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LINKAGE BETWEEN UNIVERSITY SCIENTIFIC AREAS AND ECONOMIC ACTIVITIES

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ABSTRACT

Purpose: This paper aims to establish a methodology that indicates economic activities able to absorb patents related to the main scientific areas of the Federal University of Rio Grande do Sul (UFRGS).

Methodology: Two steps were important to development this methodology. The first one was to range the UFRGS patent according their degree of importance amongst the knowledge area. For this, the International Patent Classification (IPC) was the reference to organizer the patents. The second one was indicated the industries which have more potential to absorb the UFRGS patents. For this, it was used the Algorithmic Links with Probabilities approach, developed by Lybbert and Zolas (2014).

Findings: It was found that 59% of UFRGS' patents were allocated in just ten IPC subclasses, and at least 63% of these patents refer to technological inventions in the chemistry field. The technological core of UFRGS' patents, therefore, lies in chemical science. This demonstrates that UFRGS' patents focus on specific and specialist areas, and that they have significant potential for being absorbed by those economic activities whose products are drugs, therapeutic treatment, beverages, vaccines and insecticides.

Practical Implications: This study may help the universities select both patents and priority industries in order to transfer their technology.

Originality: It is constructed an original methodology which contribute to find a market to the university innovation. Furthermore, the developed methodology can be replicated in any other TICs which have patents.

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ARTICULAÇÃO ENTRE ÁREAS CIENTÍFICAS UNIVERSITÁRIAS E ATIVIDADES ECONÔMICAS

RESUMO

Finalidade: Este trabalho visa estabelecer uma metodologia que indique atividades econômicas capazes de absorver patentes relacionadas às principais áreas científicas da Universidade Federal do Rio Grande do Sul (UFRGS).

Metodologia: Duas etapas foram importantes para o desenvolvimento desta metodologia. A primeira foi ajustar a patente da UFRGS de acordo com seu grau de importância na área do conhecimento. Para isso, a Classificação Internacional de Patentes (IPC) foi a referência para a organização das patentes. O segundo foi indicado pelas indústrias com maior potencial de absorção de patentes da UFRGS. Para isso, foi utilizada a abordagem Links Algorítmicos com Probabilidades, desenvolvida por Lybbert e Zolas (2014).

Constatações: Constatou-se que 59% das patentes da UFRGS foram alocadas em apenas dez subclasses de IPC e pelo menos 63% dessas patentes referem-se a invenções tecnológicas no campo da química. O núcleo tecnológico das patentes da UFRGS está, portanto, na ciência química. Isso demonstra que as patentes da UFRGS se

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concentram em áreas específicas e especializadas e que elas têm um potencial significativo de serem absorvidas por atividades econômicas cujos produtos são drogas, tratamento terapêutico, bebidas, vacinas e inseticidas.
Implicações Práticas: este estudo pode ajudar as universidades a selecionar tanto patentes como indústrias prioritárias para transferir sua tecnologia.
Originalidade: Construiu-se uma metodologia original que contribui para encontrar um mercado para a inovação universitária. Além disso, a metodologia desenvolvida pode ser replicada em qualquer outro TIC que tenha patentes.

Palavras-chave: Patentes, Transferência de Tecnologia, Universidade Federal do Rio Grande do Sul (UFRGS).

VINCULACIÓN ENTRE LAS ÁREAS CIENTÍFICAS UNIVERSITARIAS Y LAS ACTIVIDADES ECONÓMICAS

RESUMEN
Propósito: Este trabajo tiene como objetivo establecer una metodología que indique las actividades económicas capaces de absorber patentes relacionadas con las principales áreas científicas de la Universidad Federal de Río Grande del Sur (UFRGS).
Metodología: Dos pasos fueron importantes para desarrollar esta metodología. El primero fue el rango de la patente de la UFRGS de acuerdo con su grado de importancia dentro del área de conocimiento. Para ello, la Clasificación Internacional de Patentes (CIP) fue la referencia para organizar las patentes. El segundo se refiere a las industrias que tienen más potencial para absorber las patentes de la UFRGS. Para ello, se utilizó el enfoque Enlaces Algoritmos con Probabilidades, desarrollado por Lybbert y Zolas (2014).
Hallazgos: Se encontró que el 59% de las patentes de la UFRGS se asignaron en solo diez subclases de CPI, y al menos el 63% de estas patentes se refieren a invenciones tecnológicas en el campo de la química. El núcleo tecnológico de las patentes de la UFRGS, por lo tanto, reside en la ciencia química. Esto demuestra que las patentes de la UFRGS se centran en áreas específicas y especializadas, y que tienen un potencial significativo para ser absorbidas por aquellas actividades económicas cuyos productos son fármacos, tratamientos terapéuticos, bebidas, vacunas e insecticidas.
Implicaciones Prácticas: Este estudio puede ayudar a las universidades a seleccionar tanto patentes como industrias prioritarias para transferir su tecnología.
Originalidad: Se construye una metodología original que contribuye a encontrar un mercado a la innovación universitaria. Además, la metodología desarrollada puede ser replicada en cualquier otra TIC que tenga patentes.

Palabras clave: Patentes, Transferencia de Tecnología, Universidad Federal de Rio Grande do Sul (UFRGS).

INTRODUCTION

Educational and research institutions collaborate more and more with other non-academic organizations to generate knowledge applied to the productive sector (Perkmann et al., 2013). In this away, the interaction between the university and the productive sector have been considered as fundamental role of organizations academics (Kalar and Antoncic, 2015). In this sense, universities provide essential knowledge for the modern industrial production (Powell and Snellman, 2004). However, little is known about the models underlying technology transfer (Buenstorf and Geissler, 2012). Therefore, there is a lack of research that investigates the models of inventions transference created in universities (Desidério and Zilber, 2014).

