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Framework Proposal for Management of Knowledge and Technology Transfer in Brazilian Academic Internships

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Abstract: This article has the purpose of developing a framework for management of knowledge and technology transfer in Brazilian academic internships, with a Knowledge Management approach. The methodological procedures employed are classified as qualitative, bibliographical, documentary, and a survey, having academic internships in Brazil as the object of study. The framework proposed is an advantage in internship management, systematizing information, knowledge, and technology, in addition to increasing the potential of internship activities. The framework for management of knowledge and technology transfer in Brazilian academic internships offers its users not only a service of knowledge management, but also a Knowledge Management System with resources of Communication and Information Technology for the construction of a learning platform, in which coordinators, professors, supervisors, and student-interns would be able to manage the internship, its activities, and the online learning environment. In other words, it is an environment designed for the development of academic knowledge in professional capacities.

Keywords: Brazilian Academic Internship; Knowledge and Technology Transfer; Management of Knowledge and Technology Transfer.

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1. Introduction

With the development and widespread use of online technologies, web-based learning is increasingly more well-received by people (PENG; JIANG; ZHANG, 2013). The internet allows for the utilization of knowledge portals, an interface that facilitates interaction between users. Portals supporting Knowledge Management (KM) were designed to facilitate the transfer, storage, retrieval, creation, integration, and application of knowledge and technology.

The purpose of knowledge portals is the interaction of collaborators, including the interns among them. Internships are mechanisms of interaction between the educational institution (EI) and the organization, encompassing several forms of relationship. Among them is the Academic Internship, which is a supervised educational act developed in the work environment that aims to prepare the student for productive work. The internship is part of the student's approved coursework and of the degree's pedagogical project (art. 1st and its § 1st of Law 11.788/2008).

This context pointed to the need of pondering about the management model of Brazilian internships, which currently present a low level of KM, with the knowledge and technology acquired throughout being neglected and its results archived. The same context leads to knowledge and technology transfer (KTT), science-based knowledge and technology, and potential of market applicability. The possibility of KTT demands communication and information technology (CIT), that is, employing computers to obtain, evaluate, store, produce, present, and exchange information, in addition to communicating and participating in cooperation networks over the internet (TISSOT, 2004). The shift from a product-based to a knowledge-based economy has resulted in an increasing demand for organizations to implement knowledge management systems (KMS) at an accelerating pace (LAI; WANG; CHOU, 2009).

Knowledge Management Systems (KMS) are tools to create, select, store, and spread knowledge. In addition, they can greatly increase the creation, storage, and sharing of knowledge, and even enhance the efficiency of knowledge re-creation (SHIH et al., 2017). KMS are able to absorb explicit and tacit knowledge systematically (CHU, 2017).

Starting from the premise that the actions of internship management in Brazilian EIs are only directed toward the selection process, intern admission, and document management; and that the internship management systems do not conduct Knowledge and Technology Transfer with a KM approach, the problem is: How to transfer knowledge and technology in the interaction between Educational Institution and organization through the mechanism of Brazilian Academic Internships?

In view of all the aforementioned aspects and especially the importance of transforming the individual knowledge arising from internship activities into collective knowledge, this article has the purpose of developing a framework of KTT for Brazilian academic internships with a KM approach.

This research is part of a doctorate thesis, based on the originality criterion, and thus implies in presenting new perspectives in the approach to the research problem. The framework reformulates the Internship Management System (IMS), which becomes able to extract, memorize, share, and re-utilize knowledge and technology through a structured, systematized, and formal environment with the purpose of transforming individual knowledge into collective knowledge. Therefore, the contribution is the core condition for this research.

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2. methodological procedures

This research is classified as basic, with the objective of generating knowledge about academic internships in Brazil, knowledge and technology transfer, and knowledge management systems for the creation of the framework available for application in Brazilian EIs (GIL, 1999; OLIVEIRA, 2013). It employs a qualitative approach to the problem (MARCONI; LAKATOS, 2010) and it is descriptive in terms of objective (GIL, 2008; OLIVEIRA, 2013). The technical procedures (GIL, 2008) employed included a bibliographical research, a documentary research, and a survey.

The bibliographical research was elaborated from previously published materials, mainly books, theses, dissertations, and articles from journals available online. The documentary research was elaborated from materials that did not receive analytic treatment, such as Law no. 11.788, of September 25 2008, Internship Regulations, and Reports. The survey involved the direct investigation into Higher Education Institutions about Brazilian academic internships and their processes.

The research is classified according to the definitions and concepts presented by the authors Oliveira (2013), Gil (2008), and Marconi; Lakatos (2010). The scientific investigation approached and analyzed the BRAZILIAN ACADEMIC INTERNSHIP, this research's object of study.

The *Methodi Ordinatio* analysis was conducted (Pagani; Kovaleski; Resende, 2015), which employs the *InOrdinatio* equation to rate articles in order to select them according to their scientific relevance, taking into account the main factors to be considered in a scientific article: the impact factor (*Journal Citation Reports©* (JCR)) of the journal in which the article was published, the number of citations on *Google Scholar©*, and publication year. The rating task was carried out before the systematic analysis so that the article›s importance was recognized in the initial stages of the process. The search was conducted in three international databases (*Web of Science, Scopus, and Google Scholar©*) and *Excel©* was the tool employed to classify the articles. The results indicated that the methodology was efficient to arrange the most relevant works. The search was also conducted in databases of theses and dissertations, revealing the originality and relevance of the research.

The *Methodi Ordinatio* Analysis allowed for the construction of the problem and the objectives concerning Brazilian academic internships, management of knowledge and technology transfer, and knowledge management systems. The bibliographical portfolio revealed the importance of academic internships for professional experiences and how theory influences practice, allowing to establish metrics and systematize the viability for creating, organizing, formalizing, sharing, applying, and refining individual knowledge into collective knowledge, able of being reapplied by different users.

3. Management model for knowledge and technology transfer in Brazilian academic internships

Innovative educational technologies ensure the development of intellectual and professional competence, the wish and ability to create new knowledge, and the capability of solving tasks in a higher level of complexity (DUBININA; BERESTNEVA; SVIRIDOV, 2015). The academic internship is important for the professional life, seeing that it enables the student to plan for their professional career and highlights the importance of theory and how it influences practice.

The management model for knowledge and technology transfer (MKTT) in Brazilian academic internships approaches the organizational environment and knowledge management systems (KMS). Seeing that the research focuses on Brazilian academic internships, it contemplates the relevant elements in the context of internships and intern activities.

The Organizational Environment identified and analyzed the organizational context in which academic internships are inserted in Brazil in order to ascertain the viability of the knowledge actions intended. The KMS aims to act as a repository and enhance the access to knowledge. To meet this objective, the key questions of KM were utilized, namely: With whom to share? What to share? How to share? How do the CIT contribute? How to make KM feasible?

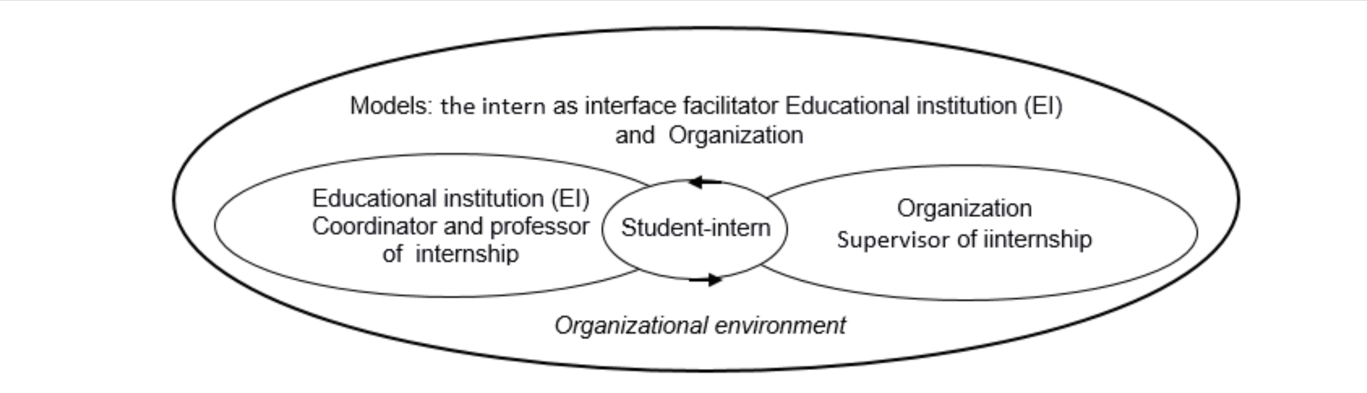
Chart 1 – Key questions of KM

Key questions of KM				
With whom to share	What to share	How to share?	How do the CIT contribute?	How to make KM feasible?
Internal and external user.	Contents, KM practices, supplies, demands, etc.	Authorized and authenticated user.	Layer of data acess.	Knowledge portal.

Source: the author

Firstly, the organizational environment is discussed in Figure 1 – Organizational Environment. The analysis concerns the models of academic internships in Brazilian educational institutions, in light of Brazilian legislation.

Figure 1 – *Organizational environment*



Source: Adapted from Francisco (2003)

The analysis employed the Organizational Environment, a part of the *CommonKads* methodology that identifies and examines the organizational context in which the framework is inserted, especially its main characteristics, in order to reveal problems and opportunities to the knowledge systems and to establish the viability of the knowledge actions intended.

3.1 Organizational Enviroment

The analysis allows to identify problems and opportunities for the framework development. These items are shown in Chart 2 – Opportunities, which presents the view of the organizational environment.

Chart 2 – Opportunities

Organizational environment	
Opportunities	**Opportunities:** - improving the actual monitoring by the professor at the educational institution and the supervisor at the organization; - proper treatment of the knowledge and technology generated throughout the internship; - large amount of reports generated and filed; - existence of different levels and types of knowledge and technology; - standardization of the communications between EI, organization, and integration agent; - definition of indices for the EI and global indices for the organization in which the intern acts, so as to manage knowledge over the entire organizational process involved; - providing a knowledge base about the internship realized in the organization; - improving the results in the activities developed throughout the internship; - possibility of learning and improvement; - aid for new interns; - virtual library of Course Conclusion Papers (TCC – *Trabalho de Conclusão de Curso*) **Problems:** - dependence of user collaboration and interaction; - lack of KM culture in the EIs
Organizational Context	EI, organization, integration agent, and processes and activities in Brazilian academic internships
Solution	Portal of Management of Knowledge and Technology Transfer (PMKTT), presented as a repository for academic internships and an interaction interface for the intern, professor, supervisor, EI, organization, integration agent, and external users, enabling the extraction, memorization, sharing, and reuse of knowledge and technology by different users (actors involved in internship activities).

Source: Research data

The effectiveness of any educational practice is related to its capability of increasing the student's involvement and the fact that the student's available time should be considered a valuable resource for the educational institution. While the educational institution has a critical role in this process, due to its responsibility to offer opportunities for the students to get involved, the students also play an essential role in view of their responsibility to make use of the opportunities offered (ASTIN, 1984).

The models of academic internships in Brazil follow Brazilian legislation, and the EI provides departments and human resources for the administrative activities (documentation) related to the internship, as well as professors with the responsibilities of coordinating and guiding the process. These actors ensure that the legislation is met by the organization and the student-intern, while pointing out low or non-existent KM practices.

There are gaps in the management of Brazilian internships and in the Internship Management Systems, such as difficulties in the interaction between EI and organization, or lack thereof, to follow the internship activities performed by the student; lack of indices; lack of previous knowledge about the internship activities already performed by areas or organizations; and the fact that the management of Brazilian internships or the Internship Management Systems do not allow the sharing of knowledge and technologies arising from internship activities.

The aforementioned gaps shed light on barriers or difficulties that must be surpassed so that the knowledge and technology present in the routines and processes of interns within organizations can escape from only documents and reports and be shared and comprehended through KM practices towards the creation of ideas and innovations in organizations and EIs.

The MKTT presents itself as a relevant, necessary intervention for the growth of organizations and EIs in several areas, highlighting the impact of the CIT for the creation of an environment of learning and collaboration, that is, new approaches for the interaction activities between the EI and the organization through the internship, exceeding theory and practice.

Maier (2007) views the CIT as facilitating elements for the effective and efficient implementation of KM, and KM instruments are developed in view of a specific goal, characterized by the treatment of contextualized information with the purpose of intervention and independence of the knowledge domain.

When a KM instrument employs CIT, it supports the Knowledge Management Systems (KMS) (MAIER, 2007), and when a KMS accesses and handles a representation of knowledge, that system may make use of Artificial Intelligence technologies (NISSEN, 2005; MAIER, 2007; QUINN, 20). Adequate repositories are made necessary for storing the data, information, and knowledge being transferred, from external and internal sources of the organization and EI, given that the CIT structure allows for the appropriate interaction between users. The CIT, regarded as complementary mechanisms and sociocultural and organizational factors, determine the success or failure of KM (VON KROGH, 2002).

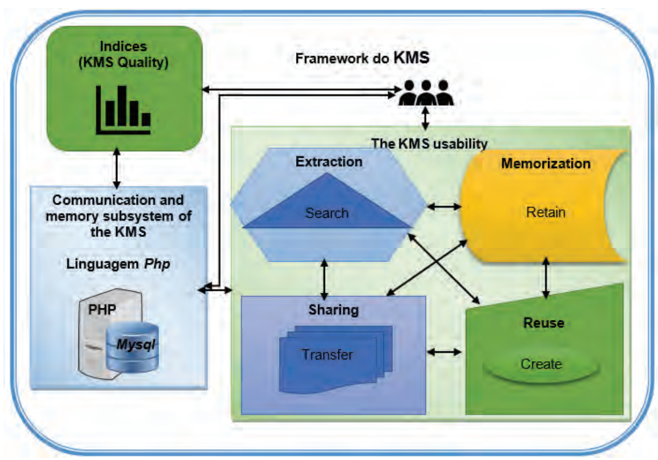
The opportunity for the intern to develop professional and intellectual competences, solve tasks of a higher complexity level, and create new knowledge may be observed in the framework for management of knowledge and technology transfer in Brazilian academic internships.

3.2 Framework for management of knowledge and technology transfer (MKTT) Iin Brazilian Academic Interships

The framework for MKTT in internship activities has a KM approach and does not contemplate the processes and activities developed in other departments of the EI and the organization. This research is a first KM approach for a KMS in Brazilian academic internships. The main constructs in the framework structure are the application of KM theories; the implementation of a systemic MKTT process in a continuous and evolving manner; the utilization of PHP and MySQL in the structure, allowing for adaptations to Brazilian academic internships.

The proposed framework employs the CIT (layer of database access), the usability and indices of KMS (layer of services), and is centered on the user, as shown in Figure 2 – Framework proposal for MKTT in the activities of Brazilian academic internships.

Figure 2 – Framework proposal for MKTT in the activities of Brazilian academic internships



Source: the author

Tian et al. (2009) suggest thinking about a creative environment in academia, employing customization strategies under the guidelines of a systemic mindset. In order to construct a culture of knowledge sharing, the environment must facilitate the communication and debate among users.

The framework is composed of users and indices, which represent different functions in the internship management system, the KMS usability, and the communication and memory subsystem of the KMS, aiming to support the management of knowledge and technology transfer.

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The elements and subsystems that compose the framework proposal are described as follows.

Communication and memory subsystem of the knowledge management system (KMS)

The framework is, importantly, a repository for the routine activities specific to Brazilian academic internships, transforming data into information and information into knowledge. It is also responsible for storing and managing the knowledge and technologies created, in addition to coordinating the research, creation, and transfer of information between users and KM practices, constituting the organizational memory.

Memory makes use of a data management process that includes data storage. According to Freitas Júnior (2003), this subsystem provides reliable information to answer user queries, obtaining data for developing, updating, and processing the models, and storing the intermediate and final results of the analyses carried out.

PHP and *MySQL* are employed to build websites. Yu; Yi (2010) hold that the design and implementation of websites based on *PHP* and *MySQL* have been the main tool of web development, seeing that they are free and open-sourced. A database allows to store, search, classify, and retrieve data efficiently. *MySQL* controls data access to ensure that only authorized users are able to obtain access. Thus, *MySQL* is a multi-user server. *SQL* (Structured Query Language) is the standard language of database search worldwide (WELLING; THOMSON, 2003).

For the extraction of information (search/need) by the users, it is important to retrieve the knowledge and technology stored. That occurs when a student-intern needs specific information, resources that enable them to extract, memorize, share, and reuse the knowledge and technology at the right moment, in consonance with the purpose of a KMS to create the capability for different types of users to perform their activities (needs).

This subsystem needs to support the other elements of the framework proposal, manually feeding the knowledge repository with documents, information, knowledge, technology, and experiences arising from the processes and activities of academic internships. To that end, definitive storage is required.

The Content Management tool is a system for the electronic management of documents, encompassing best practices, lessons learned, product development, knowledge maps, customer knowledge, among others (RAO; OSEI-BRYSON, 2005). Also known as Electronic Document Management System (EDMS), it allows for the storage, indexing, and retrieval of documents stored (BRAGA et al., 2011).

The communication and memory subsystem of the KMS will allow the users, via an interface, to access data, information, knowledge, and technology, as well as stored documents for future queries or updates.

Knowledge management system (KMS) usability

Usability concerns user satisfaction, facility to learn and solve tasks effectively and efficiently, and the collaborative and sharing process. For the integration of people, processes, technology, and content, the KMS usability makes use of the KM subprocess structure of Herrera; Bautista (2015): extraction, memorization, sharing, and reuse of knowledge and technology aligned with the user. The KMS usability is described as follows:

- extraction (search): it is characterized by the search algorithms that locate the knowledge and technology from different sources in the database. It allows the exchange of knowledge and technology (tacit information and/or primary or explicit information), experiences and competences between users through KM instruments. It also locates contents (keywords) in reports and other documents related to the internship.

- memorization (retain): resources, means utilized to collect/update knowledge/information continuously, offering proactive assistance to the knowledge workers (HERRERA; BAUTISTA, 2015). They preserve knowledge in a structured manner and represent it in the form of images, text files, databases, or videos. They are viewed as knowledge repositories, in addition to aiding in document management. Herrera and Bautista (2015) hold that Memorization encompasses the following aspects: it can retain (store) the most relevant type of knowledge necessary to support knowledge processes; the components Knowledge Repository System and Transitive Memory System emphasize the knowledge process which they can support better and directly; knowledge sources that support the Knowledge Extraction processes; specialized tools and procedures derived for potential Knowledge Reuse.

- sharing (transfer): exchange of explicit/tacit knowledge and technology between people, groups, communities or organizations (HERRERA; BAUTISTA, 2015). It is represented by the knowledge sharing tools of CIT in online or physical collaborative environments. The user transfers information, knowledge, and technology to the KMS, such as competence, supply, demand, and contents, acquired or related to the internship, which will be available for searches (stored) and retention (creating viable solutions that promote improvements and innovations), meeting the user needs and answering their questions.

- reuse (create): characterized by the incorporation of knowledge or technology (based on knowledge sources or stored contents) to regular or non-regular internship tasks (HERRERA; BAUTISTA, 2015). They aid and support the user's decision. They allow to synchronize different ways to cooperate and facilitate the visualization of contributions, encouraging the creation of new ideas.

Usability involves extraction, memorization, sharing, and reuse of integrated elements and of continuous interactions between the results from the practical activities performed by the student-intern and the other agents in Brazilian academic internships. They generate new information, knowledge, technology (tacit information and/or primary or explicit information), and experiences, which feed the repository.

Indices (KMS Quality)

The indices will enable results concerning:

- the usability or utility (about the use of the KMS by users) of documents, texts, and KM instruments. Examples: number of messages and items in the KM instruments; number of participants; number of accesses in searches; number of interns per organization or area; among others. *MySQL* provides the data and relevant, reliable information, structured for meeting the user's needs;

- facility of use;

- the KMS quality as a strategic resource for the improvement and evolution of Brazilian academic internships;

- the number of student-interns per organization or EI, etc.

The indices concern the quality of the KMS use, in addition to metrics that may be utilized by the EI and the organization, related to the intern and internship activities. Measuring KMS performance is related to the assessment of learning technology. Thus, this framework is based on a logic combination of quality and user, previous KMS dimensions.

