions regarding the management of innovation at an exploratory level, the results are limited to a public university in the south of Brazil. However, studies in other institutions (RODRIGUES; GAVA, 2016) and comparing the scientific and technological production of Brazilian universities (CANONGIA; PEREIRA; ANTUNES, 2002; DA ROSA et al., 2016) show that the scenario of the present case is possibly reflected in other national public institutions. New multi-centric studies in universities are suggested to assess the existing barriers in innovation management.

The university has a wide scientific production, and a growing technological production. However, technology transfer seems to be one of the main obstacles to innovation management. It was also observed the importance of public policies within the university itself that facilitates the interaction between academia and the productive sector and helps in technology transfer. Thus, improvements in innovation policies that stimulate researchers to produce both scientific and technological research can improve the current scenario, with possible economic and social impact in the country.

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APPENDIX A – INTERVIEW SCRIPT

Interview questions list for Group I (University Managers) and Group II: (Researchers with scientific and technological production)

1. What / How should the university's role for economic and social development be?
2. How to approach university research with the external environment so that it has an impact on society?
3. How do you seek funding for project development? Has there been any financing by companies?
4. Why do you consider research important with subsequent publication of scientific articles? What would be the importance of also filing patents?
5. Why are there researchers who do not make their publications also run patents?
6. Do you consider that the publication of articles is valued differently than the filing of patents?
7. What were the main factors and motivations that influenced patent filing and the publication of articles? Economic, academic and/or postgraduate evaluation motivation?
8. What are the interests involved in bringing patented technology to the market?
9. What are the difficulties involved in patenting the technologies developed?
10. In what ways would you consider transferring patented technology: licensing, development/incubation of start-ups, consulting? In what way?
11. How did the Coordination of Technological Innovation contribute to the patenting of technology? How could you improve your performance?
12. What are the impediments to technology transfer (patents generate products that come to market)?
13. What would be the most common cause for non-transfer of technology?
14. Would you consider partnerships with companies prior to the development and patenting of technologies? Because?
15. Have you ever interacted with how many business scientists to develop technologies? In what way was the interaction?
16. How would you improve the technology transfer process?
17. How would you describe the way you discover and get in touch with companies potentially interested in the patented technology?
18. If there was transfer of technologies, how were transfer agreements made? How was the interaction with the companies?

Interview questions list for Group III (Researchers with only scientific production)

1. What / How should the university's role for economic and social development be?
2. How to approach university research with the external environment so that it has an impact on society?
3. How do you seek funding for project development? Has there been any financing by companies?
4. Why do you consider research with subsequent publication of scientific articles important? What would be the importance of also filing patents?
5. Why are there researchers who do not make their publications also run patents?
6. Do you consider that the publication of articles is valued differently than the filing of patents?
7. How does your university/faculty/department value patent filing? Has that changed in the last few years?
8. Have you ever considered filing any technology through patents? What are the impediments to the deposit?
9. What are the incentives for the research you receive? Is there any incentive to file a patent? Are there any impediments to patent filing?