In Brazil, Law No. 10.973 (known as the Law of Innovation) was created in 2004 to facilitate the negotiation of inventions which result of academic research. This regulatory framework introduced incentives for the implementation of the Technology Innovation Centers

(TIC) in higher education institutions (Rosa and Frega, 2017). So, the aim of TIC is the encouragement and the promotion both intellectual protection and the commercialization of university's technologies in a more efficient way (Castro and Souza, 2012).

This paper aims at establishing a methodology that indicates economic activities able to absorb patents[1] related to the main scientific areas of the Federal University of Rio Grande do Sul (UFRGS). This study may offer to the TIC managers criterion to they select both patents and priority industries. Moreover, this may support the actions of market prospection and competitive intelligence analysis focused on technology transfer. Besides that, the developed methodology in this paper can be replicated in any other TICs which have patents.

The Federal University of Rio Grande do Sul is the fifth best in Brazil, according to Folha's University Ranking (RUF, 2018). This ranking is based on an indicator composed of the following aspects: research, education, market, internationalization and innovation and is intensively used in Brazil.[2]

In this sense, this work is divided into 5 sections. After this introduction, section 2 discusses the importance of patents for the economic development, patents policy dilemmas and the university patent system, in order to compose the theoretical framework of the present paper. Section 3 presents the methodology used, while section 4 discusses the research data and results, in order to present evidence concerning the correspondence between UFRGS patents and economic activities. Finally, section 5 contains the final considerations.

THEORETICAL FRAMEWORK

There is an extensive literature about the growth of the academic research commercialization spreads in several countries (Thursby and Gupta, 2007; Organisation For Economic Co-Operation and Development, 2009; Mueller and Perucchi, 2014). For implementing these marketing actions, academic inventions in developing countries began to be protected more intensively (Pereira and Melo, 2015). Thus, the royalties start to be a source of income to universities (Mueller and Perucchi, 2014).

Chamas (2003) describes how international academic institutions are organized to manage the process of economic protection and exploitation of intellectual property. Their study goes through institutional policies issues which guide the protection and exploitation of

[1] Patents are defined as temporary property titles over an invention or utility model that meets the novelty requirement (Instituto Nacional de Propriedade Intelectual, 2015).
[2] The four best universities according to this same rank are: University of São Paulo, Federal University of Rio de Janeiro, Federal University of Minas Gerais and State University of Campinas.

intellectual property. This author detects technical, legal and financial barriers which restrict the application of protection intellectual created within universities.

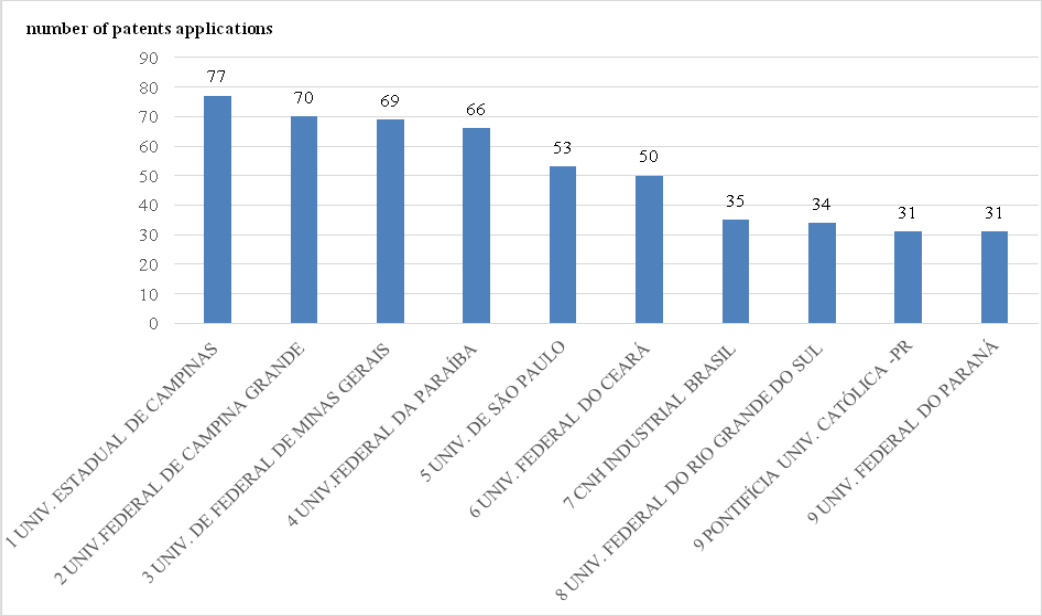
In a more recent study, Silva and Diogenes (2017) explore the competitive strategy evolution and the patent importance in the BRICS economies. According to these authors, BRICS are becoming increasingly important in the globalized scenario. Amongst BRICS countries, the Brazil had the smaller registration of the patents in 2016. Comparatively, the South Korea occupied the six place in patents registration on the world, better than all the BRICS countries.

Since 2010, it has been a growth in the intellectual property registration of Brazilian universities which had little patent activity until the 2000 decade (Oliveira and Nunes, 2009). However, according to Desidério and Zilber (2014), there are many difficulties of making feasible a pricing methodology regarding technology for a market negotiation. These last authors also mentioned the lack of effective business management for technology transfer. In this sense, few innovations are actually transferred from universities to companies (Ismail, Nor and Sidek, 2015).