User (Internal e External)

According to Townley (2003), the proposal of a KMS with a user-centered approach, based on the use of portals, is knowledge created in the research areas of interest and the search patterns developed by the users. The main actors involved are the student-intern, coordinator, professor, and supervisor, who all have knowledge needs of several types. The most relevant requisites of associated users were grouped according to the main knowledge processes involved (Extraction, Memorization, Sharing, and Reuse).

The main difficulties found in the stage of knowledge and technology sharing concern the accurate identification of knowledge needs and demands, the localization of apt sources available to transmit knowledge, competence management of sources and recipients necessary to make knowledge sharing feasible, management of organizational environment aspects, including beliefs and attitudes present in the internal culture that may impact the process (TONET; PAZ, 2006). The user will access the system through a register, via login and password, and will sign a term of commitment regarding sources, copyrights, and responsibilities within the environment.

The framework proposed constitutes an advantage in internship management, systematizing information, knowledge, and technology in Brazilian academic internships, allowing for a view of the possibilities and potentials of internship activities.

Regarding the adhesion in terms of CIT and human resources, the current infrastructure available in Brazilian EIs would meet the requirements, highlighting the viability of adoption. It is worth reinforcing that the framework encompasses the processes and activities in Brazilian academic internships to transfer knowledge and technology and provide a structure of knowledge and technology repository centered on the user. It presents as negative points the user dependence and the lack of KM culture in the EIs. The interface constitutes the construction of a prototype knowledge portal for Brazilian academic internships, adopting the framework proposal for MKTT in the activities of Brazilian academic internships.

Final Considerations

The KM approach to Brazilian academic internships aided in the reflection about the importance of the internship for professional qualification, that is, the learning experience provided by the internship practice and the knowledge transfer from individual knowledge to collective, enabling the student-intern to internalize and comprehend the organizational environment more easily.

In order to develop the framework for MKTT in Brazilian academic internships, the Organizational Environment (Educational Institution-Organization-Student/Intern) was employed to identify opportunities and problems and establish the viability of the knowledge actions intended for Brazilian academic internships. Also employed were the computational agents from knowledge engineering, communication and information technologies (CIT), and technologies supporting KM, in addition to KM instruments to support KTT in Brazilian academic internships, based on ontology learning and able to create, organize, formalize, share, apply, and refine knowledge and technology, in a user-centered proposal.

The framework elements, users and indices, present different functions in the KMS for Brazilian academic internships. KMS usability and the communication and memory subsystem of KMS support the knowledge repository and its management, in addition to systematizing and increasing the potential of the information, knowledge, and technology in Brazilian academic internships, constituting an advantage in internship management.

The activities in the internship process (management of documents and knowledge and technology created and organized) are managed by the framework's technological infrastructure, technological resources for communication and storage, which are formalized and shared by the different types of users, allowing for the application and enhancement of knowledge and technology, structure of the KMS usability.

The KMS usability, element that comprehends the KM structure, employs extraction, memorization, sharing, and reuse of knowledge and technology to ensure that adequate resources (inputs) are allocated for KM usability, considering the importance of process quality. The user transfers information, knowledge, and technology to the KMS as inputs acquired or related to the activities developed throughout the internships, which will be available (stored) for research and application, meeting the needs of users and answering their questions.

Usability involves the generation of new information, knowledge, technology (tacit information and/or primary or explicit information), and experiences through KM instruments and competences, which feed the repository. The element *Indices* will provide users with information about the KMS use quality, the university and organization, and reports with strategic information, including expertise or techniques.

This research's contribution lies in the reformulation of the Internship Management System, which acquires the KM approach in its process and, more specifically, viability to create, organize, formalize, share, apply, and refine knowledge and technology through a structured, systematized, and formal environment, with the purpose of transforming individual knowledge into collective knowledge, thus answering the starting question about how to transfer knowledge and technology in the EI-organization interaction through the mechanism of academic internships in Brazil.

The framework for management of knowledge and technology transfer in Brazilian academic internships offers not only a knowledge management service to its users, but also a KMS with CIT resources in a learning platform, in which coordinators, professors, supervisors, and student-interns would be able to manage the internship and its activities, a web-based learning environment structured for the development of academic knowledge in professional competences.

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Marketing Myopia in Brazilian Public Universities: An Empirical Study Involving Academicians

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Abstract: The objective of this study was to understand the role of marketing, from research to commercialization of technologies in Brazilian public universities. To that end, an online survey was conducted, involving 236 academicians associated with in Brazilian public universities. The data obtained were subjected to exploratory factor analysis and descriptive statistics. The results revealed the low utilization of proactive market analyses in Brazilian public universities, as well as the limited integration of marketing through interaction with companies. The strategic orientation prevalent in BPUs was geared to technology, at the expense of relationships with society and the market. An entrepreneurial orientation was not observed. The actions to promote or encourage the transfer of Brazilian public universities technologies to the market proved timid. Finally, there were several obstacles to the implementation of marketing in Brazilian public universities, characterizing the so called marketing myopia.

Keywords: patent innovation; factorial analysis; entrepreneurship; technology transfer; market orientation.

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Introduction

Universities have their roles to support teaching, research, and extension. However, the current rapid technological advancement has increased the demand for universities to collaborate to economic progress by utilizing technical and scientific skills to develop technologies that generate value for society when transformed into innovation. Thus, universities seek to convert their role from generators and accumulators of knowledge, distant from society, to knowledge centers with a prominent function in the Brazilian National Systems of Innovation (NSI) (Calderon-Martinez & Garcia-Quevedo, 2013; Marozau, Guerrero, & Urbano, 2016). The NSI includes public and private institutions that interact and form a network for scientific and technological development in the country, which is achieved through innovations (Pereira, Franco, Santos, & Vieira, 2015).

In this direction, an important milestone was the Bayh-Dole Act that was passed in the United States (US) in 1980. It led to increase American commercialization of science and other forms of university technology transfer, which influenced the introduction of similar laws in other countries. An increase in university patenting, licensing, and forming spinoff/startup companies also began to be observed in many other countries (Siegel & Wright, 2015).

In turn, Brazil has adopted legislation on the intellectual property assigned to universities, inspired by the US model. However, its universities are just beginning the work of intellectual protection and commercialization of technologies, which has a long way to go to be fully realized (Sousa, Veroneze, Zambalde, & Bermejo, 2015; Stal & Fujino, 2016). Thus, in the Brazilian context, there is the challenge of transforming science into technology that reaches markets because universities are normally responsible for research but do not always have the same capacity for the development of marketable inventions. After all, there are several paths and barriers in the industrial process or any other means of commercial application, from the discovery or scientific development of a particular technology until the product reaches the shop shelves (Siegel, Waldman, & Link, 2003; Stal & Fujino, 2016).

This situation suggests that universities should expand their relationships and practices, as well as allow their professors, researchers, and academicians alternative forms of professional performance to meet the needs and desires of society and public and private organizations (Payumo et al., 2012; Sousa et al., 2015; Veroneze, 2016). From the perspective of marketing in Brazilian public universities, it can be a problem for the already developed technology to become an innovation. The reason is that the goal of knowing and understanding customers so that the product meets their needs and sells by itself may have been ignored since the early stages of research (Lee, 2013; Mohr & Sarin, 2009). In his classic article that suggests the myopia of marketing in companies, Levitt warns "the marketing effort is still viewed as a necessary consequence of the product – not vice versa, as it should be" (2004, p. 144). Thus, it becomes necessary to understand the perceptions of the researchers and/or professors in Brazilian public universities regarding marketing and their potential contributions to the process of innovation, development, and commercialization of technologies (Sousa et al., 2015; Veroneze, 2016; Veroneze, Zambalde, Sousa, & Rennó, 2017).

It is believed that marketing must contribute to perceptions and actions on the complexities of the market and of society in general for the development of technologies in public universities (Smith, Drumwright, & Gentile, 2010; Veroneze et al., 2017; Wirtz, Tuzovic, Sven, & Kuppelwieser, 2014). Thus, this work's general aim was to understand the role of marketing, from research to commercialization of technologies in Brazilian public universities. In this context, this study's specific aims were as follows:

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1. Investigate the existence of proactive market analysis in the context of applied research.
2. Check the integration of marketing, from research until the commercialization of technologies.
3. Identify the presence of a strategic orientation of marketing in the development of applied research.
4. Identify the marketing practices used to promote the commercialization of the developed technologies.
5. Know the obstacles faced by marketing from the survey until the commercialization of technologies.

To meet the proposed objectives, a survey was conducted that included the application of a framework, based on a literature review (Bodlaj, 2010; Bouncken, Plüschke, Pesch, & Kraus, 2016; Coviello, Brodie, Danaher, & Johnston, 2002; Jeong, Pae, & Zhou, 2006; Kaymaz & Eryiğit, 2011; Kerr & Patti, 2015; Klein, Haan, & Goldberg, 2010; Malvezzi, Zambalde, & Rezende, 2014; Matsuno, Zhu, & Rice, 2014; Mu, 2015; Nabi & Liñán, 2013; Siegel et al., 2003). Such a framework comprised the following factors:

1. proactive market analysis (market sensing);
2. marketing–research integration by means of:

    a) organizations external to universities and
    b) technological innovation centers (TICs);

1. strategic orientation of marketing in research, involving:

    c) technology,
    d) consumers/citizens, and
    e) entrepreneurs;

1. contemporary marketing practices; and
2. obstacles to marketing, from research until the technologies' commercialization.

This paper is structured as follows. It presents the introduction, followed by the theoretical foundation, which deals with the evolution of marketing, the expansion of its role to serve the interests of society as a whole, and the need for its application in the context of universities, in addition to the framework that guided the research. Next, the methodological procedures and the research results are discussed. The concluding section covers the final considerations, academic and managerial implications, research limitations, and suggestions for future research.

Theoretical background

This section explains the evolution of the concepts of marketing and its relationship with the current demand for universities' greater contributions to innovation. The framework that guided the development of the research is also presented.

Marketing, society, and universities

Since its origins, marketing has been characterized as an area of knowledge that seeks to monitor society's progress and problems, constantly re-examining its focus, techniques, and targets (Kotler, 1972).

Thus, the American Marketing Association's definition of current marketing attempts to capture its broader nature: "Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large" (2015). Therefore, the essence of marketing—to interact with customers and meet their needs and those of society in general—has evolved together with its concept, since the endeavors originate from the pursuit to meet customers' needs and desires (Levitt, 2004; Smith et al., 2010). In this direction, Levitt (2004) argues that the industry must be developed from the customers' needs, offering products and/or services capable of satisfying them. Only from there should other concerns arise, such as research and development, the production process, and sales.

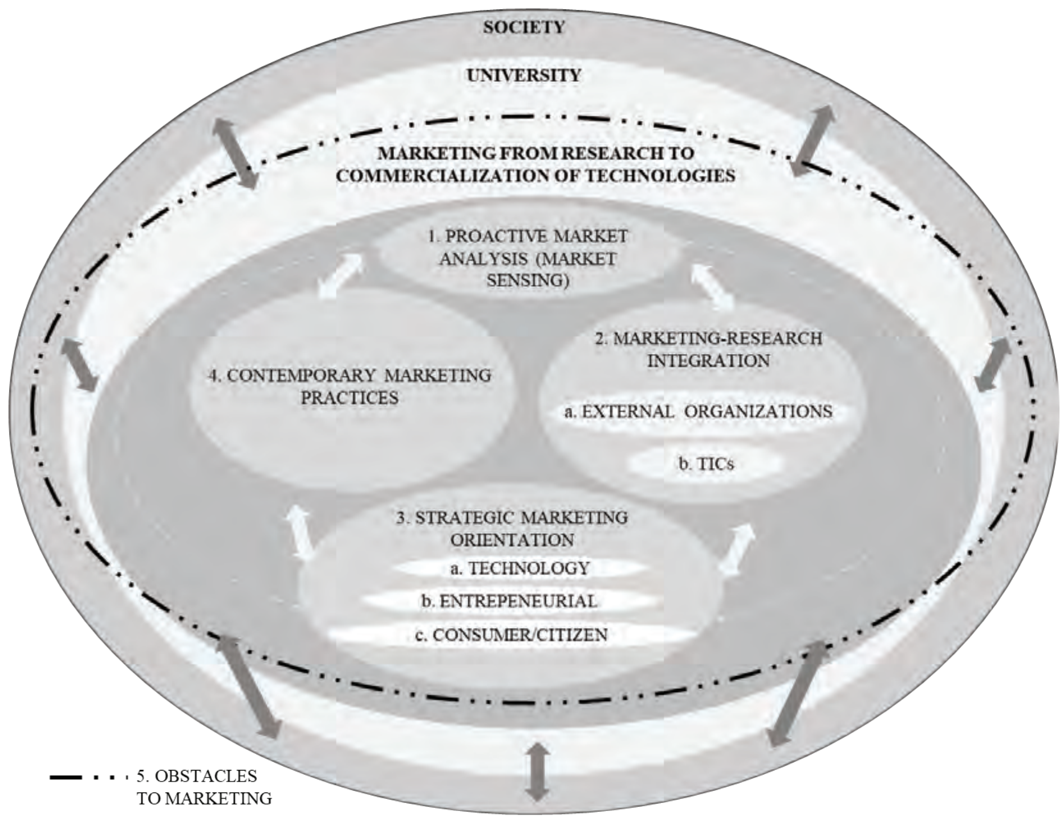
In this way, the myopia of marketing is possibly the idea of more influential marketing since its publication, being a true watershed between the approach of production/sales and the orientation of marketing (Baker, 2003; Smith et al., 2010). Since then, a lot of professionals and organizations have succeeded in focusing on consumers' needs. However, researchers should look for a new type of marketing myopia in today's business environment, that is, the lack of vision for a broad social context in decision making (Smith et al., 2010). In this regard, the role of universities in the NSI began to require an understanding of the possible contributions of marketing, from research to commercialization of technologies (Malvezzi & Zambalde, 2013; Malvezzi et al., 2014; Sousa et al., 2015; Veroneze et al., 2017).

In universities, marketing can contribute to catalyzing innovations from the overflow of scientific knowledge in various ways, such as licensing patents and forming startups or spinoffs, in line with the real needs of the markets and society (Hsu, Shen, Yuan, & Chou, 2015; Sousa et al., 2015; Veroneze et al., 2017; Wirtz et al., 2014).

Proposed framework and its principles

This study's proposed framework for application in Brazilian public universities is based on the theoretical review of the role of marketing, from research to commercialization of technologies (Bodlaj, 2010; Bouncken et al., 2016; Coviello et al., 2002; Jeong et al., 2006; Kaymaz & Eryiğit, 2011; Kerr & Patti, 2015; Malvezzi et al., 2014; Matsuno et al., 2014; Mu, 2015; Nabi & Liñán, 2013; Siegel et al., 2003), as presented in Figure 1.

Figure 1. Role of marketing in Brazilian public universities (framework)



Source: Developed by the authors based on the previously cited references

The proposed framework is based on the premise that the university is an integral part of society and points to the imperative of understanding its needs, through marketing, for the development of appropriate solutions, despite the possible obstacles. The framework's first component is (1) **proactive market analysis (market sensing)** (Bodlaj, 2010; Mu, 2015) since market orientation is the heart of modern marketing and can decisively contribute to business performance (Gummesson, 1991; Narver & Slater, 1990). The guidance for the market highlights the importance of customers and external information in creating value for customers and developing competitive advantages for organizations. Thus, the superior performance of an organization comes from its ability to detect, define, and manage customers' expectations for the delivery of superior value to them (Mu, 2015).

If a university does not understand the needs and desires of society and/or the markets, the development of technologies may result in failure in their commercialization, unnecessary costs of intellectual protection of products that will have no market demand, and therefore, a delay in the economic development of a country (Bodlaj, 2012; Veroneze, 2016; Veroneze et al., 2017). A relevant concept presented in the literature is *market sensing*, which is a marketing capability that enables an organization to forecast and act on trends, signs, and events that may indicate changes in consumers' needs and market settings (Baker, 2003; Mu, 2015; Mu & Di Benedetto, 2011).

It seems natural for universities to make use of *market sensing*. It would enable universities to anticipate the evolution of markets and their emerging opportunities for the development of technologies from a long-term perspective—based on information obtained from their complex business ecosystems—or of society as a whole (Mu, 2015; Mu & Di Benedetto, 2011; Sousa et al., 2015). On the other hand, marketing integration to obtain knowledge about the market, from the research until the commercialization of technologies, can occur in an indirect form in universities, but it can be triggered by means of partnerships with companies and/or the TICs' operations.

The framework's second component is (2) **marketing–research integration** by means of relationships or partnerships with businesses and the TICs' operations (Kerr & Patti; 2015; Matsuno et al., 2014), through which the role of marketing can be put into practice in the context of universities. This is because business partnerships can be effective for the marketing feasibility of technologies developed in universities. On the other hand, as structures specializing in the intellectual property protection and transfer of knowledge from universities, the TICs should also acquire marketing skills to fulfill their mission effectively (Hsu et al., 2015; Stal & Fujino, 2016; Veroneze et al., 2017; Weckowska, 2015).

In this sense, a relevant concept is *science-to-business*, which goes beyond the traditional view of the protection and commercialization of technologies developed by universities. It deals with the identification of potential users and customers, attempting an early anticipation of the potential applications and benefits of scientific research results in market terms (Boehm & Hogan, 2013; Kliewe, Baaken, & Kesting, 2012).

The adoption of conceptual assumptions of marketing in research and development, for the purpose of generating new technologies, allows the projects developed by universities to align better with society's demands and market opportunities (Becker & Lillemark, 2006; Griffin & Hauser, 1996; Matsuno et al., 2014). The integration of marketing and research has the goal of increasing the probability of success of new products in the market. This can occur through joint responsibility in defining the aims and priorities of the research and development of new products, enhancing existing products, and understanding consumers and cooperative activities (Becker & Lillemark, 2006; Griffin & Hauser, 1996). With marketing knowledge permeating universities, from research to commercialization of technologies, some kind of strategic marketing orientation is expected to guide technology development.

The third component of the proposed framework is (3) **strategic marketing orientation**, entailing the strategic guidelines that direct and influence the activities of all organizations, either explicit or implicit, aiming at viability and performance. After all, strategic guidance directs the support for and the allocation of resources in organizations, referring to a lasting direction of thought that leads to action (Hakala, 2011; Jeong et al., 2006). The strategic marketing orientation proposal seeks to identify specific guidance in the development of technologies in universities, involving: a) consumers/citizens, b) technology, and c) entrepreneurs (Bouncken et al., 2016; Jeong et al., 2006; Nabi & Liñán, 2013).

The consumer/citizen orientation focuses on the desires, needs, and interests of this sector. In turn, the technology orientation indicates an organization's tendency or desire to bring innovations to the market, comprising products, processes, or services. The entrepreneurial orientation concentrates on changing and shaping the environment, exploring the opportunities available for people and organizations, applying new and creative ideas with the potential to cause changes in the market, acting proactively, and anticipating future demands (Bouncken et al., 2016; Hakala, 2011). It is believed that as the marketing orientation starts to integrate the research in universities, the marketing practices will be aligned strategically for success in the commercialization of technologies.

Thus, the fourth component of the framework is characterized as the set of (4) **contemporary marketing practices** because it also seeks to understand the type of marketing practice used in universities in relation to the commercialization of technologies originating from research. This element is based on the vision of Brodie and Coviello (2008), Coviello and colleagues (2002), and Coviello, Brodie, and Munro (1997), who classify contemporary marketing practices into two broad perspectives, divided into four types of marketing: 1) transactional marketing (a. transactions marketing) and 2) relational marketing (b. database marketing, c. interactive marketing, and d. network marketing). The purpose is to classify the tendency for each practice in the Brazilian universities identified in the literature (Malvezzi & Zambalde, 2013; Malvezzi et al., 2014; Veroneze, 2016), in line with contemporary marketing practices (Brodie & Coviello, 2008; Coviello et al., 2002; Coviello et al., 1997).

On the other hand, there are countless challenges and obstacles to marketing in this context. Therefore, the fifth and last component of the framework is proposed as (5) **obstacles to marketing,** from research until the commercialization of technologies in the universities (Kaymaz & Eryiğit, 2011; Klein et al., 2010; Nabi & Liñán, 2013; Siegel et al., 2003).