In 2006, 19.842 patents were filed in Brazil. This number increased to 28.010 in 2016, which represents an annual growth of 4% along these years, according to World Intellectual Property Organization (World Intellectual Property Organization, 2018). These patents filed in this country were influenced by the universities which increasing from 168 to 293 their average number of granted patents (a growth of 42.6%) from the 1990s to the 2000s (Cativelli and Lucas, 2016). This demonstrates an expressive participation of the universities in the total of patents granted in Brazil, since the share of the universities increase from 3% in 2000 to 18% in 2012 on total Brazil granted patents. At the same time, the individuals' participation dropped from 71% to 50%, and the companies' participation increased from 26% to 33% (Instituto Nacional de Propriedade Intelectual, 2018).

The Brazilian Law of Intellectual Property from 1996 and the Law of Innovation from 2004 aroused a movement of protecting knowledge which is produced in Brazilian universities. In other words, the university knowledge became private property able to be marketed (Oliveira and Nunes, 2009; Pereira and Melo, 2015). Data from the National Institute of Industrial Property (*Instituto Nacional de Propriedade Intelectual* – INPI) show that the university patents application grew annually from 256 to 1006, between 2004 and 2016 (Instituto Nacional de Propriedade Intelectual, 2018). Chart 1 show that the main patent applicants in Brazil are mostly universities.

Chart 1 – Main invention patent applicants in Brazil, 2017



Source: Elaborated by the authors based on INPI (2018).

Amongst the top ten organizations which filed patent applications in 2017, eight are universities, as listed in Chart 1. Thus, these data indicate that universities are leading the expansion of protect intellectual regards patents in Brazil. In this sense, it is necessary to propose methodologies that could improve technology transfer.

METHODOLOGY

This paper aims at establishing a methodology that indicates economic activities able to absorb patents related to the main scientific areas of the Federal University of Rio Grande do Sul (UFRGS). In order to achieve this target, two steps were developed in this paper. First one, it was ranged the knowledge fields which UFRGS has patents published, with especially focus in fields which this university more protects its inventions. Second one, it was indicated the industries have more potential to absorb the patents listed in the former step.

In order to establish the methodology of technology transfer proposed at this paper, it was used the Orbit software, a commercial database, to search UFRGS published patents and their respective IPC codes. From this electronic system, it was extracted UFRGS patents published until May 2016, whose total number was 344[3].

[3] Orbit reports only a single IPC symbol per patent, even though the INPI generally designates several IPC classifications. In this sense, the correspondence between UFRGS IPCs and CNAE conducted in this paper considers only a single IPC per patent. However, most of the times, different IPC codes associated to each patent are identified in the Section, Class and Subclass level, being modified more frequently in the Subgroups. Therefore, the correspondence results presented here would not change significantly, even if all the IPCs used to classify each UFRGS patent were considered.

Afterwards, several patent groups were established according the IPC1 codes. So, these groups were arranged from the minor to the biggest in terms of patents number. This was done through Orbit program. After that, the percentage participation of each IPC class and subclass in relation to the total of UFRGS patents were calculated.

Hereafter, the probabilistic matching created by Lybbert and Zolas (2014) was applied – as presented in the following subsection – in order to match the nine biggest IPC classes with the CNAE. So, this match was organized in a table whose columns allocate the industries of CNAE and the rows the technology codes of IPC. After that, a multivariate analysis was conducted through Correspondence Analysis (CA) technique. In order to verify the association between rows and columns, it was applied a Chi-Square test. All these procedures were conducted using the SPPS software.

CA technique was used because it facilitates the data visualization, since it reduce the dimensional space of category in analysis (Prado, 2012). Once each IPC classes can be associated to different economic activities of CNAE, a graphic which drawing such associations would be unfeasible and inaccuracy. However, CA allowed the correspondence visualization between UFRGS-IPC patents and the CNAE-Divisions in a two-dimensional space of easy visualization. Moreover, CA is ideal to test exploratory hypotheses regarding associations between the categorical variables allocated in a contingency table which is arranged in rows and columns (Aguayo, 1993).

The Chi-Square test, which was applied on the contingency table data, is adequate to analyze if there is an association between distinct categorical data allocated in a table. Specifically in the case of this paper, the Chi-Square test was used to answers the question: is there an association of UFRGS patents with specific industry or they match with every industries?

The steps methodology presented in this section were used to develop a proposal of technology transfer from UFRGS to other organizations. But it is possible to apply this transfer tool on every university. In order to clarify in detail this methodology of technology transfer, it is show how was built the Probabilities Links Algorithmic which math the patents with the economic activities and that was developed by Lybbert and Zolas (2014).

Algorithimic Links With Probabilities Approach

The International Standard Industrial Classification (ISIC) arranges all economic activities according to rules, principles and conceptions standardized internationally. Its hierarchical disposition begins by the "Section", the broadest category and ends with a specific identification of products and services in the "Classes" (United Nations, 2008). An example of ISIC complete structure is shown in Table 1 which the code from the first row refers to distilled beverages.

Table 1 – Example of ISIC structure applied to an economic activity

ISIC – example: C11.11-9		
Section	C	Manufacturing
Division	11	Manufacture of beverages
Group	1	Manufacture of beverages
Class	1-9	manufacture of distilled beverages

Source: Elaborated by the authors based on United Nations (2008).

In Brazil, economic activities are categorized according to the National Classification of Economic Activities (CNAE). According to the United Nations, CNAE 2.0 and the ISIC 4.0 have identical structures in the first and second level, respectively, "Section" and "Division". Moreover, CNAE "Group" and "Class" level are almost equal to the ISIC. In this sense, the few difference is for fit to the peculiarities of the Brazilian productive system (United Nations, 2016).

The International Patent Classification (IPC) is a hierarchical, consistent and coherent arrange of technological areas. It is a reference used by inventor to fit the invention in technological areas. For instance, the IPC code of an Integrated Circuit is "H 03 F 3/187", as showed in Table 2.

Table 2 – Example of an IPC hierarchical structure

H 03 F 3/187	
Section H	Electricity
Class 03	Basic electronic circuitry
Subclass F	Amplifiers
Subgroup 3/187	in integrated circuits

Source: Elaborated by the authors based on IPC (2016).

Lybbert e Zolas (2014) built an Algorithmic Links with Probabilities in order to do the matching between the ISIC and the IPC. So, each economic activities of the ISIC was linked with the IPC. In this away, those authors tried approximating the patents and industrial which have potentially would receive those patents. Those authors developed techniques which connected both ISIC to IPC, as well as IPC to ISIC, as presented in the sequence. In any case, the methodological approach is the same for both the link from ISIC to IPC and the link from IPC to ISIC. Because of this, it is showed only the connection between IPC to ISIC in the following.

Correspondence from IPC to ISIC

Each IPC code may be associated to the different ISIC economic activities with different probabilities. Lybbert and Zolas (2014) started this probability calculus using the mining technique. Those authors retrieve keywords which represented each economics activities from original descriptions of ISIC. After that, they retrieve keywords which represented each patent from the titles and abstracts of patents. Finally, they performed the correspondence of both economics activities keywords and patents keywords through the following weighted frequency:

$$\text{Hybrid Weighted Frequency}(SIT\ C_i, IPC_{i\ j}) = \frac{s_{ij}\, m_{ij}}{\sum_j s_{ij}\, m_{ij}} \quad (1)$$

where s_{ij} meaning the patents participation in subclass *j* regarding to the economic activity *i*; m_{ij} indicates the number of patents of IPC Subclass *j* in relation to the patents total. In this away, m_{ij} is retrieved from the search when the keyword of economic activity is *i*. Since that, in many cases, there are multiple IPC codes associated with a single patent, so each one of those IPC codes were weighted according to equation (1). To complete, the specific frequencies were normalized in order to their sums result in 1. In this sense, each IPC is associated to an ISIC classification with different probabilities, according the patent individual participation in the total of patents.

Moreover, the authors referenced did not limit patents for a given year or country. So, it was worked with a large and varied volume of data. Moreover, it was used the World Intellectual Property Organization (WIPO) database, the PATENTSCOPE[4], to research the patents. Furthermore, economic activities descriptions were taken from ISIC. So, Table 3 presents an example of the final correspondence outcome developed by Lybbert and Zolas (2014)[5].

[4] PATENTSCOPE database is available at: <http://www.wipo.int/patentscope/en/>.
[5] The complete probabilistic matching between IPC and ISIC constructed by Lybbert and Zolas (2014) can be seen at the WIPO website (2016) available at: http://www.wipo.int/publications/en/details.jsp?id=3949andplang=EN.

Table 3 – Example of probabilistic matching

IPC Code – Subclass level	ISIC Code – Class level	Probability %
A01B	0150	20,3
A01B	0161	9,9
A01B	0164	30,4
A01B	0210	3,3
A01B	2821	30,5
A01B	2822	5,4

Source: Elaborated by the authors based on Lybbert and Zolas (2014).

In the table, IPC code A01B, on the first column, is linked to the different ISIC classifications which are displayed at the second column, whiles third column shows to the probabilities of each correspondence. This means that economic activities, whose association has higher weights, are more strongly linked with technologies represented by IPC A01B[6].

DATA ANALYSIS

Until May 2016, there were 344 published patents from UFRGS, divided in 5 Sections, 15 Classes and 20 Subclasses of the IPC. This indicates that this university had registry which covered only 11.6% of the total of the 129 IPC Classes.

Table 4 shows that in the first 10 Classes in which the university studied has registries in, 5 were emerges from Section C, Chemistry and Metallurgy. This includes, in total, 163 patents which represents 47% of the UFRGS patents total. Furthermore, 2 Classes, among the first ten, were inventoried in Section A, Human Necessities, which cover 107 patents. This number represents 31% of the UFRGS patents total. Therefore, in Sections C and A are cataloged 78% of all the 344 UFRGS patents. Thus, it is evidence that this university inventions belong to only a few specific areas.

Through table 4, it is seen that Class A61, medical or veterinary science and hygiene inventions, stands out in first place with 85 patents. The second Class with more patents, 47 in total, is the C08 which is regards to organic macromolecular compounds. Moreover, IPC Section B, Performing Operations and Transporting, and G, Physics, are also amongst the 10 largest sections in terms of patents quantity, as it is shown in Table 4. Specifically, Class B is inserted twice inside the 10 first and reaches 41 patents out of the 344, which represents 12% of UFRGS patents total. In addition, Class G stands out in the first 10 positions with 26 patents which represents 7% of UFRGS patents total.

[6] Considering that the CNAE presents the ISIC structure in the first and second levels, the probabilistic weights of Lybbert and Zolas (2014), which distribute patents among economic activities, can be applied between IPC and CNAE in both levels.