Method

To meet the overall objective of understanding the role of marketing, from research to commercialization of technologies in Brazilian public universities, a descriptive-like research was carried out by means of a survey. Such research counted on self-reporting electronic spreadsheets, which were made available on the internet for academicians involved in projects involving research, development, and commercialization of technologies affiliated with several Brazilian public universities. Specifically, the following were included in the sample: (1) professors, researchers, and students in Brazilian public universities who were identified as inventors of patents filed by the National Institute of Intellectual Property (*Instituto Nacional da Propriedade Industrial*, INPI), for which universities are defined as depositors; (2) professors and leaders of research groups who are active in the Directory of Research Groups of the National Council for Scientific and Technological Development (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*, CNPq) and deal with the theme of innovation; and (3) officers and employees of TICs in Brazilian public universities. To describe the role of marketing in a structured way, we opted to develop a quantitative and descriptive research (Malhotra, Rocha, Laudisio, Altheman, & Borges, 2005).

As mentioned, the field survey was conducted online using the *SurveyMonkey*® tool, between November 2016 and January 2017. The respondents were sent an email invitation to participate in the research. The database for the recruited sample was generated from internet searches, comprising 3,173 faculty members, researchers, and graduate students from Brazilian public universities. In total, 303 questionnaires were filled in and returned; however, after excluding those that were incomplete or inappropriately filled in, the final sample was reduced to 236 completed questionnaires, which were used in the analysis.

Taking into account the framework proposed in Figure 1, the instrument for the data collection consisted of 26 indicators, including the following factors: (1) proactive market analysis (market sensing), (2) marketing–research integration (external organizations and TICs), and (3) strategic marketing orientation (entrepreneurial, consumer/citizen, and technology). Additionally, 14 questions were included that formed the block on (4) marketing practices in universities and

19 other issues, corresponding to the possible (5) obstacles to marketing for the interactions among the universities, markets, and society for the development and commercialization of technologies.

In these first five blocks, responses indicating agreement or disagreement on a five-point scale were used, from 1 = "strongly disagree" to 5 = "completely agree." As Antonialli, Antonialli, and Antonialli recommend (2017), this method assumed the ordinal scale of agreement or disagreement to be by intervals. The last block comprised 11 questions about the respondents' profiles.

The data were analyzed by means of basic descriptive statistics, such as frequency distributions, averages, standard deviations and tables crossing, as well as exploratory factorial analysis (EFA). The EFA allowed synthesizing the research variables in a smaller set of common latent dimensions, called factors. For the extraction of the factors, the method of principal components was used, and the rotation used was the Varimax (Hair Jr., Anderson, Tatham, & Black, 2005). The constitution of the factors contributed to understanding the marketing role, from the research until the commercialization of technologies in Brazilian public universities, by also allowing the evaluation of the degree of its application in this context.

Results and Analyzes

The sample comprised respondents representing 48 academic fields and 57 Brazilian public universities. Table 1 presents the profiles of the sample, plus the details of the respondents with or without patents filed (under review or already granted). Overall, 236 valid questionnaires were obtained, considering that due to some issues about the respondents' profiles (e.g., privacy or confidentiality), several questions were allowed to be unanswered. The main characteristics are discussed next.

Table 1. Sample characterization

Variables	Does it have a patent (under review or already granted)?								
	Yes	**%**	**No**	**%**	***Subtotal***	**NR[1]**	**%**	**%**	**Total**
	185	78.39	49	20.76	*234*	2	0.85	100	236
Bachelor's Degree	5	2.12	4	1.69	*9*				
Master's Degree	16	6.78	11	4.66	*27*	2	0.85	100	236
Doctoral Degree	164	69.49	34	14.41	*198*				
Professor	124	52.54	34	14.41	*158*				
Researcher	21	8.90	2	0.85	*23*				
Masters or doctoral students	26	11.02	6	2.54	*32*				
Administrative staff members and technicians	2	0.85	3	1.27	*5*	3	1.27	100	236
TIC employee	2	0.85	4	1.69	6				
Undergraduate student	1	0.42	0	0.00	*1*				
Other	8	3.39	0	0.00	*8*				
Research under contract (yes)	86	36.44	17	7.20	*103*	2	0.85	100	236
Research under contract (no)	99	41.95	32	13.56	*131*				
Consulting (yes)	75	31.78	24	10.17	*99*	2	0.85	100	236
Consulting (no)	110	46.61	25	10.59	*135*				
Male	108	45.76	31	13.14	*139*	3	1.27	100	236
Female	76	32.20	18	7.63	*94*				
Research group leader	104	44.07	31	13.14	*135*	2	0.85	100	236
Non-leader of research group	81	34.32	18	7.63	*99*				
Already transferred/licensed patent	28	15.14	156	84.32	*184*	1	0.54	100	185
Tutors graduate students	127	53.81	25	10.59	*152*	35	14.83	100	236
Does not tutor graduate students	32	13.56	17	7.20	*49*				
Participates in *spinoff*	25	10.59	1	0.42	*26*	9	3.81	100	236
Does not participate in *spinoff*	155	65.68	46	19.49	*201*				
Has participated in academic *spinoff* and transferred/licensed his or her patent:									9
Administrative counseling (yes)	9	3.81	3	1.27	*12*	2	0.85	100	236
Administrative counseling (no)	176	74.58	46	19.49	*222*				

[1] Did not answer (No response).

Source: Research data

The majority of the respondents comprised doctors with patents (69.49%), followed by doctors without patents (14.41%) and master's students with patents (6.78%). The professors represented 66.95% of the sample, 52.54% with patents and 14.41% without patents. The respondents who had already conducted research under contract and had patents comprised 36.44% of the sample, while those who had not yet undertaken research under contract but had patents made up 41.95%. The respondents who had patents and had already done consulting work totaled 31.78% of the sample, while those who possessed patents but had not yet taken on consulting jobs comprised 46.61%. Among the 185 respondents with patents, only 28 (15.14%) had already transferred/licensed their patents, and only 25 reported participating in a spinoff/startup, representing only 13.51% of this group (25÷185) and highlighting the low level of entrepreneurship in the academic environment.

Factors related to marketing, from research until commercialization of technologies in Brazilian public universities

To achieve the first three specific goals of this study (check the existence of proactive market analysis in the research context, verify the existence of marketing integration, and identify the presence of a strategic orientation of marketing in the development of applied research in Brazilian public universities, from the research until the commercialization of technologies), EFA was used. In such factorial analysis, 26 variables of the scales proposed were used, which generated an average of 9.08 respondents per variable (263÷26), slightly below the ideal proportion of ten respondents per variable suggested by Hair Jr. and colleagues (2005). The Kaiser-Meyer-Olkin (KMO) test result was 0.904, a value within the excellence zone of sampling adequacy (Field, 2009). In turn, the result of Bartlett's test of sphericity was significant (Sig. 0.000), corroborating the use of EFA.

Six factors were extracted (Table 2), with a total explained variance of 73.082%. Cronbach's alpha value for the totality of the variables was 0.941, indicating coherence in the respondents' answers (Field, 2009). Table 2 also verifies the general view of the answers to each factor, allowing visualization of the discordance or concordance factor regarding the affirmative presented. Given that the scale ranges from 1 = total discordance to 5 = total concordance, the value of three (3) indicates an average point between the extremes.

Table 2. Factorial analysis

Factors	Indicators	Factorial load	Average	Standard deviation	Factors' average	Cronbach's alpha
Proactive market analysis (market sensing)	B1.3	0.812	2.83	1.10	2.87	0.900
	B1.4	0.771	2.92	1.15		
	B1.5	0.748	2.76	1.15		
	B1.1	0.720	2.87	1.07		
	B1.2	0.681	2.99	1.12		
Marketing–research integration (external organizations)	B2.1	0.838	3.24	1.20	2.88	0.874
	B2.2	0.774	3.16	1.22		
	B2.3	0.713	2.64	1.14		
	B2.4	0.621	2.82	1.16		
	B2.5	0.605	2.57	1.09		
Marketing–research integration (TICs)	B3.3	0.861	2.87	1.13	3.03	0.910
	B3.4	0.855	2.90	1.18		
	B3.2	0.829	2.94	1.09		
	B3.1	0.728	3.42	1.17		
Consumer/citizen orientation	B4.7.c	0.808	2.88	1.19	2.88	0.923
	B4.6.b	0.773	3.08	1.25		
	B4.5.a	0.748	2.86	1.18		
	B4.8.d	0.738	2.71	1.15		
Entrepreneurial orientation	B4.3.c	0.837	1.93	1.03	2.27	0.778
	B4.4.d	0.754	2.04	1.02		
	B4.2.b	0.722	2.35	1.09		
	B4.1.a	0.483	2.75	1.14		
Technology orientation	B4.9.a	0.828	3.63	1.18	3.29	0.844
	B4.10.b	0.813	3.38	1.09		
	B4.11.c	0.772	3.32	1.21		
	B4.12.d	0.558	2.84	1.16		

Note: Cronbach's alpha (α) for total (26 items): 0.941. Extraction method: Analysis of principal component.
Rotation method: Varimax with Kaiser normalization; rotation converged in 7 iterations.

Source: Research data

The first factor extracted comprised the originally proposed five variables, adapted from the works of Mu (2015) and Bodlaj (2010) Thus, the proactive market analysis (market sensing) had an average of 2.87, lying mainly in the area of disagreement regarding its existence in Brazilian public universities. This finding demonstrates the dissonance among the fundamental precepts of marketing and the development of technology in Brazilian public universities, highlighting these institutions' inability to anticipate and act on trends, signs, and events that permeate the evolution of the needs of the markets and society (Mu, 2015; Mu & Di Benedetto, 2011).

The second factor extracted, composed of five variables, was entitled as marketing–research integration (external organizations). This factor originated from the scales proposed by Matsuno and colleagues (2014) and Kerr and Patti (2015), and refers to the understanding that marketing may be present in universities, through research, interactions with organizations (companies, hospitals, cooperatives, etc.) and increasing accessibility to the needs, desires and demands of the market / society. The average number of responses to this factor (2.88) was in the area of disagreement, demonstrating the respondents' tendency to disagree about the existence of marketing–research integration by means of interaction with various organizations. This result demonstrates that academicians from Brazilian public universities still do not understand the importance of greater interaction with organizations in the various sectors of the economy to develop technological research that meets the needs and demands of business and society as a whole. This situation reinforces the need for the stimulation of the university–industry interaction in Brazil, as well as the development of a share of science with a business focus, which can be a viable path for the university researchers who are more apt for a marketable interaction (Boehm & Hogan, 2013; Ismail, Nor, & Sidek, 2015; Kliewe et al., 2012; Stal & Fujino, 2016).

The third factor extracted, marketing–research integration (TICs), aimed to verify if the role of marketing in research can be performed in universities through the interaction between the TICs and the researchers/research groups, for the purpose of understanding and meeting the needs, wants, and demands of the market and/or society as a whole. The proposed scale comprised four variables and was adapted from the work of Matsuno and colleagues (2014).

The overall average of the responses to the third factor was 3.03, in the area of neutrality (neither agree nor disagree) but with a slight tendency to agreement. This shows that the TICs can offer a natural path for the adoption of marketing, from research until the commercialization of technologies in Brazilian universities. However, in their patenting, the TICs still seemed focused on intellectual protection of existing technologies, acting more bureaucratically than mercadologically (Stal & Fujino, 2016; Veroneze, 2016; Veroneze et al., 2017).
The last three factors extracted concerned the type of strategic marketing orientation (consumer/citizen, technology, and entrepreneurial), observed in Brazilian public universities, for technologies originating from the body of research. The questions were adapted from the works of Bouncken and colleagues (2016), Jeong and colleagues (2006), and Nabi and Liñán (2013).

The consumer/citizen orientation comprised four variables, and the overall average of the responses was 2.88, within the area of disagreement with the statements presented. This finding shows that consumers' desires and needs in the markets, as well as those of citizens in general, are not considered so widely in Brazilian public universities. This confirms that interaction with markets has not naturally occurred in the academic environment (Siegel, Waldman, Atwater, & Link, 2004), setting aside the focus on the consumer/citizen in the body of research developed in the context of Brazilian public universities, which seems inconsistent with the role demanded of such institutions in current times (Calderon-Martinez & Garcia-Quevedo, 2013; Marozau et al., 2016).

In turn, the entrepreneurial orientation showed the lowest mean score among all the factors covered in this study (2.27), demonstrating the scant attention and stimulus to entrepreneurship occurring in the environment of research in Brazilian public universities. Such a situation weakens the marketing role and obstructs an alternative in order for determinate technologies to obtain success in the markets, through formation of university spinoffs/startups (Payumo et al., 2012).

Finally, among all the factors included in this study, the technology orientation presented the highest average score of responses (3.29). Despite being next to the neutrality zone, some tendency to agreement was shown, compared with the other dimensions presented. Such a situation, associated with the TICs' typical focus on intellectual protection, contributes to a distorted vision of the market, generating a wrong sense of value of the technologies produced in universities. This is because such a vision prioritizes the generation of patents, which naturally incurs costs but does not always obtain the desired market success (Hall, Matos, Bachor, & Downey, 2014; Mohr & Sarin, 2009).

Marketing practices used to promote the technologies' commercialization

To attain the fourth specific objective of this work (to identify the marketing practices used to promote commercialization of the technologies developed in the context of Brazilian public universities), a relationship was developed among 14 variables. The respondents were instructed to indicate their degree of agreement or disagreement with the statements on a five-point scale, ranging from 1 = "never" to 5 = "very often." Table 3 presents the results, listed in the order of agreement by the respondents.

Table 3. Marketing practices used to promote the technologies' commercialization

Means	Average	Frequency	NS[1]	Tend.[2]
Technological fairs and events	3.40	225	11	T/I
Specialized journals	3.31	215	21	T
Journalistic reports in newspapers/radio/TV	3.02	221	15	T
Partnerships—there are technologies developed with partners [...]	2.96	198	38	I/R
Divulging the TIC's work in the university	2.92	223	13	T/I
Companies' incubation of technological/spinoffs' base	2.88	219	17	I
Projects' pre-incubation—environment for academicians—entrepreneurs to develop [....]	2.87	220	16	I/R
Stimulus action for entrepreneurship and innovation among the professors/researchers (leaflets/lectures, etc.)	2.79	226	10	I
TIC's meetings with companies	2.72	193	43	B/I
Webpage with catalogue on technologies	2.65	205	31	T
Social networks	2.62	199	37	T/R
E-mail marketing	2.38	205	31	B
Co-working space	2.05	170	66	I/R
Marketing plans for each technology	2.04	193	43	T/I/R/B

[1]NS: Did not know. [2]Tend.: Tendency. T: Transactional. B: Database. I: Interactive. R: Network.

Source: Research data

The marketing practice that received the highest score involved "technical fairs and events," with an average of 3.40, followed by "specialized journals" (3.31) and "journalistic reports in newspapers/radio/TV" (3.02). Considering the contemporary marketing practices proposed by Coviello and colleagues (2002), it is verified that in a relatively weak way, the three best practices highlighted by the respondents tend to be transactional. Among these, the most prominent—the exposure of technologies in "technical fairs and events"—as well as the transactional aspects, could be considered interactive, by allowing the beginning of an interaction between universities/TICs and companies/entrepreneurs willing to license technologies or expand relationships for future research.

On the other hand, the practice of creating a marketing plan for each technology, allowing the identification of specific strategies to enhance the results of the technology transfer/marketing, exhibited the lowest overall average of the responses (2.04). Additionally, 43 people were unable to respond to this question, demonstrating their ignorance about the potential contributions of developing marketing plans for the commercialization of each technology.

The development of technologies through "partnerships [...]" had an overall average response of 2.96; however, 38 scholars did not know how to answer the question. This confirms Stal and Fujino's (2016) considerations regarding the non-verification of an improvement in cooperation between universities and companies in Brazil over the last decades.

Overall, this study's participants perceive that the universities' marketing practices that aim to promote the commercialization of technologies that are developed based on academic research are quite limited. Thus, they understand that not even the developed technologies have received due attention so that they could fulfill the needs, desires, and demands of society and/or the market (Calderon-Martinez & Garcia-Quevedo, 2013; Marozau et al., 2016; Siegel & Wright, 2015; Stal & Fujino, 2016).

Obstacles to marketing from research until commercialization of technologies in Brazilian public universities

The fifth and last specific goal of this study was to know the obstacles faced by marketing from the research until the commercialization of technologies in Brazilian public universities. To this end, a list of 19 variables was made, based on the relevant literature (Kaymaz & Eryiğit, 2011; Klein et al., 2010; Nabi & Liñán, 2013; Siegel et al., 2003; Siegel et al., 2004; Veroneze, 2016). The respondents were asked to indicate their degree of agreement/disagreement with the statements on a five-point scale, with the same range of items as those of the previous ones. The main findings on such obstacles are presented and discussed in the sequence.

The point with the respondents' greater agreement on the obstacles to marketing was "the bureaucracy and the inflexibility of the administrators of the university", with an average of 4.29. This brings to the fore the need to develop practices for the management of intellectual property in universities, which is possibly at an embryonic stage in Brazil (Siegel et al., 2003; Veroneze, 2016).

The problem regarding the scarce development of the relationships between universities and companies in Brazil is also evidenced by the high overall average (4.19) received by the "lack of communication between the university and companies." The "lack of resources aimed at technology transfer from the university" (4.03) is also noteworthy, confirming some studies' reported findings about the TICs' lack of material and human resources and the minimal or non-existent training in business and marketing provided to the TICs' personnel (Hsu et al., 2015; Veroneze, 2016; Weckowska, 2015).

The "lack of stimulus to entrepreneurship in the academic environment", average (4.02), is an obstacle that can undermine entrepreneurship as a path for the availability of university technologies to the market and society (Payumo et al., 2012).

The strong discordance (4.00) that the "insufficient benefits to professors/researchers from the university on technology transfer" can contribute to the weakening of commercialization of technologies because professors/researchers are pointed out as key actors in the transfer of technologies (Markman, Gianiodis, Phan, & Balkin, 2005).

The "legislation (laws, standards, and regulations) creates difficulties for the commercialization of technologies" was the sixth most relevant obstacle (3.96), followed by the "insufficient publicity for mutual possibilities offered by the university and companies" (3.91), which must be objects of attention by Brazilian public universities and legislators.

Finally, it should be emphasized that the respondents' perceptions on the "university distancing itself from society's demands for new technologies" (3.78) show their opposition to the current role expected of universities (Calderon-Martinez & Garcia-Quevedo, 2013; Marozau et al., 2016). The respondents are also against the most current definitions of marketing and its relationship with the context of academic research for the development of technologies (Levitt, 2004; Sousa et al., 2015; Wirtz et al., 2014).

This whole scenario demonstrates the large and complex obstacles faced by marketing from the survey until the commercialization of technologies in Brazilian public universities. This situation demands rethinking of management practices and public policies on science and technology in public universities.

Discussion

The goal of understanding the role of marketing, from research until commercialization of technologies in Brazilian public universities, has been reached, according to the perceptions of the survey respondents, composed mostly of professors/researchers with patents. The data obtained has allowed an analysis from the perspective of individuals directly involved in the development of new technologies from academic research. Most of the professors/researchers with patents have neither undertaken research under contract nor consulting work, showing their distance from the market and society.

The EFA has allowed the identification of six factors that contribute to the perception of the fragility of the market approach in Brazilian public universities. An important point lies in providing guidance for technologies, specifically those oriented to the consumer/citizen and the entrepreneur. This demonstrates that the technology/product itself has been the main driver of research, neglecting the needs of the market and society (Baker, 2003; Bodlaj, 2012; Levitt, 2004). In this sense, the universities need to develop marketing capabilities to enable them to anticipate and act on changes in markets and society. They should do so from a long-term perspective, in an active and relevant way, with the aim of contributing more directly to the economic and technological development in Brazil (Baker, 2003; Mu, 2015; Mu & Di Benedetto, 2011).

The results indicate the weak and predominantly transactional marketing practices that are used to promote commercialization of the technologies developed in Brazilian public universities, corroborating the imbalance of marketing in the analyzed context. Even the technologies that are already developed have received insufficient or inappropriate attention for marketing purposes.

The obstacles to marketing (from research until commercialization of the technologies highlighted by the respondents) highlight the need for changes in the management of these institutions to align with the new demands imposed on them in current times (Calderon-Martinez & Garcia-Quevedo, 2013; Kaymaz & Eryiğit, 2011; Marozau et al., 2016; Nabi & Liñán, 2013; Siegel et al., 2003).