The main information extracted from the previous analysis is that 47% of UFRGS patents total are classified in Section C; and if it is considered Section C and A together, this number rises to 78%, this measure reaches 90% by including Section B; lastly if it sum the Section G, this percentage increases to 97%, thereby, although the IPC be constituted by 129 Classes, UFRGS patents are restricted to only a few of them. This study shows that UFRGS concentration of technology production is restricted to some fields of knowledge. This assumption is confirmed through a more detailed IPC analysis, the Subclass analysis.

Table 4 – Number of UFRGS patents by Section and Class, 2016

No. of patents	Section	Class	Name
85	A	61	medical or veterinary science; hygiene
47	C	08	organic macromolecular compounds; their preparation or chemical working-up; compositions based thereon
43	C	07	organic chemistry
30	C	12	biochemistry; beer; spirits; wine; vinegar; microbiology; enzymology; mutation or genetic engineering
26	G	01	measuring; testing
22	A	01	agriculture; forestry; animal husbandry; hunting; trapping; fishing
19	B	01	physical or chemical processes or apparatus in general
16	B	82	Nanotechnology
14	C	25	electrolytic or electrophoretic processes; apparatus therefor
10	C	02	treatment of water, waste water, sewage, or sludge
7	C	01	inorganic chemistry
7	C	23	coating metallic material; coating material with metallic material; chemical surface treatment; diffusion treatment of metallic material; coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapor deposition, in general; inhibiting corrosion of metallic material or incrustation in general
7	H	01	basic electric elements
6	B	29	working of plastics; working of substances in a plastic state in general
5	C	09	dyes; paints; polishes; natural resins; adhesives; compositions not otherwise provided for; applications of materials not otherwise provided for
Total 344			

Source: Elaborated by the authors based on UFRGS' patents.

The evidence that UFRGS is specialized in the production of specific technologies is strengthened by a more detailed analysis of its patents. For this, Table 5 shows the IPC Subclasses registration. It's seen that UFRGS concentrates its patents in only 30 Subclasses which covers 4.6% of the 640 IPC Subclasses total. Thus, the table 5 distributed, in descending order, UFRGS patents classified by IPC Subclasses. So, in the first 20 Subclasses, 12 are registered in Section C, Chemistry and Metallurgy, whilst 4 are registered at Section A, Human Necessities. Thereby, the first 20 Subclasses concentrated most of all patents and 80% of them

is inserted in the Section C and A. So, this confirms that UFRGS is specializes on specifics area regards its technological production.

In addition, the chemistry and engineering scientific field (in which the metallurgical production is included) are the two major highlights in terms of UFRGS patent. This is evidenced because the IPC Subclass C (Chemistry and Metallurgy) is responsible for 60% of the 20 Subclasses most important in terms of patents quantity. Moreover, this percentage reaches 80% including the Subclass A (Human Necessities), the second most important. Further, Subclasses B (Performing Operations and Transporting) and G (Physics) are registered only in 20% of the 20 Subclasses with a higher number of patents. Besides that, by considering the total number of patents, Subclasses C (Chemistry and Metallurgy) includes 47% of UFRGS Subclasses. In short, almost half of the UFRGS patents are related to the chemistry and engineering linked to the metal field. At the same time 60% of the most intense Subclasses in patent quantity are concentrated in Section C.

Considering Subclass C (Chemistry and Metallurgy), chemistry is dominant and there are few technologies applied to metallurgy. This is proven by several measurements. First, Subclass A61K – Preparations for Medical, Dental, or Toilet Purposes – is the classification with a higher number of patents, 45. If Subclass A61K is look into in more detail, 41% of the patents are allocated in Subgroup A61K9 which is called “Medicinal preparations characterized by special physical form” which patents regards drug technologies. Second, all Subclasses, from the second to the twelfth (totalizing 178 patents), ranked on table 5 come from the chemical science field. Third, the Subclasses range from the thirteenth to the thirtieth (totalizing 121 patents), also on table 5, still are related to chemistry area, for instance C08G, C25B, C07F, C09D. Thus, it is possible to affirm that at least 63% of UFRGS patents refer to technological inventions in the field of chemistry.

Table 5 – Number of UFRGS patents by Section, Class and Subclass, 2016

No. of patents	Section	Class	Subclass	Name
45	A	61	K	preparations for medical, dental, or toilet purposes
33	A	61	P	specific therapeutic activity of chemical compounds or medicinal preparation
23	C	12	N	microorganisms or enzymes; compositions thereof
21	G	01	N	investigating or analyzing materials by determining their chemical or physical properties
19	B	01	J	chemical or physical processes, e.g. catalysis or colloid chemistry; their relevant apparatus
16	C	07	C	acyclic or carbocyclic compounds
14	C	07	D	heterocyclic compounds