To paraphrase Levitt (2004), the results obtained jointly lead to the conclusion that (limited to the general perception of this sample) in Brazilian public universities, marketing efforts are still considered necessary consequences of the product/technology developed, not the product/technology as a consequence of marketing, as it should be, leading to an evident marketing myopia, from research to commercialization of technologies.

A limitation of this study concerns the sampling by convenience and accessibility to respondents, which makes it non-probabilistic, limiting the extrapolation of the results. The lack of a culture of research geared to the needs, desires, and demands of society and the market may have restricted the academicians' ability to respond to this survey. Additionally, for the sake of the schedule for the development of this study, the data were collected from November 2016 to January 2017, corresponding to the vacation period in public universities. It is believed that if the collection was done at other times, the response rate would have been higher.

It is suggested that new studies be conducted from the marketing perspective, particularly to deepen the knowledge about the professors/researchers who have transferred/licensed technologies and/or have a stake in spinoff/startup university companies. Another suggestion for future research would be to use the theoretical bases of organizational culture to understand more deeply the aspects related to the values, beliefs, habits, assumptions, and traditions in Brazilian public universities and apparently affect the adoption of marketing, from research to commercialization of technologies in Brazilian public universities.

This work's main academic contribution is the implementation of a framework of studies built on a large body of literature, involving marketing, entrepreneurship, and issues concerning technology transfer from universities (Bodlaj, 2010; Bouncken et al., 2016; Coviello et al., 2002; Jeong et al., 2006; Kaymaz & Eryiğit, 2011; Kerr & Patti, 2015; Malvezzi et al., 2014; Matsuno et al., 2014; Mu, 2015; Nabi & Liñán, 2013; Siegel et al., 2003). With such fragility of marketing, it is suggested that these institutions, especially through the development of physical structures, people, and processes of TICs' management, apply the strategies and concepts already consolidated in marketing, aiming to offer the researchers the knowledge and marketing interaction relevant for their research.

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Patents Go to The Market? University-Industry Technology Transfer from a Brazilian Perspective

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Abstract: The purpose of this paper is to explore the TT between university-industry from a Brazilian perspective, with special reference on the university Intellectual Property – IP and TT legal instruments. The methodology was designed on a quantitative approach aiming to provide a better understanding of the problem. Secondary data collection was performed through documentary analysis that aims to identify and quantify the variables related to patents, licensing and TT agreements. Later, data are grouped, classified and treated, which allowed inference and interpretation. The results show that the TT between university-industry is in an embryonic stage in Brazil, even if occurred a considerable increase of IP required over the last few years. In this context, it is possible to affirm that the academic research outcomes are not being absorbed in an effective way by the industries, and, as a consequence, just an insignificant percentage of the patents go to the market.

Keywords: technology transfer; university-industry; brazilian universities; TTO; Innovation.

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1. Introduction

The role of university has become very dynamic and challenging in the last three decades, considering that the university is expected to assume a more active role in the regional and national economic development (Piirainen, Andersen, & Andersen, 2016). This necessary change and new alignment with environmental and economic demands of society occurred mainly in reason of the knowledge has become the most significant source of innovation (Anatan, 2015; Pausits, 2015).

This slow but continuous process of changing has created a new mission for universities in addition to traditional teaching, research and extension activities (Ranga & Etzkowitz, 2013). This third-mission refers to all activities related to the generation, use, application and exploration of the academic research outcomes aiming to benefit the society, through the application of scientific principles to solve practical problems (Molas-Gallart & Castro-Martínez, 2007; Wahab, Rose, & Wati, 2012).

Etzkowitz (1998) and Siegel, Veugelers, and Wright (2007) mentioned that the third-mission activities might also be called Technology Transfer - TT, with focus on a dimension of interaction and commercial exploration of academic research outcomes. It is also an opportunity to continue the opening of the universities through exchanges with the outside of the scientific system to find real answers to social issues (Pausits, 2015).

Shane and Venkataraman (2007) point that there is a strong link between academic research outcomes, innovation industries and social benefits. Despite of it, this relationship is not a linear process. It has interference from the historical development of countries and regions, as well as a number of industry and firm-specific factors (Ramirez, Love & Vahter, 2013).

Current researches (Phan & Siegel, 2006; Clarysse, Tartari, & Salter, 2011; Perkmann et al., 2015) have shown that TT between university-industry can generate innumerous benefits to society by promoting industrial competitive advancement and consequently improves regional economic development. In addition to generating this benefits, Markman, Gianiodis, Phan, and Balkin (2005) argue that the TT is actively used in many universities to maximize rents and generate a large amounts of profits, as well as build relations with external stakeholders (Link, Siegel, & Bozeman, 2007).

Nevertheless, the TT process is only successful if the new technology is used by society (Fontana, Geuna, & Matt, 2006). In other words, it is when new ideas are raised from academic research outcomes becoming a concrete product ready to go to the market (Shane, 2002; Warren, Kitagawa, & Eatough, 2010).

In this context, there is a growing international attention to the importance of innovation generated by university-industry relationships (Siegel et al., 2007). Consequently, governments in many developed and developing countries are encouraging universities to improve innovation activities through policies designed to promote and maintain university-industry interaction. It is the goal of improving the capacity to generate and transfer new technologies based on knowledge and skills of these organizations (Wahab et al., 2012; Ranga & Etzkowitz, 2013). Despite these efforts, TT processes are in the early stages in a number of developing countries, especially compared to other countries such as the UK and the USA (GII, 2015).

The purpose of this paper is to explore the TT between university-industry from a Brazilian perspective, with special reference on the university Intellectual Property – IP and TT legal instruments. The core argument is that universities produce several patents and other IP assets but do not license or use other legal instrument for commercialization to industries, on which it is evident that the process in Brazil is still embryonic.

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Despite growing interest in university-industry interaction to explain and to justify the process of the TT processes, there are insufficient theoretical and empirical evidence on the commercialization of research and technology across the organizations (Markman et al., 2005; Link et al. 2007; Mowery & Ziedonis, 2015; Anatan, 2015), with many unsolved managerial and policy issues (Phan & Siegel, 2006).

Several studies have been focused on patents (Geuna & Nesta, 2006; Crespi, D'este, Fontana, & Geuna, 2011; Walter, 2016; Verhoeven, Bakker & Veugelers, 2016) and license (Thursby, Jensen, & Thursby, 2001; Kim & Vonortas, 2006; Macho-Stadler, Perez-Castrillo & Veugelers, 2007; Mowery & Ziedonis, 2015), unfortunately there is a limited number of researches available that analyses the relationships between patents-license on commercialization process of university-industry, specally in Brazil.

The methodology of this paper was designed on a quantitative approach aiming to provide a better understanding of the problem. In order to build a theoretical framework consistent with the theme, the bibliographic review was directed to the main international databases for subsequent tabulation through analytical and interpretative reading. Secondary data collection was performed through documentary analysis that aims to identify and quantify the variables related to patents, licensing and TT agreements. These data were obtained foremost in documents from the Intellectual Property Policy of the Scientific and Technological Institutions Forms of Brazil - FORMICT, Ministry of Science, Technology and Innovation Reports - MCTI, Global Innovation Index Results - GII and World Intellectual Property Organization Reports - WIPO. Later, data are grouped, classified and treated, which allowed inference and interpretation.

This paper is organized in the follow way: Section 2 presents a discussion of the literature review of Technology Transfer. The section 3 and 4 are focused on the University-Industry Technology Transfer and Technology Transfer Commercialization framework. Furthermore, the section 5 refers to the imminence of patents to go to the market. The section 6 is presented and explains the highlights of the IP and TT in a Brazilian Perspective. Section 7 presents the conclusions with limitations of research and directions for further researches.

2. Technology Transfer

The Roman Empire at the height of territorial expansions has already developed TT with the conquered countries, not only in matters of military infrastructure, essentially for logistics achievements, but also in fields such as agriculture, medicine, arts and philosophy (Holt, 1990; Greene, 1994). Many years have passed, it is only in the early 80s a number of policy initiatives and incentive programs were created in the United States and major European countries, focused on research, technologies and mechanisms to improve the TT (Bozeman, 2000).

TT is not just a transmission of knowledge from one country to another, it is a transfer process of any type of scientific findings from one organization to another addressed to expand the innovation capacity (Chapple, Lockett, Siegel, & Wright, 2005; Audretsch, Lehmann, & Wright, 2014). However, TT is not just a movement or delivery innovation, it is a dynamic, complicated and a transdisciplinary process whose success owes to factors coming from other sources (Jafari, Akhavan, & Rafiei, 2014). Besant and Rush (1993) elucidated that it involves any type of activities and processes through the incorporated products, processes or knowledge which are passed from one user to another.

Bukala (2008) and Gervais, Marion, Dagenais, Chiocchio, and Houlfort (2016) argue that the TT is a combination of activities that requires multidimensional approach and interaction instruments between two or more organizations during a knowledge or technical producing process to create a new product or service. Cruz and Bezerra (2017) add that the TT must be understood as the process of dissemination and exchange of information, matching technology with needs and creative version of items with new applications.

The dynamic nature of TT has contributed to the appearance of many definitions and conceptions (Anatan, 2015). Nevertheless, the conceptualization of TT refers to use, mobilization, application, exchange, development and management related to a product, service, technology and knowledge. (Reddy & Zhao, 1990; Etzkowitz & Leydesdorff, 1998; 1999; Chapple et al., 2005; Phan & Siegel, 2006; Ranga & Etzkowitz, 2013; Audretsch et al., 2014).

The extent of the definition demonstrates the complexity and diversity of TT fieldwork. It resultes from dynamic elements in cross-institutional activities and relationships between individuals and organizations that may have different points of view about the value and potential use of technology, creating distinct interfaces very often chaotic and disorderly (Etzkowitz & Leydesdorff, 1998; Bozeman, 2000).

In fact, the TT processes are nonstop reshaping in an endless transition with four interfaces possibilities between organizations, which involves: industry-industry, university-industry, government-government and university-government. However, the relation between university-industry is generally the major player in the innovation process, producing an important relationship between science and technology (Etzkowitz, & Leydesdorff, 2000; Dooley & Kirk, 2007; Schaeffer, Dullius, Maldonado, & Zawislak, 2015).

Nevertheless, one of the best ways to promote the innovation country capacity is through university-industry interactions, where the university carries out the TT from academic research outcomes to industries that previously were unaware of them, to put into operation new products or processes of transformation, or manufacturing (OECD, 2007).

3. University-Industry Technology Transfer

For a long period, universities and industries have been focused on their own traditional functions, closed in their bubbles and in their strongly defended boundaries (Etzkowitz, 1998). However, both (university-industry) recognized the mutual benefit that can be gained through collaboration on discovery research in the innovation process to confront the high complex and turbulent environments that occurred in the last two decades (Dooley & Kirk, 2007; Gunsel, 2015).

According to Audretsch et al., (2014), university-industry relationships are essential to create new connections between science and technology. Nowadays academic research and industrial innovation become increasingly important in countries and regions at various stages of economic development (Schaeffer et al., 2015; Ramirez et al., 2013)

Schaefer et al. (2015) add that the University Industry Technology Transfer – UITT is a fundamental activity for the application of scientific knowledge in the production sector, which stimulates and influences the innovation processes in both organizations. As a result, Geuna and Muscio (2009) point that many universities are trying to promote UITT with new mechanisms to be successful in the third mission activities.

In today's world there are several formal UITT mechanisms, which include, but it is not limited to: collaborative research, joint ventures research, technology consulting, strategic alliances, licensing and acquisition, spin-off companies and incubators (Markman et al., 2005; Link et al., 2007, Muscio, Quaglione, & Vallanti, 2014; Ranga et al., 2016).

On the other hand, the informal TT includes, but it is not limited to: meetings, conferences, communication processes, publications, reports, undergraduate courses at university, consulting, recruiting former graduate students, PhD supervision and ad hoc advice (Hertzfeld et al., 2006; Phan & Siegel., 2006; Geuna & Muscio., 2009; Bodas-Freitas, Geuna, & Rossi, 2011; Bollin & Ericksonn, 2016).

For university-industry establish and sustain collaboration, they must gain mutual benefit from these interactions (Dooley & Kirk, 2007), however until 80s the knowledge or even physical product developed at universities were mostly informally transferred in an one-way course to industries that were benefited with the gains from this new technology, with nothing addressed to the universities (Markman et al., 2005; Perkmann et al., 2013). Even though it has been almost 40 years, this unfortunate situation still exists today in many developing countries according to international statistics (GII, 2015).

In this context, Bodas-Freitas et al. (2011) argued that the UITT process must be formal, supported by legal instruments signed between the parties, respecting the division of work and the rules for joint decisions and actions. Thereby providing safeguard of university's IP, such as a patent or any other protected asset, is a disposition to allow some kind of exploration from industries partners with mutual benefit (Thursby et al., 2001; Link et al., 2007).

Bodas-freitas et al. (2011) research has shown that the diversity of the industrial sectors and the geographical proximity between university-industry provides a formal UITT with interconnections and interdependent process (Perkmann et al., 2013) able to produce innumerous benefits to society by promoting the advancement of the industrial competitivity and consequently improving of the national and regional economic growth.

Beyond the advance in the competitivity and the economic development, the UITT allows researchers to conduct a better basic research and it gives them a different perspective, which can sometimes be the inspiration for innovative researches (Geuna & Muscio, 2009). In fact, the interaction between university-industry does not only mean transferring knowledge from producer to buyer, it works in both directions.

Briefly, this multi-stage process includes: research, disclosure, patenting, licensing and commercial use (Link et al., 2007). Although all these steps are important, to be successful in UITT the commercialization stage must be done in a way that the academic research outcomes could go to the market.

4. Technology Transfer Commercialization

The term "transfer" added to "technology" usually results in a process of "selling" such technology (Zhao & Reisman, 1992). For this reason, the term Technology Transfer Commercialization - TTC is found in several studies (Siegel, Waldman, Atwater & Link., 2003; Siegel et al., 2007; Chapple et al., 2005; Markmann et al., 2005; Perkmann, 2013; Geisler & Turchetti, 2015; Mattila & Lehtimaki, 2016).

According to Geisler and Turchetti (2015), the goals of TTC is to generate a process where academic research outcomes play a useful role in society, through the introduction of a new idea, a technological solution, a product, a service, a procedure, a policy, an organizational form or a firm to the market (Link et al., 2007; Mattila & Lehtimaki, 2016).

In the last two decades, the TTC activities have become increasingly important on the role of universities, particularly in the setting of a direct source of funds derived from TTC transactions and as a means of acquiring visibility and legitimacy in the research field (Bodas-Freitas et al., 2011; Pausits, 2015; Piirainen et al., 2016) with the objective to obtain financial benefits (Perkmann et al., 2013).

Phan and Siegel (2006) argue that TTC can potentially result in financial benefits for the universities. It happens mainly when the universities are interested in maximizing their social return on public investment in research and in the effort to improve their self-sustenance (Gervais et al., 2016), creating revenue, which is typically reinvested in academic research (Chapple et al., 2005).

To support commercialization activities, many universities have established the Technology Transfer Offices - TTOs, Science Parks and Incubators to create supportive internal rules and procedures for exploration of academic research outcomes and resources (Siegel et al., 2003; Clarysse et al., 2011). This infrastructure is significant not only for an inclusion of a marketing support, but also for its ability to enhance the commercialization of academic knowledge (Etzkowitz, 2003; Perkamnn et al., 2013).

Once the patent has been granted, the TTO must carry out four activities in order to succeed the commercialization of the technology.

The first activity involves the measuring of operational and economic viability of this patent. The second is the mapping of industries or entrepreneurs, identifying potential stakeholders with financial support conditions. The third activity is the conducting of the negotiation meetings with the selected industries for define the agreements of licensing or other protected IP. In the fourth and final phase, the technology is converted into a commercialized product (Siegel et al., 2003; Markman et al., 2005).

Consequently, commercialization is related to all university activities that are involved in achieving a new technology or any finding resulting from academic campus and the attempt to incorporate these results into the market (Geuna & Muscio, 2009). The key of UITT is to make their findings marketable (Audretsch et al., 2014), nevertheless, universities, industries and other players cannot succeed without boundary-spanning activities in the organizations involved (Taheri & Geenhuizen, 2016).

Unfortunately, managing the TTC process is a serious challenge. It can be painful and difficult to achieve (Wright, Birley & Mosey, 2004; Ambos, Mäkelä, Birkinshaw, & d'Este, 2008). It may become a chaotic and disorderly process involving groups and individuals who may hold different views about the value and potential use of the technology (Bozeman, 2000). This unsuccessful situation occurs because of the mix of factors that adversely affect the process, which include, but are not limited to: public policy, commercial network, financial incentives, involvement, bureaucracy and culture are factors that interfere in the TTC process (Siegel et al. 2003, Geisler & Turchetti, 2015).

Despite evidence of some improvement in the commercialization process in the last years (Perkmann et al., 2013; Geisler & Turchetti, 2015; Mattila & Lehtimaki, 2016), there is still an enormous gap between universities and industries to ensure that patents become licensed, and posteriorly a product in the market.

5. Patents go to the market

Until nowadays, the universities are still called "ivory tower", a metaphor of isolation from market or government influence that refers to the academic impenetrable boundaries (Thursby et al., 2001; Taheri & Geenhuizen, 2016). In this context, conducting boundary-spanning between university-industry may be the most difficult challenge in the UITT (Wright et al., 2004; Perkmann & Schildt, 2015).

Consequently, it is also important to note that analyze and understand the process of technology transfer from universities into marketable ideas became one of the most important topics in academic research (Audretsch et al., 2014). Bozeman (2000) argue that the definition of UITT sometimes create conflicts due to different references involved. However, one thing is certain: it will succeed when the technology is introduced into the market with a purpose for further use and commercialization (AUTM, 2002; Geuna & Muscio, 2009).

In this context, patents assume a protagonist role in the transformation of knowledge and technology into marketable products (Etzkowitz, 1998). Then license has become the most popular mechanism of universities commercialization (Muscio et al., 2014). In addition, Phan and Siegel (2006) argue that UITT can potentially result in financial gains for the university and job creation in the local region. According to Perkmann et al. (2013), in the past many universities have passively licensed their technologies, nowadays most have actively created ways for commercialization mechanism. This is the reason why in the last decades, numerous countries promoted policies, programs and institutional structures, which gave to the universities the right to retain title and license inventions (Thurbsy et al., 2001; Ranga et al., 2016).

To improve competitive advantage in the fast-changing global economic environment (Burhanuddin, Arif, Azizah, & Prabuwono, 2009), industries are forcing the innovation processes to become more open and distributed, considering the growing importance of scientific knowledge in technological change and their role in economic development (Ramirez et al., 2013). The result has been the reshapes of the Research and Development (R&D) industries and the universities goals towards a TT that require new institutional arrangements and alignments (Etzkowitz & Leydesdorff, 1999; Siegel et al., 2003). Nevertheless, Kim and Vonortas (2006) argue that there is an extensive evidence of the increasing use of licensing agreements in the industries.

Even though the UITT looks like an easy process, many attempts have been unsuccessful. Previous studies (Wright et al., 2004; Bekker & Bodas-Freitas, 2008; Bozemann, 2000; Crespi et al., 2007; Gervais et al., 2016; Markman et al., 2008; Perkmann et al., 2013; Wallin et al., 2014) demonstrated that some technologies have difficults to achieve the market.

Furthermore, Muscio et al. (2014) consider that there is a gap in the connection between university and nonacademic institutions, because some researches have no impact in the local economic development and in the industry competitive advantage (Anatan, 2015; Guan, Mok, Yam, Chin & Pun, 2006). As a result, to be effective in the third mission, the universities need to improve their technology transfer process to create a positive impact in the society and a competitive advantage in the industries.

6. Brazilian Perspective

Economically, Brazil is considered one of the major developing countries with enormous potential for industrial development, domestic demand and innovation capacity. However, it is essential to improve the country's innovation and technological fieldwork through the modernization of infrastructure, consolidation of investment funds, attraction and retention of human resources and promotion of technological innovation at universities and industries (MCTI, 2016).

Brazil is considered a continental country divided in five regions: north, northeast, center-west, south and southeast, having a total of 200 million inhabitants living in an enormous economic-regional inequality with a cultural diversity between the regions mentioned above (IBGE, 2016). Since the sugarcane cycle in the seventeenth century, passing through the mining and coffee economies in the nineteenth and the process of industrialization in the 20th century, the five regions of Brazil have always presented different levels of economic development, with a concentration of production and income in the Southeast region (Casali, Silva & Carvalho, 2010).

The Brazilian diversity among the regions is not just a reflection of economic development inequality, but it is also related with the development of education, technical training and university infrastructure. Brazil has 195 universities, mostly in the Southeast region with 78 universities, followed by the south with 47, the northeast with 39, the north with 17 and the center-west with 14 (IBGE, 2016). Despite of that, just 18 universities in Brazil have an international level according to the 1.000 best universities world ranking Center for World University Rankings (CWUR, 2017).

In this context, it can be noticed that regional development has a direct influence on the educational level in Brazil and on the development of universities, which explains the fact that Brazil has some universities that are so developed and others with a high disability index. It reflects directly on the innovation and technology transfer rates discussed in this article.

In order to maximize the innovation capacity in Brazil, the Innovation Law was created in 2004, establishing among others features, the reinforcement of the Research Institutions – RIs, composed mostly of universities, technological institutions, research centers and technological parks. To better understand this innovation progress, the Ministry of Science, Technology and Innovation - MCTI has published annual reports, called FORMICT.

The 2007, 2008 and 2009 reports presented a superficial analysis of the national panorama, with a punctual and disordered IP and TT data. Despite 2010 FORMICT reports began to be published with a large range of data, the data are still statics nowadays. As a result, this article is mainly focused on the classification, grouping and treatment of the data from 2010 to 2014 editions of the report, with the purpose of making inferences and more qualified interpretations, as presented below. There is no data available referring to 2015 and 2016 editions at the time of the production of this article.

In 2010, there were 164 RIs identified, increasing to 176, 193, 261 and 264 between the years 2011 and 2014. In this period, there was a 62% increase due to the democratization and expansion of higher education policies implemented in Brazil, in response to the low number of graduate students in the country as well as the centralization of universities located mostly in regions with higher GDP (Cruz & Santos, 2017). It should be noted that most of the universities are public, federal level and located in the Southeast, Northeast, South, Center-West and North regions, respectively. This differentiation between these regions shows that the most developed regions with higher concentration of income can have better expressive numbers of TT, besides that the universities located in these regions have more experience considering that they were created it has been a long time and they also have access to resources, concentration of industries and universities and infrastructure. The Southeast region, the most economically developed region, concentrates 70% of the costs of developing technologies carried out by Brazilian industries (Casali et al., 2010).

However, there was also a superior involvement by some RIs with the innovation field, outstanding the implementation of the Innovation Law which aims to stimulate technological innovation and R&D activities through financial incentives for projects of scientific and technological research carried out with partnerships between university and industry in Brazil (MCTI, 2016).

The implementation of TTOs in RIs also showed a growth. In 2010, 57% of the RIs had a TTO implemented, followed by 66%, 73%, 64% and 68% in the subsequent years. The findings between 2010 and 2014 have a modest growth, equivalent to 11% in 5 years.

Nevertheless, the Innovation Law establishes that all public RIs have their own TTO or are associated with other institutions with the purpose of promoting the IP and TT fields (Brazil, 2016). This modest growth rate probably occurs due to the discontinuation of financial support funds for scientific research, the lack of technical training and the inadequate way of human resources contracting to manage TTOs, since the most universities in Brazil are public (Torkomian, 2009).

Table 1. Brazilian RI Evolution

VARIABLES		2010	2011	2012	2013	2014
RI researched		164	176	193	261	264
RI with TTO		57%	66%	73%	64%	68%
TTO with filed patents or other IP requests		61%	65%	69%	56%	61%
Patents and other IP	Filed	1078	1595	1769	1901	2163
	Granted	169	208	207	271	350
Filed patents and other IP requests by applicant country	Brazil	90,9%	91,7%	90,3%	91,7%	93,7%
	Foreign countries	6,8%	8,0%	8,4%	8,0%	6,1%
	Brazil + Foreign countries	2,3%	0,3%	1,3%	0,3%	0,2%
Granted patents and other IP by applicant country	Brazil	85,8%	90,9%	80,2%	90,8%	92,6%
	Foreign countries	13,0%	8,2%	19,8%	8,9%	71,0%
	Brazil + Foreign countries	1,2%	1,0%	0,0%	0,4%	0,3%
RI with TT agreements/contracts		22%	25%	23%	17%	18%

RI=Research Institutions. TTO= Technology Transfer Office. IP= Intellectual Property. TT=Transfer Technology

In this context, in 2010 there were 61% RIs with patents filed or other IP requests, reaching 65% in 2011, 69% in 2012, 56% in 2013 and 61% in the year 2014. The findings have a little rate fluctuations over the years with a zero increase between 2010 and 2014. The number of RIs with patents filed or other IP requests is very low and stagnant over the 5 years. Outstanding the excess of bureaucracy, difficult alignments among the Brazilian legislations, inexpressive integration between institutions and researchers, and a low funding in R&D from industries (Fujino & Stal, 2007). Mazzucato (2016) considers that demand for knowledge produced by university-industries partnerships is very low in Brazil.

In 2010, Brazil had 1078 patent applications or other IP requests, increasing to 1595, 1769, 1901 and 2163 in the following years. There has been a significant growth in the number of requests between 2010 and 2014, reaching more than 100% in 5 years. It is maybe a reflex of the government programs established to support and strengthen the TTOs by expanding the universities physical structure, improving the quality technical support and in the consolidation of the IP protection culture in Brazil (MCTI, 2016). In this context, Mazzucato (2016) believe that the Brazilian scientific research field has improved substantially in recent decades.

However, when comparing the filed and granted patent or other IP, the findings present an inexpressive number of granted, with an average of 13% along the years, in which only 169 were granted in 2010, 208 in 2011, 207 in 2012, 271 in 2013 and 350 in 2014.This very low rate is probably linked to the INPI's (National Institute of IP) delay in granting a patent application in Brazil, which currently takes 12 years on average, or even the failure to analyze the patent application by the TTOs when examining the patentability requirements (Torkomian, 2009).

Most of the applications, 90.9%, 91.7%, 90.3%, 91.7% and 93.7%, respectively between 2010 and 2014 were made in Brazil. Applications in foreign countries are still very low with 6.8%, 8.0%, 8.4%, 8.0% and 6.1%, over the years. The patent or other IP filed in Brazil along with foreign countries has a decrease over the 5 years, representing 2.3% in 2010, 0.3% in 2011, 1.3% in 2012, 0.3% in 2013 and 0.2% in 2014.
Consequently, the patent granted are mostly in Brazil, with 85.8% in 2010, followed by 90.9%, 80.2%, 90.8%, 92.6% in the following years, presenting an average of 80% between the years 2010 to 2014. The protection granted in foreign countries is median, with 13.0% in 2010, followed by 8.2%, 19.2%, 8, 9% and 7.1% in 2014. The protection granted in Brazil along with foreign countries are inexistent, with 1.2%, 1.0%, 0.0%, 0.4%, 0.3%, respectively, representing 0.5% between 2010 and 2014.

This situation may be explained by the low quality of the TTOs human resources, the lack of interest from researchers to protect their inventions abroad, the excess of bureaucracy in Brazilian legislation, the high cost of filing an international patent application and the low investment of innovation industries in foreign countries. This statistic reflex the low internationalization of Brazilian universities and industries, which directly affects Brazil's ranking global innovation index (Torkomian, 2009; Fujino & Stal, 2007; Kenny & Mowery, 2014).
The findings have a very low number of RIs with TT agreement, with 22% in 2010, 25%, 23%, 17% and 18% in the following years, representing 21% among 2010 to 2014. This is a reflex of the inexpressive patents granted to universities and a weak partnership between university-industry despite the increasing number of TTOs implemented and patents filed over the 5 years.

The number of TT agreements between university-industry is very shy, which only 18% of RI had some of it in 2014. It shows that the TT processes is in embryonic stage in Brazil, considering that the innovation culture in many universities and industries around the country still need to be established. Fujino and Stal (2007) add that the TTOs in Brazil have not yet achieved a level of autonomy and infrastructure adequate to the operation of a licensing policy.

According to the Brazilian legislation, there are several TT legal instruments for universities that allows the industries to explore or use their patents or other IP assets, that include but it is not limited to: licensing agreement, R&D partnership agreement, know-how and technical assistance contract, share agreement of equipment, laboratories, materials and other facilities, non-disclosure agreement, co-ownership contract and biological material transfer (MCTI, 2016). The statistics of Brazilian TT legal instruments were published in 2011 for the first time by MCTI. Before that there is no official data available.
The most common TT legal instrument is the licensing agreement, representing 77.3% in 2011, followed by 76.1%, 64.1% and 63.6%, respectively. There was a decrease over the 4 years associated by the previously issues discussed in the article.

Table 2. TT Legal Instruments between Brazilian University-Industry

TT LEGAL INSTRUMENTS BETWEEN UNIVERSITY-INDUSTRY	2011	2012	2013	2014
Licensing agreement	77,3%	76,1%	64,1%	63,6%
R&D partnership agreement	7,0%	10,4%	7,5%	17,5%
Know-how and technical assistance contract	2,2%	0,9%	9,0%	8,9%
Share agreement of equipment, laboratories, materials and others facilities	1,5%	2,3%	0,3%	1,3%
Non-disclosure agreement	0,0%	0,0%	3,6%	4,4%
Co-ownership contract	4,4%	3,6%	4,5%	3,4%
Biological material transfer	4,7%	1,2%	0,3%	0,4%
Other agreements/contracts	2,7%	5,5%	10,8%	0,5%

The R&D partnership agreement is another type of TT legal instrument very similar to the licensing agreement, but in this case, there is a participation of a public institution in the TT process (Pimentel, 2010). The findings present 7.0% in 2011 with an increase to 10.4%, 7.5% and 17.5% in the following years. It shows a little progress in the relationship between private and public institutions in Brazil.

The Know-how contracts are another kind of TT legal instrument that aim to obtain knowledge and techniques not protected by property rights, destined to the production of industrial goods and services (INPI, 2016). The rate of know-how, technical assistance and other services contracts are low, with a 2.2% in 2011, followed by 0.9% in 2012, 9.0% in 2013 and 8.9% in 2014. Despite the little growth over the years, there are a few contracts for know-how, technical assistance and other services, especially when compared to developed countries.

Share agreement of equipment, laboratories, materials and other facilities are another type of TT legal instrument that allowed industries to use RIs laboratories and equipment in a joint innovation process (Pimentel, 2010). The findings are quite inexpressive, with 1.5%, 2.3%, 0.3% and 1.3% over the years. In 2013, there is a larger drop related to the low number of research project performed between university-industry.

Non-disclosure agreements provide an obligation to not disclose scientific or technological data, information or knowledge, restricting the access to this information only to people expressly authorized by the parts of the project execution, on which the terms are fixed by several clauses (Pimentel, 2010). There are no findings in 2011 and 2012, registering only 3.6% in 2013 and 4.4% in 2014. It showss the low concern of TTO researchers and officials about the importance of signing a confidentiality agreement aiming to protect information from UITT partnerships against undue disclosure to other organizations.

Co-ownership agreements are a TT instrument that establish the organization activities involved and how they will share the commercial results (Pimentel, 2010). The findings have a fairly low rate, representing 4.4%, 3.6%, 4.5% and 3.4% between 2011 and 2014, respectively. In addition, there was no growth over the years, with a decrease in 2012 with 3.6 and in 2014 with 3.4%. This fact can be related to the low index of licensing contracts, to the innovation policy of some universities that do not allow co-ownership, to the low number of projects of R&D developed in partnership between university-industry.

The contracts for the transfer of biological material are a TT legal instrument to formalize the exchange of biological genetic heritage carried out between RIs based in Brazil and overseas, according to the Convention on Biological Diversity (CBD). It regulates the national sovereignty over biodiversity, the prior informed consent, and the benefit sharing, stemming from the use of genetic heritage (Cruz & Menuchi, 2007). This type of contract represented a decline over the years, representing 4.7% in 2011, 1.2%, 0.3% and 0.4% in the following years. This is probably a reflex of the difficult to carry out new contracts of biological material due to the implementation of the CBD in 2010 which established legal marks for the development of biodiversity activities (Brazil, 2015).

These results show that the TT between university-industry is in an embryonic stage in Brazil, requiring research efforts and financial investments to reach the product even if occurred a considerable increase of IP required over the last few years (Póvoa, 2010). Considering that there are 32% RIs without TTOs, the rate of IP granted are very low and TT agreements are inexpressive. In this context, it is possible to affirm that the academic research outcomes are not being absorbed in an effective way by the industries, and, as a consequence, they not always go to market.

The stagnation of Brazilian innovation becomes even more dramatic when compared to developed countries such as the United States, UK and South Korea, it evinces an amateur internationalization of the Brazilian IP and an inexpressive relationship between university-industry for TT processes that affects directly Brazil's (GII, 2015). Notwithstanding, the WIPO report shows that Brazil ranks the 19th with 41.453 patents, behind all BRICS countries, in which China has 875.000, Russia 181.000, South Africa 112.000 and India 42.991 patents (GII, 2015).

7. Conclusion

Although there has been a significant investment by the Brazilian government in programs to improve the technological innovation and research activities in universities in recent years, Brazil is in 29th place in the R&D world investments ranking, with only 1.24% of national GDP (CNI, 2016). It is possible to affirm that the innovation in Brazil is in an embryonic phase if compared to the world average and it has the worst performance in innovation compared with the BRICS countries, and a much lower position when compared to the best countries in innovation quality like United States, Switzerland, Canada, Germany, France, China.

These investments have resulted in a significant increase of more than 100% growth in the number of patent applications between 2010 to 2014. However, when comparing applications and IP, it can be seen that Brazil still has a low number of patents granted representing an average of 13.8% of the requests. This low index can be linked to the INPI's delay in analysing a patent application, which currently takes an average of 12 years, or even the failure to analyse the patent application by the TTOs with regard to patentability requirements: novelty, inventive activity and industrial application. In their majority, the TTOs that are responsible for managing all IP and TT of the RIs still lack infrastructure and personnel with adequate technical capacity.

The number of RIs with technology contracts is also very inexpressive either, accounting for 21% of the average between 2010 to 2014. The low percentage of RIs with technology contracts is a reflection of the low index of RIs with IP applications, as well as the reduced number of TT carried out in the country and the low industries financing, considering that most of the financing in Brazil comes from the government. Thus, university-industries partnership is increasingly important to leverage the country's economic development and increase the TT.

The data exposed above show several gaps: the absence of a clear and specific legislation to stimulate the UITT in Brazil , defensive culture of universities regarding to partnerships with industry; low autonomy of TTOs and adequate infrastructure to manage the IP and promote a better TT; lack of personnel with low technical capacity in the TTOs to apply the IP protection and conduct economic and technical feasibility studies of patent applications, technological prospecting, innovation management and patent negotiation; the high cost to carry out an international patent application; INPI's delay in examining patent applications.

In this context, the Brazilian universities have a significant number of patent applications, but these technologies do not reach the market, considering that they are not licensed or transferred to any industries. This situation goes against the basic principles that state that all the technologies can only be considered innovations once they go to the market. There is no effectiveness in R&D investment for innovation if there is no policy aimed at stimulating TT between university-industry.

8. References

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Organizational Ambidexterity: A Study in Brazilian Higher Education Institutions

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Abstract: The purpose was to understand how the ambidexterity degree (exploration + exploitation actions) can explain the variance of the *number of students*. As theoretical foundation, it was considered the arguments proposed by March (1991) and Tuschman and O'Reilly III (2004) about organizational ambidexterity (balance of incremental and radical innovation initiatives). About the methodology, a quantitative approach was used, and the sample counted with 79 executives of higher education institutions (HEI). For data analysis, descriptive statistics, chi-square, cluster analysis, correlation analysis and multiple linear regression were used. As outcome, the confirmation that ambidexterity can explain variance of the number of students in 20.6%. However, it was also observed that it cannot explain variation of the main index of teaching quality: General Course Index. Finally, there is a proposition of a maturity degree for ambidexterity, subdivided into four levels: I - Embryonic, II - Structured, III - Semi-developed and IV - Developed.

Keywords: Innovation management; Organizational ambidexterity; Higher education institutions.

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Introduction

In 2004, Tushman and O'Reilly III published an article in Harvard Business Review, titled Ambidextrous Organizations, in which in its first few lines they present an analogy about a manager's ambidextrous capacity. The researchers describe that the Roman God Janus had two pairs of eyes, one of them to look at what was behind (past), and the other to look at what was yet to come (future). In the analogy pointed out by the authors, top executives should be able to focus their managerial efforts on improving already established products and processes while, at the same time, channel efforts and generate innovations that will define the company's future. Perhaps this is one of the most complex managerial challenges of an executive, and overcoming this may define the trajectory of his or her company.

In a more pragmatic way, several empirical works present outcomes and reflections of organizational ambidexterity. Three jobs can be highlighted. The first study is authored by Nicholas Tay (University of San Francisco) and Robert Lusch (University of Arizona) entitled *Agent-based modeling of ambidextrous organizations: virtualizing competitive strategy*, published in 2007 by IEEE Intelligent Systems. In its genesis, that research used definitions of ambidexterity defended by March and Tushman & O'Reilly III (the same authors that inspired this research), and the element of interest of the investigation refers to the analysis horizon, using agent-based modeling (ABM). In the study, using the sophisticated technique ABM in their tests, Tay and Lusch (2007) observed that although an organization is ambidextrous in a turbulent market, it will not have a competitive advantage; however, such organization has more evolved learning capacity than other companies. In short, after the control of variables, as the authors proposed, due their exploration and exploitation skills, ambidextrous organizations learn 20% faster than other companies.

Second survey, conducted by authors Henry K. Kombo (Egerton University) and Peter K'Obonyo and Martin Ogutu (Nairobi University), is entitled *Knowledge strategy and innovation in manufacturing firms in Kenya*, published in October 2015 at International Journal of Scientific Research and Innovative Technology. In that paper, researchers investigated empirically for the purposes of strategic knowledge in innovative organizations. The study was transversal and its sampling was stratified - totaling 266 companies, representing 12 subsectors of manufacturing industry. The major hypothesis from Kombo, K'Obonyo and Ogutu (2015) emphasized that knowledge strategy has a positive effect on organizational innovation. To validate this hypothesis, authors used multiple regression technique. The research's outcome indicates that 24.2% of organizational innovation's variance is explained by variables derived from the knowledge strategy construct. Thus, researchers were able to conclude that knowledge strategy has a significant effect on organizational innovation, that is, companies that have higher levels of knowledge also generate more organizational innovations.

And, finally, the third study, by authors Paul Bierly and Paula Daly (Baylor University), entitled *Alternative knowledge strategies, competitive environment and organizational performance in small manufacturing firms*, that was published in 2007 at the Entrepreneurship Theory and Practice Journal. The research examined relationship between strategic knowledge, involving exploration and exploitation actions, and performance in small industries, including moderation variables involving external environment. Research results show that relationship between exploration and performance is linear and positive, and relationship between exploitation and performance is concave. The researchers also point out that outcomes provide valuable insight regarding the small manufacturers participating in the research, although it is not possible to generalize the study. On this regard, Bierly and Daly have suggested more in-depth studies of ambidexterity in service companies, which would make it easier to understand this much more complex sector of companies.

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Analyzing the essence of all those research, such as relationship between ambidexterity and performance, organizational learning, data analysis and, hence, need for research on the topic in service providers, the research's problem is outlined: **How much the ambidexterity degree (exploration + exploitation actions) can explain the variance of variable *number of students* (performance variable) in service companies, more specifically in higher education institutions (HEI)?**

Based on the above research problem, general objective of this research was to **understand how much the ambidexterity degree (exploration + exploitation actions) can explain the variance of the variable *number of students* in the investigated HEI.**

About the theoretical justification of the work, it is important to indicate that the seminal research on the construct investigated in this study was published in 1991 in Organization Sciente journal, by March, with his paper entitled *Exploration and exploitation in organizational learning*. Since then, worldwide, several other researches have investigated this construct. In Brazil, when accessing the scientific bases – a) Scientific Electronic Library Online - Scielo, b) Scientific Periodicals Electronic Library - Spell and c) Commission of Improvement of Personnel of the Superior Level - Capes, being this last one holder of the bank of dissertations and theses of the Brazilian graduate programs – searching for ambidexterity and ambidextrous organizations (in the title, abstract or keywords), it is realized a timid diffusion of this theme. Four studies were found in Scielo, two studies published in Spell, and two papers at Capes (a thesis defended at Universidade Federal do Parana and a dissertation defended in the professional master's degree of Uninove University).