12	C	08	K	use of inorganic or non-macromolecular organic substances as compounding ingredients
11	C	08	F	macromolecular compounds obtained by reactions only involving carbon-to-carbon unsaturated bonds
10	C	02	F	treatment of water, waste water, sewage, or sludge
10	C	08	L	compositions of macromolecular compounds
9	A	01	N	preservation of bodies of humans or animals or plants or parts thereof
8	B	82	B	nanostructures formed by manipulation of individual atoms, molecules, or limited collections of atoms or molecules as discrete units; manufacture or treatment thereof
8	B	82	Y	specific uses or applications of nanostructures; measurement or analysis of nanostructures; manufacture or treatment of nanostructures
8	C	07	K	peptides
8	C	08	J	working-up; general processes of compounding; after-treatment not covered by subclasses
8	C	25	D	electrolytic or electrophoretic processes; apparatus therefor
7	A	61	L	methods or apparatus for sterilizing materials or objects in general; disinfection, sterilization, or deodorization of air; chemical aspects of bandages, dressings, absorbent pads, or surgical articles; materials for bandages, dressings, absorbent pads, or surgical articles
7	C	01	B	non-metallic elements; compounds thereof
7	C	12	Q	measuring or testing processes involving enzymes, nucleic acids or microorganisms; compositions or test papers therefor; processes of preparing such compositions; condition-responsive control in microbiological or enzymological processes
7	C	23	C	coating metallic material; coating material with metallic material; surface treatment of metallic material by diffusion into the surface, by chemical conversion or substitution; coating by vacuum evaporation, by sputtering, by ion implantation or by chemical vapor deposition, in general
7	H	01	M	processes or means, e.g. batteries, for the direct conversion of chemical energy into electrical energy
7	A	01	H	new plants or processes for obtaining them; plant reproduction by tissue culture techniques
6	A	01	P	biocidal, pest repellant, pest attractant or plant growth regulatory activity of chemical compounds or preparations
6	B	29	C	shaping or joining of plastics; shaping of material in a plastic state, not otherwise provided for; after-treatment of the shaped products, e.g. repairing
6	C	08	G	macromolecular compounds obtained otherwise than by reactions only involving carbon-to-carbon unsaturated bonds
6	C	25	B	electrolytic or electrophoretic processes for the production of compounds or non- metals; apparatus therefor
5	C	07	F	acyclic, carbocyclic, or heterocyclic compounds containing elements other than carbon, hydrogen, halogen, oxygen, nitrogen, sulfur, selenium or tellurium
5	C	09	D	coating compositions, e.g. paints, varnishes or lacquers; filling pastes; chemical paint or ink removers; inks; correcting fluids; woodstains; pastes or solids for coloring or printing; use of materials therefore
5	G	01	B	measuring length, thickness or similar linear dimensions; measuring angles; measuring areas; measuring irregularities of surfaces or contours

Source: Elaborated by the authors based on UFRGS' patents.

Alternatively, it is possible to see, based on Table 3 and 4, that 203, amongst 344, patents are allocated on the first 10 Classes and Subclasses sorted in descending order by patents number. This decile encompasses 59% of all UFRGS patents and 42% of them are cataloged therein Section C, Chemistry and Metallurgy, while 38% are classified in Section A, Human Necessities. Completely, 59% of the 10 more numerous IPC Subclasses of UFRGS are allocated in only 1.5% of the 640 IPC Subclasses.

The main results reached so far can be summarized as: the 10 more numerous IPC Subclasses catalog 59% of UFRGS patents and at least 63% of UFRGS patents are related to technological inventions from the chemistry field. This means that despite hundreds of patents, UFRGS technological core is chemical science.

The exercise of classifying patents by technological areas in the case of UFRGS is the first step to develop a methodology for managing technology transfer. In this sense, the second step is presented in the following subsection which indicates economic activities with most technical probability to absorb patents from this university.

Correspondence Between Ufrgs Patents and Economic Activities

Table 6 presents the results from the application of probabilistic matching established by Lybbert and Zolas (2014). Therefore, the first row shows the economic activities code based on the CNAE-Divisions, while in the first column is displayed UFRGS-IPC Subsections[7]. Thus, each cell registers the number of patents corresponding to the respective row and column[8].

Based on the data structured at Table 6, it was applied a Correspondence Analysis whose result is shown in Figure 1. In this way, the relative neighborhood between points, on figure 1, represent stronger association between UFRGS-IPC (at Subsections level) and one CNAE-Divisions. Therefore, Figure 1 demonstrates economic areas that have potential to absorb patents.

[7] Annex I describe each of the economic activities at the CNAE-Division level, represented by the numbers in the first row of Table 4. The technological areas referring to the patent codes presented in the first column are shown in Table 5.
[8] In cases where the weighting resulted in a total of patents lower than 0.5, it was assigned value zero for the cell. At values above 0.5 and below 1, it was assigned value 1.

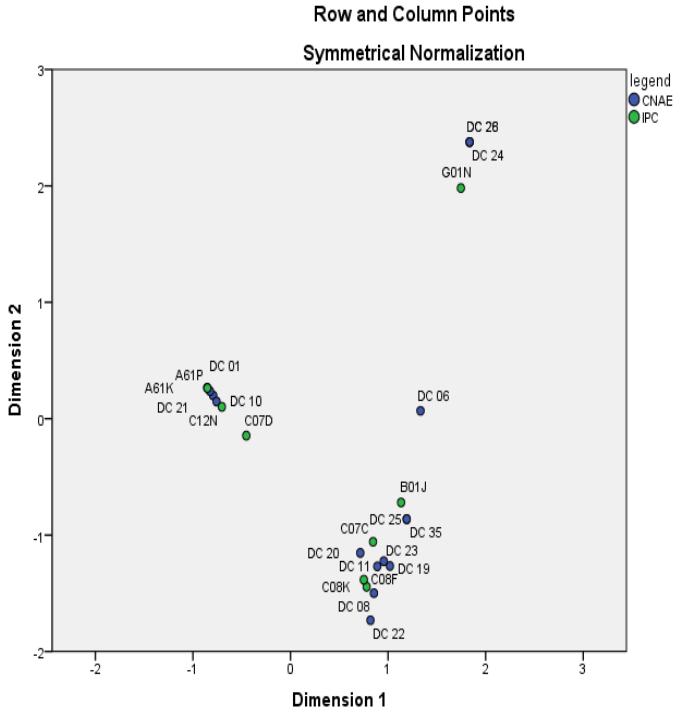
Table 6 – Correspondence between 9 largest IPC Subclass of UFRGS patents and CNAE-Division