These results confirm the need for Brazilian scientific maturation in relation to the organizational ambidexterity construct. In view of this, theoretical justification of this research is to contribute to the scientific maturation on the ambidexterity phenomenon, especially because the study has been applied in service companies, thus, allowing for new and unprecedented reflections - with the intention of dilating the existing theory on the subject.

From the practical perspective, it is worth remembering that the sector studied by this research undergoes a deep change. With the political, economic and financial crises that began in Brazil in 2014, directors and deans of private HEI were forced to rethink several organizational practices, since the main Fund for Student Finance (FIES), that financed the students and guaranteed financial resources to HEI, has changed, the access became more restricted, reducing the number of enrolled students in the program. Although the higher education sector cannot measure, yet, the full impact of this change, HEI managers have begun to channel more efforts into managerial efficiency, closely monitoring organizational performance. That said, this research seeks to contribute to the management model of Brazilian HEI, reporting more pragmatically how relationship between the exploration and exploitation actions and the variation in the number of students works.

Theoretical framework

Organizational ambidexterity

Professor James March (Stanford University) published, in 1991, a seminal article entitled *Exploration and exploitation in organizational learning*, strengthening the concept of **organizational ambidexterity**. At the time, March (1991) showed concern from part of the researchers to develop studies aimed to investigate the adaptive process of an organization, emphasizing several and new possibilities (exploration) of investment, with clear and deep-rooted certainties (exploitation) of the resource consumption units. However, even earlier, in 1963, authors Cyert and March, based on theories of limited rationality, were already debating the balance of exploration and exploitation activities, emphasizing the role of goals.

The great dilemma that the theory proposes to cover, especially in organizational learning studies, refers to the impact of non-balancing between exploration and exploitation activities by part of the managers, thus, generating several consequences to the management and directly influencing the development and survival of an organization (MARCH, 1991).

About this dilemma, yet, Tushman and O'Reilly III (1996) present an even more complex trade-off, which is the managers' understanding of the short and long-term needs of an organization. For the researchers, the short-term needs refer to the search for the constant increase of adjustments or alignments in the productive process of the organization, that is, a permanent search for incremental innovations, and the long-term needs, in turn, it is the commitment to focus efforts accompanying and/or promoting revolutionary changes, called radical innovations.

Tushman and O'Reilly III (1996, p. 24) also emphasize that managers should be able to understand that "[...] contrasting managerial demands require managers to periodically destroy what has been created, in order to rebuild a new organization more appropriate for the next wave of competition or technology". Thus, ambidextrous organizations are those that can deal with this paradox, and that seek to consolidate the abilities to simultaneously develop the actions of incremental (exploitation) and radical (exploration) innovations to better position them in their business environment (MARCH, 1991; TUSHMAN & O'REILLY III, 1996).

Some concepts are essential to understand organizational ambidexterity. Next, definitions and characteristics of incremental innovations (which from now on are called exploitation) and the radical innovations (called exploration) are presented.

Exploitation actions

Activities of exploitation (incremental innovations) are those that seek to implement, fill and encourage the process of change in search of a constant improvement, being: a) qualitative change in existing product, b) improvement in an industry process, c) opening of a new market to sell existing products; and (d) development of new sources of raw material or other inputs (OCDE, 1997).

Tushman and O'Reilly III (2004) explain that exploitation actions are indispensable for a company to thrive, because these are the practices that will enable the organization to constantly evolve, seek improvements in its products and operations, and, then, operate more efficiently. March (1991) points out that an organization with high level of exploitation is able to refine its operations, obtaining greater efficiency in the selection, production, implementation and execution of its routines. Popadiuk (2015, p. 30), in turn, indicates that the exploitation activity is the "[...] usage of tangible and intangible resources [...]. Because of the exploitation orientation, organization develops activity regarding refinement, choices and improvement of processes, routines and personnel."

In short, organizations focused on exploitation actions generate successive improvements in an existing process or product, in order to enhance the company's added value, influencing the general rate of productivity growth, resulting from increased technical efficiency, productivity, precision in the processes, among other elements that seek to achieve better quality of the products, together with the reduction of costs or the increase of profit margins (PEREZ, 2004).

Exploration actions

With respect to exploration actions (radical innovation), March (1991) defines them as initiatives, in an organization, that strive for research, experimentation and discovery of a new technology. Tushman and O'Reilly III (2004) indicate that exploration actions are essential for the development of an organization, since through them companies will achieve solid technological advances, leading to deep changes in their components (products or services), productive processes, and even in their business.

Popadiuk (2015, p. 28) contributes by pointing out that exploration actions in an organization refer to "[...] research, search, discovery, study, observation, entrepreneurship, survey, prospecting, and experimentation [...] is the search and creation of new knowledge that can be originated from both external and internal environment." The Oslo Manual (OCDE, 1997, p. 70), on the other hand, describes that these actions have a "[...] concept centered on the impact of innovations [...] impact can, for example, change the market structure, create new markets or making existing products obsolete".

Reis *et al.* (2011), when discussing the theme, conceptualize the action of exploration as outcome of an idea that results in an absolutely new product, service, process or business, not yet available in the market. Its introduction in the market generates a structural break, establishing new segment, industry and market.

Thus, it is possible to conclude that exploration actions contribute to generation of a new product or process, capable of initiating a new technological course and, in some cases, being able to consolidate and conceive a whole new industry. This innovation is directly related to a rupture in the economy, being that, after the break, little by little, the technology will obtain a market position (PEREZ, 1998).

After knowing the difference between exploitation and exploration, it is important to emphasize that the strategies assumed by the organization tend, of course, to guide the company towards the development of a type of innovation. However, some organizations that have a more sophisticated management model are able to equalize the conceptions of their innovations, acting in a balanced and orchestrated way on both fronts (exploitation and exploration actions). These organizations, therefore, are known as ambidextrous organizations.

Ambidextrous organizations

The definition of ambidextrous organizations presented by March (1991) defends that there are organizations that can deliberately maintain a balance between exploitation and exploration actions, therefore, being classified as ambidextrous. Tushman and O'Reilly III (2004) complement it, by reaffirming that ambidextrous organizations are those that can balance their efforts in exploitation and exploration. They point out, however, that because of the complexity of meeting these two perspectives, it is necessary for organizations to establish different strategies for managing their structures, processes and culture.

The secret of ambidextrous organizations is, therefore, the excellence for conducting simultaneously exploration and exploitation actions. With this know-how, organizations can balance / orchestrate their efforts and organizational resources, keeping ahead of their competitors. According to the Schumpeterian theory, organizations that innovate perform better than companies that do not innovate, and ambidextrous organizations perform better than companies that innovate from only one perspective, such exploitation or exploration (SCHUMPETER, 1985).

While on the subject, finally, a critical point of the above theory relates to the use of a measurement scale that is capable of measuring the level of organizational ambidexterity present in the management model of a given company. The scale used to measure the ambidexterity of the organizations investigated in this research is the scale developed by Lubatkin *et al.* (2006). This choice is justified by a) extent of the scale, both in theoretical and empirical perspectives, b) best adaptation to the economic segment of the companies investigated.

Hence, this subsection concludes the theoretical basis of this research. Next, the research methodology is presented, detailing the problem's specification, as well as delimitation and design of the research.

Methodology

This section presents the delimitations of the nature (ontology) and the phenomenon's knowledge (epistemology) referring to this research, mainly the ways the researcher has chosen to access, to study and to analyze primary data in the investigation. To facilitate the understanding of the adopted methodology, **Descriptors of Research Planning**, as described by authors Cooper and Schindler (2003), are indicated in Box 1, with the key aspects of the research.

Box 1: Descriptors of Research Planning.

Category	Category
Degree to which research questions were crystallized (Level of elaboration of research questions)	Exploratory study
Method of data collection	Question / Communication
Researcher's power to produce effects on the variables being studied (Control of variables by the researcher)	*Ex-post-factor*
Study objective	Descriptive
Time dimension	Transversal
Topic scope - amplitude and depth	Statistical study
Research environment	Field environment
People's perceptions about the research activity	Real routine
Population and sample	Censitary by adhesion
Research subject	Director General or Dean
Data collection feature	Online questionnaire available on the Survey Monkey
Data collection period	06/27/2016 - 07/12/2016

Source: Adapted from Cooper and Schindler (2003, p. 129).

Regarding population and sample, it is important to highlight that the investigated HEI are part of the same Brazilian educational group, and the sample was censitary based on adherence, that is, questionnaire was sent to the entire population (110 Directors or Deans), with participation of the interested ones. Research subjects were all those who decide on the HEI's allocation of resources; these, in turn, assume roles of Director General, in the case of colleges, and Dean, in the case of university centers and universities. Data collection period is between June 27, 2016 and July 12, 2016.

Before addressing the research hypothesis, it is necessary a conceptual approach. Martins and Theóphilo (2009, p. 30) define hypothesis as "[...] a proposition, with sense of conjecture, of supposition, of anticipation of response to a problem, that can be accepted or rejected by the research results". The hypothesis of this investigation, therefore, was:

Research hypothesis: The **ambidexterity degree** (exploration actions + exploitation actions) can explain the variance of the variable *number of students* in the investigated HEI.

Context: Empirical studies on ambidexterity constantly seek to investigate its relation to organizational performance. In this case, what is studied is how organizational ambidexterity can explain one given performance variable in service companies, and for this research, the chosen variable is the number of enrolled students. The choice of this variable is surgical, since it will derive financial and teaching quality results of a HEI.

Statistical tests: Correlation, Multiple Linear Regression.

Regarding the **measurement scale**, it should be noted that in order to measure the organizational ambidexterity phenomenon there were two factors: a) exploration actions and b) exploitation actions. Each factor had seven variables, each one measured on a five-point Likert scale, considered as a scale of intensity, ranging from 1) Very Small; 2) Small; 3) Average; 4) Big and 5) Very Big. By adding up the score of each variable, it was possible to totalize up to thirty-five points per factor. The variables used were:

Exploration actions - key question:
Regarding the actions of your unit, related to **DEVELOPMENT and FORECASTING NEW TECHNOLOGIES**, in the last three years, what was the INTENSITY of your company for:

(+)15.1 Searching for "out of the box" technological solutions, that is, search for solutions outside the company´s limits, researching technologies different from the current ones?
(+)15.2 Explaining the company's performance due to the exploitation of innovative technologies, that is, basing its success in the ability to explore new technologies?
(+)15.3 Focusing on the creation of new products and/or services?
(+)15.4 Looking for creative and differentiated ways to meet the students' needs?
(+)15.5 Using new products to operate in new markets?
(+)15.6 Using new services to operate in new markets?

(=) SUMMATION FORMS THE EXPLORATION DEGREE (EXP)

Exploitation actions - key question:
Regarding the actions of your unit, related to **IMPROVEMENT AND EXPLOITATION OF CURRENT TECHNOLOGIES,** in the last three years, what was the INTENSITY of your company for:

(+) 16.1 Seeking to gradually improve the quality of products and services?
(+) 16.2 Seeking to gradually reduce the costs of products and services?
(+) 16.3 Seeking to gradually increase the reliability of products and services?
(+) 16.4 Seeking to increase the levels of automation in operations?
(+) 16.5 Researching frequently the satisfaction of current students?
(+) 16.6 Developing offerings of products or services, carefully observing characteristics of current students?
(+) 16.7 Seeking to strengthen and deepen relationship with current students?

(=) SUMMATION FORMS THE EXPLOITATION DEGREE (EXP)

By summation (EXP + EXT = AMBIDEXTERITY DEGREE), it is found the AMBIDEXTERITY DEGREE (AMBD), according to guidelines of Lubatkin *et al.* (2006) and Scandelary and Cunha (2013). At this moment, the section about research methodology is concluded. Next, results are presented, divided into a) characterization of the managers and investigated HEI, b) organizational ambidexterity, c) proof of the research hypothesis, and d) analysis beyond the research hypothesis.

Data presentation and data analysis

Before presenting the survey data, it is necessary to present the test results referring to the scale quality used in the research. These tests, as well as their results, are briefly presented in Box 2.

Box 2: Scale Quality. Source: Author, based on Marôco, 2016.

	Test	Description	Result
VALIDITY The goal is to realize if collected data measures what the researcher intends to "supposedly" measure.	**Content**	Degree in which the content of the items adequately represents the universe of all relevant items under study.	After completing data collection instrument (version 1), based on the theories studied, it was sent to an ambidexterity researcher (this researcher is among the three most cited in the country on ambidextrous organizations), in order to check if such variables are enough to measure the factors and, consequently, the construct. The researcher made valuable considerations, which were incorporated into the instrument. Then, the questionnaire (version 2) was sent to pre-test, counting on the contribution of 5 researchers in innovation. After their contributions and adjustments, the questionnaire (version 3) was sent to the two vice presidents of the investigated company, and they made contributions to make the instrument more connected with organizational terms and culture. After these steps, data collection instrument was finalized (version 4).
	Criteria	Degree in which the predictor is adequate to capture the relevant aspects of the criteria.	As the architecture of this instrument is unique, especially for the investigated organizations being service companies and HEI, it was not possible to proceed validation of criteria, because there were no previous published similar researches.
	Construct	It attempts to identify the implicit constructs, from the proposed test, that are measured, and determine how the test represents those constructs.	To perform the validation of the construct, **convergent validity** was performed. With convergent validity by factor, it was possible to verify that, essentially, all variables had positive and significant correlations, confirming the consistency of the items. No discriminant validation was required because the study used only one construct.
RELIABILITY It is the estimation of instrument's ability to measure repeatedly and consistently.	**Cronbach's alpha**	It measures the internal consistency of items that make up the scale.	The value of Cronbach's alpha showed a high reliability (above 0.70). The coefficients are described below. Factor / Construct Coefficient Number of items EXP 0,885 7 EXT 0,793 7 AMBD 0,891 14
SENSITIVITY The goal is to understand if the measure is able to discriminate structurally different individuals.	**Distribution tests**	**Kurtosis (Ku)** Value above 7 represents serious problems.	Construct Ambidexterity Ku = 0.383 Value below the critical value, demonstrating normal distribution of data.
		Asymmetry (Sk) Value above 3 represents serious problems.	Construct Ambidexterity Sk = 0.563 Value below the critical value, demonstrating normal distribution of data.

After presenting the consistency of the data collection instrument, main findings of the research are presented next. The presentation is divided in three blocks, being 1) characterization of managers and investigated HEI, 2) Ambidexterity degree, and 3) Analysis of Research Hypotheses.

Characterization of managers and investigated HEI

From the answers to the research questions, it was possible to verify that the respondent managers are, for the most part, men (63.3% of the total respondents). In 78.5% of cases, managers are between 36 and 54 years old. Regarding their education, 48.1% have a Master's degree, and 40.5% have a postgraduate degree (Sensu Lato course). A significant number of managers have background in human sciences (38%) or social studies (32.9%). The largest share (54.4%) of them work in higher education between 11 and 20 years, and 54.4% have no more than 10 years of work in the company.

Regarding characteristics of the investigated HEI, more specifically the type of academic organization, there were 72 colleges, 4 university centers and 3 universities. In general, these HEI represent 652,470 students, 1,338 higher education courses, 9,382 technical-administrative staff and 10,674 teachers.

After knowing the respondents profile and structure of the investigated HEI, the following are the main results from the organizational ambidexterity construct.

Ambidexterity degree

As presented in the theoretical framework, organizational ambidexterity occurs when a company is able to orchestrate actions of exploration and exploitation (March, 1991). Based on the model of analysis proposed by Lubatkin *et al.* (2006) and adopted by Scandelari (2011), average of responses per variable are indicated in Table 1. It should be noted that the weight of each variable orbits between 1 and 5 points.

Table 1: Variables and Factors. Source: Author.

Factor	Variable	N	Average	Standard deviation	Variance	Asymmetry (SK)	Kurtosis (KU)
EXPLORATION DEGREE (EXP)	15.1	79	3.96	.898	.806	-.578	-.358
	15.2	79	4.04	.823	.678	-.637	.033
	15.3	79	4.03	.920	.846	-.558	-.619
	15.4	79	4.24	.683	.467	-.346	-.824
	15.5	79	3.86	.873	.762	-.315	-.614
	15.6	79	3.90	.914	.836	-.415	-.657
	15.7	79	4.13	.838	.702	-.648	-.268
EXPLOITATIONDEGREE (EXT)	16.1	79	4.23	.659	.435	-.280	-.715
	16.2	79	4.43	.812	.659	-1.246	.627
	16.3	79	4.22	.745	.556	-.755	.435
	16.4	79	4.00	.716	.513	-.645	.882
	16.5	79	3.86	.930	.865	-.402	-.243
	16.6	79	3.91	.880	.774	-.751	.124
	16.7	79	3.92	.903	.815	-.921	.848

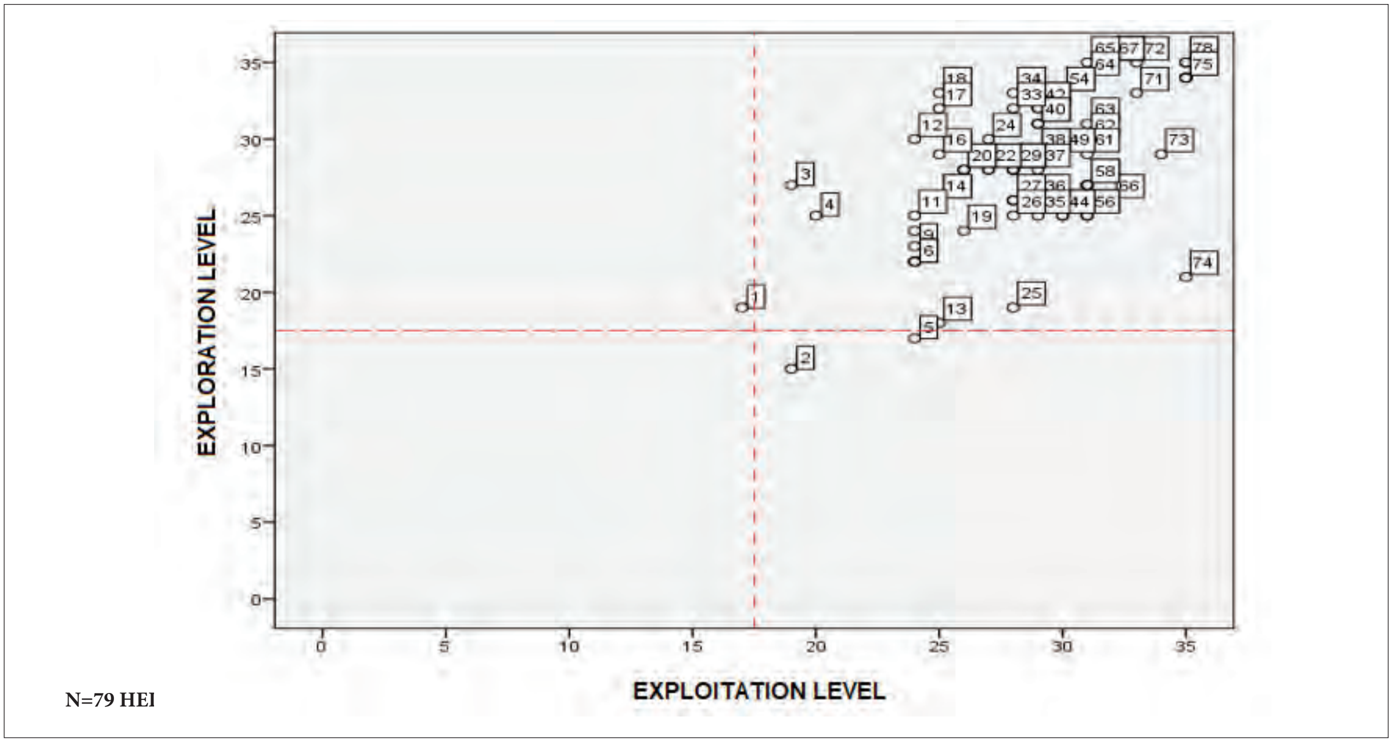
By checking these data, especially EXP factor, it can be noticed that the variable with the highest average was 15.4 (Looking for creative and differentiated ways to meet the students' needs), totaling 4.24. It is important to highlight that this variable was the one that obtained the lowest variance and, consequently, the best standard deviation, that is, there was a greater homogeneity among the respondents. Other variables that stood out were: 15.2 (Explaining the company's performance due to the exploitation of innovative technologies, that is, basing its success in the ability to explore new technologies) and 15.3 (Focusing on the creation of new products and/or services), with average of 4.04 and 4.03, respectively.