CNAE IPC	1	6	8	10	11	19	20	21	22	23	24	25	26	28	35	row sum
A61K	12	0	0	2	0	0	0	31	0	0	0	0	0	0	0	45
A61P	11	0	0	2	0	0	0	20	0	0	0	0	0	0	0	33
C12N	8	0	0	7	0	0	2	6	0	0	0	0	0	0	0	23
G01N	0	5	0	0	0	0	1	0	0	0	1	0	5	10	0	21
B01J	0	8	0	0	0	1	6	0	0	0	0	3	0	0	1	19
C07C	0	3	1	0	1	3	8	0	0	0	0	0	0	0	0	16
C07D	4	0	0	0	0	0	3	7	0	0	0	0	0	0	0	14
C08K	0	0	1	0	0	1	8	0	2	0	0	0	0	0	0	12
C08F	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	11
column sum	35	16	1	11	1	5	39	65	2	1	1	3	5	10	1	194

Source: Elaborated by the authors according to the research data.

Based on Table 6 data, also shown in Figure 1, the following analyzes were performed.

Figure 1 – Correspondence analysis between UFRGS IPC Subsections and CNAE/Divisions



Source: Research data with automated generation in the SPSS program.
Note: DC = CNAE-Division. Economic activities related to each CNAE-Division will be found at Annex I.

The economic activity that would receive 69% of the 45 UFRGS inventions classified by IPC A61K (the highest in patent quantity) would may be the manufacture of pharmacochemical and pharmaceutical products (as identified in CNAE-Division 21). Since the chemical area is that with a greater number of patents, it seems appropriate that the pharmacochemical and pharmaceutical industry absorbs the patents related to the A61K classification (Preparations for medical, dental, or toilet purposes).

It is verified that the manufacture of pharmacochemical and pharmaceutical products is also an economic activity that could receive 61% of the 33 inventions allocated at the IPC A61P (Specific therapeutic activity of chemical compounds or medicinal preparations). It confirms that industries related to the chemical area stand out as UFRGS potential customers.

Additionally, CNAE-Division 01 (agriculture, livestock and related services) is the second economic activity which more potential to receive patents of UFRGS. Moreover, the IPC-Subsections liked to this economic activity are A61K and A61P both related to the chemical scientific area. So, the UFRGS patents range on the A61K and A61P Subclasses are related to animals' vaccine and chemical products for agriculture.

In the sequence, from the 23 patents inventoried at IPC Subsection C12N, 35% are allocated at CNAE-Division 01 (agriculture, livestock and related services), while 30% drops at the CNAE-Divison 10 (manufacture of food products). Since patents covered by the C12N, classified as to micro-organisms or enzymes and their compositions, are linked with economic activities turned to agriculture and food, they applications, probably, fall on chemical products within food field, like agriculture and animal husbandry. Thus, it is possible that the patents involved in this case are projected to develop pesticides, seeds and vaccines.

CNAE-Division 28 (manufacture of machine and equipment) accommodated 48% of the 21 patents inventoried at IPC Subsection G01N (Investigating or analyzing materials by determining their chemical or physical properties). In the same time, CNAE-Division 06 (extraction of oil and natural gas) and the 26 (manufacture of computer equipment, electronic and optical products) may absorb 24%, each one, of the 21 patents inventoried at IPC Subsection G01N. In this sense, it appears that the inventions related to the G01N classification may have applications for testing physical and chemical components of equipment, like machinery and products linked to oil extraction, or computer and electronic products, as well as capital goods.

Additionally, 42% of the 19 patents cataloged at IPC Subsection B01J are linked to CNAE-Division 06 (extraction of oil and natural gas), while 32% of them with are connect with CNAE-Division 20 (manufacture of chemical products) and 30% of them doing pair with CNAE-Division 10 (manufacture of food products). Once the patents of Subclass B01J embody technologies for chemical or physical process (for instance, Catalysis and colloidal chemistry), the economic activities previously cited may use these patents to develop chemical processes regards energy (oil and natural gas), and other chemical products.

The 16 patents inventoried at IPC Subsection C07C (acyclic or carbocyclic compounds) are accommodated in the following CNAE-Divisions: 50% of them are framed at the 20 (manufacture of chemical products), 19% in the 06 (extraction of oil and natural gas), and other 19% in the 19 (manufacture of coke, and products derivates from petroleum and biofuels). This last CNAE-Division engages patents whose chemical components would be applied in the production of chemical products in general, as well as in the specific products related to the production of oil, gas and mineralized energy.

Concerning the 14 patents cataloged at IPC Subsection C07D, they present 70% of linkages with CNAE-Divisions strictly related to economic activities in the manufacture of chemical products, i.e., the 20 (manufacture of chemical products) and the 21 (manufacture of pharmacochemical and pharmaceutical products). Additionally, 29% of the C07D patents may have correspondence with CNAE-Division 01 (agriculture, livestock and related services) and it may be used to develop chemistry products applied on the veterinary area, since the C07D subsection is called Heterocyclic Compounds.

C08K (use of inorganic or non-macromolecular organic substances as compounding ingredients), penultimate IPC Subsection of Table 6, registered 12 patents and 67% of them correspond to CNAE-Division 20 (manufacture of chemical products), while 17% of them are linked to CNAE-Division 22 (manufacture of rubber and plastic products). The former economic activity is related to the manufacture of chemical products. Besides that, C08K patents may contain possibly new knowledge whose application would help chemical processes necessary for the improvement of rubbers and plastics, considering that this Subclass-IPC is linked to inorganic or non-macromolecular substances. Finally, the IPC Subsection C08F, the last one analyzed at Table 6, contains all its 11 patents related to CNAE-Division 20 (manufacture of chemical products).