In turn, about the analysis of EXT factor, the variable that obtained lower average was to 16.2 (Seeking to gradually reduce the costs of products and services), with average of 4.43. This same variable obtained the lowest variance (0.435) and the lowest standard deviation (0.659). Subsequently, variables 16.1 (Seeking to gradually improve the quality of products and services) and 16.3 (Seeking to gradually increase the reliability of products and services) obtained the second and third largest averages, with values 4.23 and 4, 22, in due order.

It is worth mentioning that, when analyzing the asymmetry (SK) column, all variables are below the critical value (3.00). Also, the same occurs when analyzing the data of the kurtosis (KU) column, whose critical value is 7.00. With these results, it is possible to conclude that the data distributions are considered normal.

Next, after knowing the averages of each variable, weights of the factors are indicated. For that, the scores of each variable were added per company, thus, forming the EXP and EXT factors. The possible dispersion of data would be 7 to 35 points. To better synthesize the data, Chart 1 is presented, in a composition of two axes (as XXX and XXX, 2011 suggests). Loads from Y axis represent Exploration Level (EXP), with Exploitation Level (EXT) on X axis. To form the four possible taxonomies, data of the table highlighted in the section that deals with the methodology are used.

Chart 1. Ambidexterity Level. Source: Author.



According to the chart, it is possible to verify that, with the exception of three HEI, all institutions were concentrated in the quadrant of **Ambidextrous Organizations**. Thus, evidences are:

a) No HEI was considered **Non-Innovative Organization**;
b) Only one organization is strongly oriented just to **Exploration actions** (Case #1);
c) In the case of organizations that are heavily targeted just for **Exploitation actions**, there are only two institutions, cases #2 and #5;
d) In the quadrant of **Ambidextrous Organizations**, there are the other institutions (76 cases).

After knowing the ambidexterity degree of the investigated HEI, results of the hypothesis tests of the research are found.

Proof of research hypothesis

The research hypothesis sought to show that "the **ambidexterity degree** (exploration actions + exploitation actions) can explain the variance of the variable **number of students** in the investigated HEI". To prove this hypothesis, it was used the Correlation Analysis and the Multiple Linear Regression.

Correlation analysis is, according to Dancey and Reidy (2007), a test that seeks to understand if two variables (or factors) are associated or correlated. According to Fávero, Belfiore and Chan (2009, p. 346), linear regression has the purpose of "[...] study the relationship between two or more explanatory variables, which are presented in linear form, and a dependent variable".

In this research, the dependent variable in the model is the number of students reported by the organization, that is, secondary data. The choice made, for the variable to be explained, stems from the fact that this is one of the most important performance variables of an educational institution, since it directly influences the financial, managerial and qualitative indicators of any HEI.

In order to increase the reliability of the findings, it is worth noting that all the assumptions of the linear regression cited by Fávero, Belfiore and Chan (2009, p. 346 *apud* KENNEDY, 2003) were analyzed and respected, being them:

a) Dependent variable is a linear function of a specific set of variables and error;
b) Expected value of the error term is zero;
c) Error has normal distribution and does not present auto correlation or correlation with any variable X;
d) Observations of the explanatory variables can be considered fixed and in repeated samples;
e) There is no exact linear relationship between explanatory variables and there are more observations than explanatory variables.

By performing the Regression test, it was possible to verify that the correlation index of EXT and EXP compared to the number of students was 0.454. Using the criteria of Dancey and Reidy (2007), the correlation is considered moderate, that is, there is a moderate relationship between the EXP and EXT variables and the number of students.

Regarding Multiple Linear Regression test, before presenting the coefficient, it should be noted that the model obtained a *sig* value lower than 0.005, being interpreted as a consistent model. About the variance explained, the factors EXPLORATION DEGREE (EXP) and EXPLOITATION DEGREE (EXT) explain in 20.6% the variance of the variable NUMBER OF STUDENTS. For some sciences, such as engineering and health, this explained variance is considered low; however, considering that these two factors can explain 20.6% of the variation in the number of students of the investigated HEI, this value becomes significant.

In this way, it is possible to conclude, finally, that the initial research hypothesis, which conjectured that "the **ambidexterity degree** (exploration actions + exploitation actions) can explain the variance of the variable number of **students** in the investigated HEI" was duly confirmed.

Analysis beyond hypothesis

The analisys of Chart 1 allows to visualize that, in 96% of the cases, investigated HEI were considered **ambidextrous organizations**. However, although all HEI are part of the same company, it is seen that there was a great dispersion among the researched cases. On this respect, a proposition was raised for the existence of **different stages of ambidexterity**, that is, there are HEI that work at a more evolved ambidexterity level than others - being this phenomenon preliminarily called **Maturity Degree of Organizational Ambidexterity**.

To materialize this proposition, a K-means cluster analysis was performed, dividing the population into 4 groups. Before presenting the groups, however, it is important to note that the researchers performed three grouping tests, which are explained below.

1) In the implementation of Two Step Cluster, although the Quality cluster was higher than 0.5, indicating a good clustering, SPSS proposed the creation of only two clusters, so it was not possible to establish a maturity degree about the ambidexterity;
2) Hierarchical Cluster was not used, since it is clear the theory that guides the research;
3) In the realization of K-means, test was executed, initially, to generate 5 clusters. On the occasion, two clusters were generated with 2 cases in each of them and, when analyzing the average values of the cases, little difference was noticed, that is, it would not be necessary to divide them into two groups.

After the explanation above, Table 2 presents the average values of the ambidexterity degree of each formed cluster.

Table 2: Cluster Creation.

Grouping variable	Cluster (Group)			
	1	2	3	4
Ambidexterity degree (centroids)	57	39	48	67
Quantity of cases per cluster	46	4	12	17

Source: Author.

After SPSS generated the centroids and grouped the cases over them, 4 clusters were formed. In theory, they represent the level of maturity of the ambidexterity in the investigated companies, and each group was named as follows:

Level I - **Embryonic** (Group 2): it represents the first stage of ambidexterity. Although the organization is already considered ambidextrous, it still needs to potentiate / encourage more exploration and exploitation actions;

Level II - **Structured** (Group 3): in the second stage of the ambidexterity, exploration and exploitation actions are more elaborate and structured;

Level III - **Semi-developed** (Group 1): in the third stage of ambidexterity, exploration and exploitation actions respect a continuous flow;

Level IV - **Developed** (Group 4): the fourth stage of ambidexterity is the most developed stage, in which exploration and exploitation actions are constant, permanent, with consistent and well-structured projects, often refined and evaluated.

In order to verify if maturity levels of ambidexterity (ordinal variable) had some relation or interaction with a set of other variables (nominal or ordinal), Pearson's chi-square test was performed, considering a p value of 0.05. The following results were obtained:

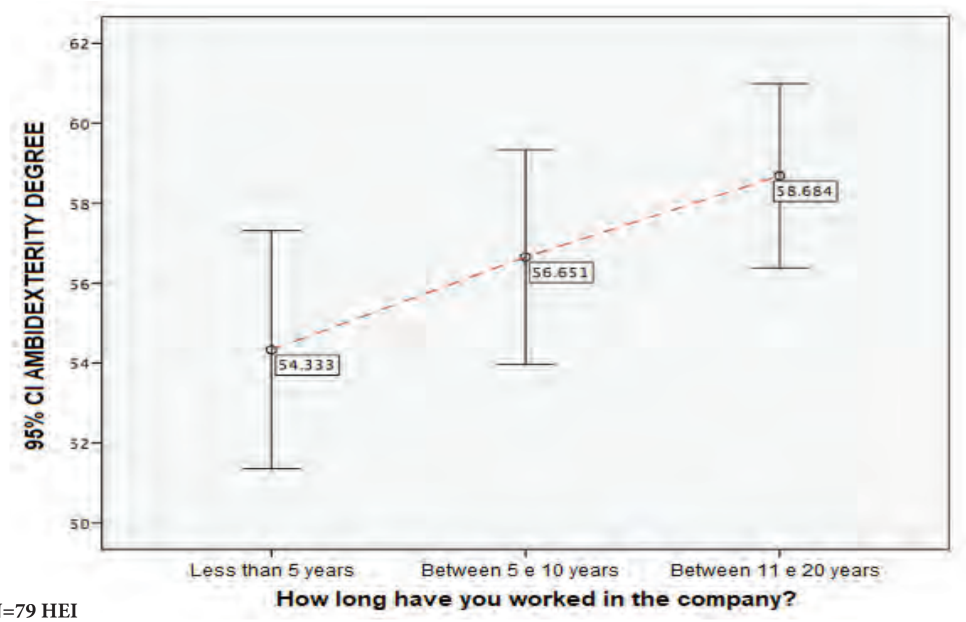
Table 3: Analysis of Pearson's chi-square test. Source:

Pearson's chi-square test	
Analyzed Variables	sig
Gender * Ambidexterity level	.945
Age group * Ambidexterity level	.144
Education degree * Ambidexterity level	.912
Educational background * Ambidexterity level	.886
Working time with Higher Education * Ambidexterity level	.703
Working time in the company * Ambidexterity level	.041

Author.

With the above data, it is possible to realize that the only variable that has an interaction or dependence relationship with the ambidexterity levels proposed by the work is the variable "working time in the company". To further analyze the data, it is also verified that the longer a person works in the company, the greater the average ambidexterity degree. Chart 2 allows an easier understanding of this evidence.

Chart 2: Average working time and ambidexterity degree.



N=79 HEI

Source: Author.

Another investigated aspect was how much EXT and EXP factors could explain the General Course Index (GCI). GCI is the most important quality indicator of Brazilian HEI, being, in theory, updated annually. The effort, at this moment, is not to dissect the indicator, but to present how much of its variance can be explained by the studied construct. Considering the current IGC of each investigated HEI (July 2017), it was possible to notice that EXP and EXT factors explain 0.20% of the IGC variance of HEI. That is, less than 1% of the variation of the IGC is explained by exploration and exploitation actions of HEI, thus, generating a series of reflections, such as the two highlighted statements below.

a) The innovative ability of HEI is not privileged among the evaluation criteria used by the Brazilian Ministry of Education;
b) GCI, as indicator, is composed of so many other variables that explain its variance is a great challenge for any quantitative research.

Finally, the data presentation and analysis presentation section is concluded and, next, concluding remarks of the research are presented, highlighting its general objective, research hypothesis, main findings and, then, indications for future research.

Concluding remarks

The general goal of the research was to understand how the ambidexterity degree (exploration actions + exploitation actions) can explain the variance of the variable number of students (performance variable) in HEI. Investigated HEI are part of the same economic group, and the subjects of the research were General Directors or Deans of these institutions. After data collection, there were 79 valid cases, among these 72 colleges, 4 university centers and 3 universities.

The research hypothesis was confirmed by multiple regression statistical test (*sig* less than 0.005), thus, showing that the exploration and exploitation actions of HEI can explain the variance of the variable number of students in 20.6%.

Another contribution of this research is the proposition of taxonomies involving ambidexterity. Up to the present study and according to the theoretical framework studied, there were only 4 taxonomies to study the ambidextrous organizations, being a) non-innovative company, b) company with high level of exploration, c) company with high level of exploitation, and d) ambidextrous companies. However, as the study was carried out in companies that are part of the same company, many of them classified as ambidextrous organizations, but with a large dispersion of data, this led to believe in the existence of a **MATURITY DEGREE OF AMBIDEXTERITY**. As to this degree, ambidextrous organizations can be reclassified through their ambidexterity levels (centroids), which, in this research, were defined as Level I - Embryonic; Level II - Structured; Level III - Semi-developed; Level IV - Developed.

In addressing the research limitations, there is the widespread inability of research findings. This means that the conclusions are applied only to the sample investigated, since the time horizon refers to a cross-section analysis exclusive for the period between 2013 to 2016; finally, although the subject of the research was the HEI's main manager (Director General or Dean), top executive, there was only one response per company investigated.

As suggestions for future research, it is indicated:

a) **Replication of the research for public and private HEI:** when applying the same data collection instrument in public and private HEI (with and without capital available on the Bovespa - Brazilian Stock, Mercantile & Futures Exchange), it will be possible to compare the similarities and heterogeneities of multiple regression coefficients, allowing to understand in which of the three groups this model better fits;

b) Maturity Degree of Ambidexterity: it is suggested replication of the data collection instrument, as well as the classification among the levels of organizational ambidexterity of future companies to be investigated; afterwards, an in-depth qualitative research would be conducted with companies of one of the levels, seeking to understand the operational singularities between them and, consequently, the differences between levels;

c) Relationship between the Ambidexterity Degree and Competitiveness Degree: it is suggested to investigate the relationship between the organizational ambidexterity construct and competitiveness, since both theories are associated to the explanation of the variation of organizational performance; for this research, it is suggested to use a more sophisticated statistical test, such as analysis of structural equations.

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Blind Technology Transfer Process from Argentina[1]

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Abstract: Since the 19th century, Argentina has been characterized as an agro-exporting country reaching its peak after the First World War. Nowadays, in addition to exporting agricultural goods, Argentina has become a producer of an increasingly valuable raw material in the business world: scientific information. The accelerated increase in the production of scientific articles in high impact international journals makes Argentinean science visible all over the world. With the present study, we intend to unveil how Argentinean scientific information serves as building blocks of patents requested by foreign companies and institutions. According to the area of knowledge analyzed, we identify a differential flow of information towards the development of technologies in industrial countries. Moreover, we detected that the blind technology transfer phenomenon is a dynamic process. Herein, we present relevant evidence of scientific information flowing towards foreign technologies within 2 years after the article publication. These results suggest the need for the development of strict technology transfer policies in Argentinean universities and academic institutions in order to protect the state investment in science. Our findings highlight scientific production as a unique opportunity for economic growth and expansion of the country. This may become a fertile ground for political and economic debate.

Keywords: technology transfer; universities; patents; citations

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Introduction

The novel production methods together with the new ways of generating knowledge have produced technological changes in organizations driving to the deployment of a new social era.

In production terms, innovation[2] becomes a key strategy for entrepreneurial and territorial development (David & Foray, 2002, Freeman 1982, Freeman 1987, Lundvall 1985, Nelson 1993, Nelson & Winter, 2009, Teubal 1996). Technology developments emerge from a complex set of relationships among research centers, universities, companies, and governments. The flow of technology and information between the main actors in the process of generating knowledge promoted the creation of the National Innovation System (SNI).

In this context, knowledge and technology management has become an important factor in explaining growth and economic development. As a result, the continuous search for competitiveness prompted companies (especially multinational companies) to adopt strategies focused on innovation and cooperation to support and develop competitive advantages, particularly through partnerships with research groups under the conceptual framework of open innovation (Chesbrough, 2003). Finally, civil society has become increasingly involved in innovative processes through availability and greater access to technologies and information (Campbell & Carayannis, 2012).

The previously described patterns have had their effects on universities. On the one hand, there was an increasing effort to develop research policies expecting to apply R&D results (Gibbons, 2015). On the other hand, the conceptualization of the Triple Helix model (Etzkowitz & Leydesdorff, 1997) modified the relationship between universities and society, especially as regards the associative role with other organizations.

This led to address the complexity of technology transfer processes from novel and different conceptual approaches. For example, studies on strategy and capacities for intellectual property management, technology marketing (Bozeman, 2000, Bozeman, Fay, & Slade, 2013, Markman, Siegel, & Wright, 2008) or different transfer channels enforcement (Alexander & Martin, 2013).

As a result, universities started to introduce the issue of technology transfer in their political agendas and hence, academic efforts to understand it increased drastically (mainly from Bayh-Dole law enactment in the USA in 1980 which enabled R & D centers to appropriate and commercialize technologies). This led Universities to the development of a great diversity of institutional arrangements to meet technology transfer challenges as well as the creation of specialized units called Technology Transfer Offices (OTTs).

Nowadays, universities are involved in the process of appraising research results through mechanisms that may or may not include intellectual property records. In this regard, the topic of knowledge and technologies appropriation arises along the process of technology transfer management. In this direction, the fusion of boundaries between science and technology reveals the tensions of the traditional conception: science is a field of knowledge accumulation characterized by the tendency to publish while technology developments rely on knowledge generated by other harness intellectual property strategies (Narin & Noma, 1985).

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(2) Innovation is the implementation of a new or highly improved product (good or service) or process, or a new marketing or organization method applied to business practices, the workplace or foreign relations. Adapted from Oslo Manual–OECD (2005).

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However, valuation of research results and assessment of their technological potential require visualization and detection of scientific knowledge flow from the scientific towards the technological field. An interesting strategy to find traces of this flow is through the analysis of scientific citations in patents (Jaffe, Henderson & Trajtenberg, 1993).

Several studies (Meyer-Krahmer & Schmoch, 1998; Narin & Olivastro, 1992; Noyons, van Raan, Grupp, & Schmoch, 1994; Olivastro, 1995; van Vianen, Moed, & van Raan, 1990) have demonstrated the presence of scientific publications in patents as an appropriate indicator to reflect science-technology relationships (Acosta, 2002, Guan & He, 2007).

Studies of scientific citation in patents generate, among other things, information for the design of policies. For example, a South Korean study was carried out (Park & Kang, 2009) to determine how technology production is related to Korean scientific production and how it spreads towards the industrial field. This study concluded that the spreading speed of scientific knowledge towards the technological field differs according to the area of application. Consequently, we proposed the need to adopt focused policy design approaches and strategies. For emerging technologies such as nanotechnology and biotechnology, high presence of scientific articles quoted in patents suggests that the number of citations in patents can be used as a metric of the scientific intensity of the technological field.

Van Raan (2017) presented an article reviewing the state of the art in scientific citation analysis in patents, which estimates that only 3% -4% of scientific publications are cited in patents. This percentage increases up to a 15% when research works are made collaboratively between university and industry. In addition, the speed with which scientific knowledge flows towards technology acquires relevance. In the same work, Van Raan (op. Cit) defined “time lag” as the time between the year of article publication and the year of patent application. In this sense, the time lag heavily depends on the field of technological knowledge and can vary between 3 and 20 years. For example, the average time lag in the nanotechnology field is between 3 and 4 years (Finardi, 2011).

Besides, scientific articles cited in patents are mainly a product of public research (Carpenter, Cooper, & Narin, 1980; Carpenter & Narin, 1983; Narin & Noma, op.cit). In other words, scientific research generates information flowing from the public sector to the industry. This phenomenon is especially relevant in underdeveloped countries, which do not have consolidated industrial structures capable of absorbing the scientific knowledge available.

In Argentina, scientific activities are essentially carried out in the public domain. Although research results can lead to industrial applications, there is a very low probability of local appropriation. In fact, foreign industrial companies can use the results of Argentinean scientific activity. This phenomenon has been studied and conceptualized from the point of view of technology transfer (Codner, Becerra & Díaz, 2012). The flow of scientific knowledge to foreign company patents has been referred to as a blind technology transfer process (BTTP). The present study provides information about how scientific knowledge is applied to the development of technology. Scientific knowledge cited in patents may be exploited in three different ways, which are: contributing to locate the technology in a field of knowledge; providing scientific evidence, or offering methodologies for the development of technological products.

While the study showed the BTTP phenomenon conducted in the field of biotechnology, this phenomenon is presumably present in other fields of knowledge as well. In this context, we propose to understand and describe the BTTP in different disciplines with the expectation of improving the design of policies to promote research and technology transfer between the public and industrial sectors.

Methodology

The present research was based empirically on the identification of scientific articles of Argentinean researchers referenced in patents applied in the United States Patent and Trademark Office (USPTO), the State Intellectual Property Office of China (SIPO) and the European Office of Patent (EPO). The measurement was made by combining available patent databases such as Espacenet, WIPO, USPTO and Google Patent.