The most relevant economic activities to the invention transfer of UFRGS patents are CNAE-Division 21, 20 and 1, respectively, manufacture of pharmacochemical and pharmaceutical products; manufacture of chemical products; agriculture, livestock and related services. In this sense, 34% of the patents may, technically, be linked to Division 21, while 20% of them would be absorbed by Division 20, and 18% of them would be colligate to Division 01. So, it is estimated that 72% of the UFRGS patents classified amongst the first 9 most numerous IPC-Subclasses may be applied to these economic activities. Complementarily, CNAE-Divisions 06, 10, 28, called respectively, extraction of non-metallic minerals,

manufacture of food products, and manufacture of machine and equipment are economic activities adequate to receive, in the same order, 8%, 6% and 5% of UFRGS patents.

Table 7 presents the importance of CNAE-Divisions 20 and 21 which are regarding pharmaco chemical and pharmaceutical products, as possible customers of UFRGS patents. Such economic activities doing correspondence with 53% of patents which are ranked at 9 most numerous IPC-Subclasses of UFRGS.

Table 7 – Correspondence of UFRGS IPC Subsections and CNAE-Divisions regarding the manufacture of chemical products

A	B	C	D	E	f	g
Order	Patent name	No. of patents	Patents corresponding to CNAE-Division 20	Patents corresponding to CNAE-Division 21	Sum d + e	d+e (%)
1	A61K	45	0	31	31	69
2	A61P	33	0	20	20	61
3	C12N	23	2	6	8	35
4	G01N	21	1	0	1	5
5	B01J	19	6	0	6	32
6	C07C	16	8	0	8	50
7	C07D	14	3	7	10	71
8	C08K	12	8	0	8	67
9	C08F	11	11	0	11	100
TOTAL		194	39	64	103	53

Source: Elaborated by the authors according to the research data.

The exploratory analysis between the nine major UFRGS IPC-Subclass and the CNAE-Division suggest that the patents of this university would be linked to specific industries. In order to verify this consistency, the Chi-Square test was applied in the data. This statistic tool allows answering the question: are the 9 most numerous UFRGS IPC Subclass associated with any type of industry or only to specific industries? In this way, the null hypothesis is that there is no specific association between UFRGS IPC-Subclass and the CNAE-Divisions. Consequently, the alternative hypothesis is that UFRGS IPC-Subclass are associate with specific economic activities. So, the result of the Chi Squared statistical test is x^2 = 446,422 with 272 degrees of freedom and probability of significance (value-p) well below 5%. Thus, it is possible to reject the null hypothesis that there is no existing association between UFRGS IPC patents and the CNAE-Divisions. In other words, there is a significant relationship between UFRGS patents and specific economic activities.

CONCLUSIONS

This paper proposed a methodology to establish correspondence between university patents and economic activities. Considering the case analyzed, the inventions selected to be

related to industries were the nine UFRGS IPC-Subclass with greater number of patents. In this university, the most inventions belong to only a few specific areas, since the 9 most numerous IPC Subclasses included 59% of UFRGS patents. Thus, UFRGS is specialized in patents of determined technologies and the chemistry area has the highest patent proportion because, at least, 63% of UFRGS patents total came from this area.

The methodology developed in this paper allowed doing the correlation between UFRGS patents and the economic activities. This is important to search economic application for UFRGS patents. So, the fabricators which may be UFRGS customers to deal with business of the patents are: pharmacochemical and pharmaceutical manufacture; chemical manufacture, and livestock farming and related services. These industries have potential to receive 72% of UFRGS patents total and should be the focus of the technology sales strategies from this university. In addition, economic activities related to extraction of non-metallic minerals, manufacture of food products, manufacture of machine and equipment, create an industry group with the second higher potential to absorb UFRGS patents.

The strategy to link patents and activities economics develop in this paper contribute for the technological transfer from university to other organization. Moreover, the correspondence displayed link patents and industries according to the weight that the scientific areas occupies in the university research structure. In this sense, the study of this paper supports a sell based in market intelligence. The research next step is to conduct a market study of the industries with potential to absorb the patents of UFRGS.

The methodology developed in this paper can be replicated in other universities and support a strategic management and execution for technology transfer, offering to universities criteria for negotiating its patents. Therefore, market prospection and competitive intelligence studies for the universities would become more effective if the model developed in this paper to be applicated in the market study to sale of technologies. Thus, the possibility of a dialogue between university patents and economic activities extends the possibility of an effective negotiation linked to technology transfer by providing information concerning industries that have the greatest potential to acquire patents.

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ANNEX I

Table 8 – CNAE – Divisions associated to UFRGS IPCs

01	agriculture, livestock and related services
06	extraction of oil and natural gas
08	extraction of non-metallic minerals
10	manufacture of food products
11	manufacture of beverages
19	manufacture of coke, and products derivates from petroleum and biofuels
20	manufacture of chemical products
21	manufacture of pharmacochemical and pharmaceutical products
22	manufacture of rubber and plastic products
23	manufacture of non-metallic mineral products
24	Metallurgy
25	manufacture of metal products, except machine and equipment
26	manufacture of computer equipment, electronic and optical products
28	manufacture of machine and equipment
32	manufacture of various products
35	electricity, gas and other utilities

Source: Elaborated by the authors according to the research data.