Since 1996, the largest resources to fund R&D projects in Argentina have been obtained through the National Agency for Scientific and Technological Promotion (AGENCIA). AGENCIA is the public organization whose mission is the promotion of scientific and innovation activities through the competitive distribution of economic resources among researchers, research groups, scientific organizations and companies (Lugones, Porta & Codner, 2014). Obtaining financial resources from the AGENCIA represents a hallmark of prestige and quality within the Argentinean scientific community

In 2010, a study was carried out to measure the impact of AGENCIA’s financing instruments on Argentinean science (Codner, 2011). This study analyzed the incidence of financing in the scientific productivity of a sample of 254 researchers (project managers) who competed for the AGENCIA’s funding between 2004 and 2015. Herein the same sample of researchers was used because they represent a group of highly competitive researchers since they aspired to obtain financial resources from the most important and strict institution of research promotion.

The selection of the sample leaves out an important group of researchers who do not seek funding through the AGENCIA, so it is not completely representative of the universe of Argentinean researchers.

The researchers for the ample were selected proportionally and randomly considering the different areas of knowledge defined by the AGENCIA, with the following distribution (Table 1):

Table 1: Researchers sample by knowledge area

Knowledge area	Researchers amount per area
Chemical Technology	15
Medical Sciences	45
Biological Sciences	51
Food Technology	10
Mechanical and Materials Technology	15
Mathematics and Physical Sciences	14
Earth and Hydro-atmospheric Sciences	13
Chemical Sciences	19
Agrarian, Livestock, Forestry and Fishing Technology	54
Other	18

Source: own

Regarding search methodological aspects, the criteria used were the surnames and initials, institutional affiliation and field of knowledge. In order to rule out false positives generated by very common surnames, such as Gomez, we used the abbreviation of journal name where the researchers had applied.

Another substantial aspect is that only one record per technology has been considered, that is to say, only one patent per "patent family[3]". In addition, patents of Argentinean scientists were excluded to avoid duplication and self-citations. Once the patents referring to articles by Argentinean researchers were identified, ownership of the patent was analyzed as well as reference country and technological value applying the methodology used in previous articles (Codner, Becerra & Diaz, op.cit).

Results

From the 254 researchers studied, 37.5% (94 researchers) were referenced by their scientific publications on 341patents.

Table 2 shows the distribution of patents found by discipline (according to categories used by the AGENCIA) and per researcher.

Table 2: Distribution of patents including citation per discipline and researcher

Area	Amount of researchers per area	Patents	Patent/researcher
Chemical Technology	15	48	3.2
Medical Sciences	45	132	2.9
Biological Sciences	51	91	1.8
Food Technology	10	10	1.0
Mechanical and Materials Technology	15	10	0.7
Mathematics and Physical Sciences	14	9	0.6
Earth and Hydro-atmospheric Sciences	13	7	0.5
Chemical Sciences	19	10	0.5
Agrarian, Livestock, Forestry and Fishing Technology	54	24	0.4
Other	18	0	0.0

Source: own

On the one hand, we observed that 80% of citations in patents belonged to Chemical Technology, Medical Sciences and Biological Sciences disciplines. On the other hand, the ratio patent /researcher is a proxy which shows the BTTP with variations according to the area of knowledge analyzed. In this context, although it was not possible to determine if this happens due to intrinsic aspects of the discipline, the state of development of the medical and biological sciences in Argentina has a strong tradition. This may be an aspect revealed by the fact that the only three Nobel Prizes in science obtained by Argentineans come from these fields of knowledge. In any case, this phenomenon is an indicator of differential flow of knowledge related to disciplines and therefore, an issue to take into consideration for the designing of scientific-technological policies.

Patent analysis showed that patent owners belonged mainly to the non-academic world (see Table 3). This means that the private sector is actively monitoring and taking advantage of scientific data generated in Argentina. Interestingly, a high percentage of applicants were from foreign academic institutions, which showed the important role played by the TTOs from main worldwide academic institutions.

(3) A set of data consisting of publications of equivalent patents, and refer to the same invention. The same patent can be requested in different regional offices (USPTO, SIPO, EPO) presenting the same information in each of them.

Table 3: Patent owners distribution

Patent owner	*Sample distribution*
Firms	47%
Individuals	10%
TTOs	43%

Source: own

We studied the origin of patents that incorporated citations of scientific articles produced in Argentina. As table 4 shows, these patents were applied by firms and TTOs of developed world countries. This feature indicates that BTTP is a process which frames and reinforces the global economic concentration. It is important to highlight that no patents of Argentinean companies were found, which shows the industrial gap between Argentina and other countries.

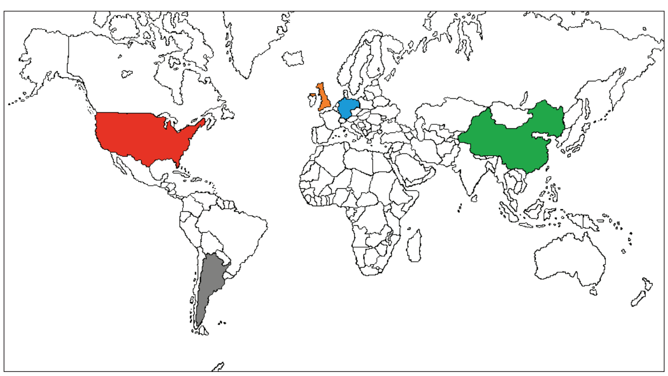
Table 4: Patent owner countries

Country	Sample distribution
United States	49%
Great Britain	8%
China	7%
Germany	7%
France	5%
Canada	4%
Others[1]	29%

Source: own

As illustrated in Figure 1, Argentine scientific information flows mainly to foreign patents[4] belonging to leading multinational companies such as Monsanto, Du Pont, BASF and leading educational and scientific institutions such MIT, the University of Manchester, Max Planck Society and the University of Beijing.

Fig 1. Major countries citing articles from Argentinean researchers in their patents

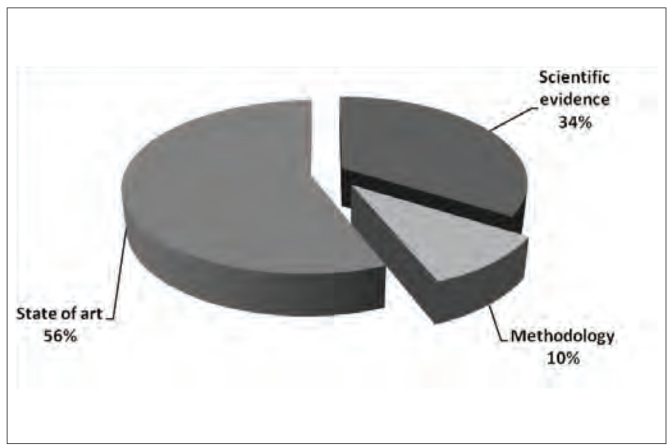


Source: own

Previous works (Codner, Becerra & Diaz, op cit) showed that citations of Argentinean scientific articles present a different meaning according to the way in which they are referenced in patents. In this study, we determined that scientific articles in patents are used to support or validate protected technologies in three different ways: being part of the technology state of the art (identifies the field of knowledge in which that technology intervenes); as scientific evidence (references to previous research results made by R & D groups); or as a methodology (necessary to carry out the technology addressed). Scientific evidence and the development of methodologies represent the real technological appraisal mechanisms of the scientific article. Figure 2 shows the distribution of scientific articles according to the previously mentioned categories.

From the referenced articles, 44% were used as scientific evidence or methodology. These items represented time and money saving for the patented technology developers. In this sense, it can be assumed that if patent owners had lacked access to these studies, they should have had to carry out experiments or develop relevant methodologies to support their inventions. Because information categorized as state of the art does not necessarily represent a source of inspiration or an intrinsically technological value to the patent, it was decided to exclude this group of patents from subsequent analyzes.

Fig 2. Technological value provided by the paper



Source: own

In agreement with the work of Park & Nang (op.cit), we confirmed the existence of differences among technological fields regarding the intensity of scientific articles citation in patents (see Table 5). Data indicate that the BTTP from Argentina is strongly concentrated in the field of biomedicine and biological sciences.

(4) Some of the patents owners are: Colgate-Palmolive Company; Antioxidant Pharmaceuticals Corp; Monsanto; E.I. Du Pont De Nemours And Company; Gema Diagnostics, Inc; Synthonics, Inc; Hershey Foods Corporation; Kraft Foods R&D, Inc; Apicore, Llc; Abbott Laboratories; Ford Global Technologies, Llc; Aurora Algae, Inc; Dyax Corp; Promega Corporation; Regeneron Pharmaceuticals, Inc; Agilent Technologies INC; Gilead Sciences Corp; Amura Therapeutics Limited; Galecto Biotech AB; Xention Ltd, Fresenius Kabi Deutschland GmbH; Nano-X Gmbh; Immatics Biotechnologies GmbH; BASF, Shanghai Lawring Biomedical Co., Ltd; China National Petroleum Corp; Tat Life Sciences Ltd; Micro Technology Co; Ltd, Agirx Limited; Massachusetts Institute Of Technology (MIT); Baylor University; Syracuse University; Boston Biomedical Research Institute; Northwestern University; Yale University; Washington University;Boston University; University of Pennsylvania; Mayo Foundation for Medical Education and Research; University Of Manchester; The University Of Warwick; The University Of Bristol; Max Planck Society for the Advancement of Science; Charité- UniversityMedicine Berlin; Dusseldorf University; University of Ulm; University of Wurzburg; Nanjing University; Binzhou Medical College; Jiaotong University; Beijing University; Wuhan University, among others.

Table 5: Paper technological contribution per discipline

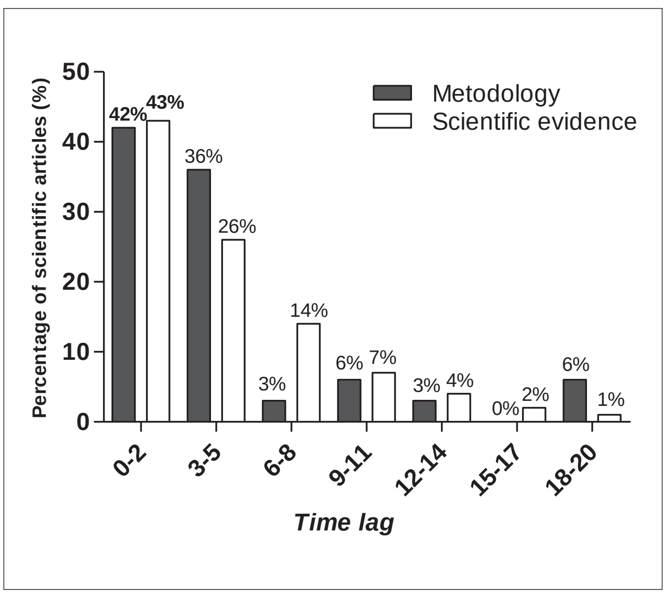
Área	Methodology	Scientific Evidence
Chemical Technology	7	6
Medical Sciences	5	56
Biological Sciences	15	31
Food Technology	1	3
Mechanical and Materials Technology	1	5
Mathematics and Physical Sciences	0	5
Earth and Hydro-atmospheric Sciences	0	7
Chemical Sciences	2	1
Agrarian, Livestock, Forestry and Fishing Technology	2	8

Source: own

Finally, together with the technological appraisal mechanisms of the scientific articles, "time lag" is a relevant aspect to understand and describe the BTTP process and its impact. Shorter time lag records indicate closer time proximity between the scientific result and the technological use.

More than 40% of the articles used as methodology or scientific evidence presented a time lag within 2 years after article publication (see Figure 3). This showed, on the one hand, an important acceleration in the use of research results and, on the other hand, the intrinsic value of the research results carried out by Argentinean scientists.

Fig 3. Time between scientific article publication and patent application (time lag) according to technological value



Source: own

Conclusions

The present work aims at contributing to the understanding of blind technology transfer process in Argentina by analyzing a pool of foreign patents which incorporated citations from Argentinean researchers specialized in various fields of knowledge.

In the first place, our results confirm that BTTP is an extended phenomenon in many fields of research. This phenomenon is especially relevant in the field of biomedical science, due to the high concentration of articles cited in foreign patents. This is an indicator of the quality and quantity of Argentinean scientific research in this field.

Secondly, scientific knowledge flows mainly to technologies developed by companies and institutions in developed countries (especially the United States, Great Britain, China, and Germany); and, to a lesser extent, it flows to emerging economies and developing countries, without any Argentinean company being among the patents that make reference to Argentinean scientists' publications. This feature points out that BTTP is a phenomenon which denotes the process of industrial capacities concentration of a small group of countries, replicating the process of global economic concentration. Moreover, the significant number of patents in the academic sector also highlights the influence of TTOs as a tool for promoting technological development.

Furthermore, the study confirmed that both scientific evidence and methodology development are technological appraisal mechanisms of scientific articles and they can be used as proxy indicators of the impact of science on technology.

Interestingly, we also found that information spread by scientific journals rapidly flows (within two years after publication) to technology. This work presented the first evidence of the existence of a time lag shorter than 2 years, which reinforces the idea of using time lag as an indicator of the impact of science on technology.

To conclude, this research provided elements to strategically consider the analysis of the technological value of the scientific articles cited in patents to design harmonized research policies as well as technology transfer policies focused on both field of knowledge and industrial development policies.

Furthermore, the analysis of citations in patents allowed us to know the technological relevance of scientific publications with political implications by making visible the traces of the flow of knowledge.

Finally, this paper brings into question the center-periphery relationship between countries since it emphasizes the need to reflect on the efforts to promote scientific development and local industrial capacities in order to absorb the results from public research. That is to say, while promoting science is an action which a priori capitalizes the underdeveloped countries, the lack of industrial development expectations determines the possibility of the local absorption of efforts. In this way, the underdeveloped countries will continue to subsidize developed countries industry through their public investments in science which, in turn, will reinforce the economic gap between countries.

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Object and Means of University-Firm Technology Transfer

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Abstract: Greater demand for food and the scarcity of natural resources reinforce the importance of research at universities and the transfer of their technologies to firms, particularly in the case of crops. In this context, the general aim of this study is to analyze the alignment of the object and means of university-firm technology transfer in Brazilian and American agriculture schools. The research is qualitative in nature, with multiple case studies of two American universities and a Brazilian university, selected using criteria such as excellence, accessibility and technological similarities. Among the results and contributions to the field, the innovations that were generated and the identification of the differences and similarities in formal and informal processes of university-firm technology transfer may be highlighted.

Keywords: Object and means of technology transfer; universities; firms; innovation; agriculture.

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Introduction

The USA, due to its concept of universities and innovation incentive policies, stand out on the world scene in terms of university-firm technology transfer (U-FTT), with the Bayh-Dole Act of 1980, promoting innovation processes resulting from university-firm (U-E) interaction (Mowery & Sampat, 2005; Siegel *et al.*, 2003; Mowery *et al.*, 2001; Jensen & Thursby, 2001; Henderson *et al.*, 1998). Furthermore, an embedded culture of innovation and interaction is consolidated as one of the main mechanisms for the development and diffusion of technologies. Meanwhile, in developing countries like Brazil, this process is hindered by outdated S&T policies that are often ineffective and slowed down by a bloated bureaucracy, lack of investment in research and backward technology. All of these factors lead to an incipient culture of U-F interaction, with few patents and innovations resulting from research (Garnica & Torkomian, 2009; Stal & Fujino, 2005; Melo, 2002; Alves, 2015; WEF, 2015).

Considering the peculiar aspects of the USA and Brazil's national innovation systems, and in an attempt to learn from successful experiences, the general objective of this study is to analyze the alignment of the object and means of university-firm technology transfer at agriculture schools in Brazilian and American universities.

Despite the difficulties involved in U-FTT, and considering the shorter production cycles and lack of structure in companies for technological development with their own resources, there is growing interest in relationships with universities that result in benefits for both firm and university (Etzkowitz & Leydesdorff, 2000). It is understood that the USA enjoy greater technological development and a closer relationship between academia and organizations compared with Brazil. These factors, combined with the importance of agribusiness in the Brazilian context (with a considerable share of GDP) and international context, with a rising population creating a greater demand for food in the face of scarce natural resources, emphasize the importance of this study, particularly with regard to crops.

Literature Review

U-FTT is the passing of knowledge generated by a university to a company, enabling it to innovate and increase its technological capacity to obtain a competitive advantage in the market (Zucker & Darby, 2001; Closs & Ferreira, 2012; Ankrah & Omar, 2015; De Fuentes & Dutrénit, 2016).

U-FTT can be classified as formal or informal. Formal technology transfer lies in the means of transferring a research result into a patent or license to use the technology, including property rights. In informal transfer, this outcome is not expected (Lee, 1996; Grimpe & Fier, 2010; Lai, 2011; Miller *et al*., 2018; Baglieri *et al*., 2018). Link, Siegel and Bozeman (2007), Grimpe and Fier (2010) and, more recently, Bradley, Hayter and Link (2013), demonstrated the need for greater attention to informal technology transfer as the focus of studies. According to Grimpe and Fier (2010), examples of informal technology transfer could be contact between members of academia and firms at conferences, in joint publications, academic consultancies and other informal contacts like conversations and meetings. Bradley, Hayter and Link (2013) add further examples, such as technical assistance and joint (cooperative) research.

When it comes to theoretical models on U-FTT, the Contingent Effectiveness Model of Technology Transfer of Bozeman (2000) stands out, as it prioritizes the effectiveness of results. Furthermore, elements and criteria of effectiveness in TT are presented and, as the name suggests, it is 'contingent', enabling the inclusion of new variables (Bozeman, 2000). The model considers formal and informal TT (Bozeman, 2000), and authors such as Grimpe and Fier (2010), Link *et al.* (2007), Bradley *et al.* (2013) and Bigliardi, Marolla and Verbano (2015), point out the importance of studying informal TT informal. This is because, despite being widely used in practice, few studies have addressed the theme.

In the model by Bozeman (2000), the effectiveness criteria of technology transfer involve (1) out-the-door, (2) market impact, (3) economic development, (4) political reward, (5) opportunity costs and (6) scientific and technical human capital. The properties of these criteria and the resulting research propositions are presented below.

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Table 1. Theoretical construct of the study regarding effectiveness criteria of U-FTT processes.

Categories	*Properties*	*Authors*
(1) Out-the- door	Compliance with delivery deadlines; receipt of TT as agreed; distribution of resources (payment) as agreed; checking for dissatisfaction with received technology.	(Bozeman, 2000; Rosenberg & Nelson, 1994; Harmon *et al*., 1997; Piper & Naghshpour, 1996; Bozeman *et al*., 1995).
(2) Market impact	Product realization; profitability; larger market share and increase in sales.	(Bozeman, 2000)
(3) Economic development	Creation of new jobs; new jobs downstream and upstream; new business downstream and upstream.	(Bozeman, 2000; Harmon *et al.,* 1997).
(4) Political reward	Public recognition through TT: for the agent and recipient.	(Bozeman, 2000; Crow & Bozeman, 1998; Di Gregorio & Shane, 2003; Zucker & Darby, 2001; O'Shea *et al*., 2005).
(5) Opportunity cost	Losses or gains of TT in relation to laboratories, equipment, training and mission	(Bozeman, 2000; Crow & Bozeman, 1998; Woerter, 2004).
(6) Scientific and technical human capital	Greater participation in collaboration networks and workgroups and more people available; More people available; greater scientific production (articles)	(Bozeman & Rogers, 1998; Lynn *et al*., 1996; Bidault & Fischer, 1994; Malecki, 1981; Malecki & Tootle, 1996).

Method

The study is qualitative in nature as it is a more in-depth study of relationships, processes and phenomena. Furthermore, it is predominantly based on the testimony of the participants (Minayo *et al*., 1994; Eisenhardt, 1989).

The approach is exploratory (Babbie, 1998; Cervo & Bervian, 1983; Eisenhardt, 1989), as priority was given to understanding University-Firm Technology Transfer to discover new propositions for the Bozeman's (2000) Contingent Effectiveness Model of Technology Transfer.

This study specifically addresses a multiple case study (Yin, 2001): Brazilian University (BU) and American University (AU). The analysis units were three Technology Transfer processes, specifically involving the agricultural school and firms, namely Processes ALPHA and BETA at the American University (AU) and Process GAMMA, connected with the Brazilian University (BU), with details provided in the following table.

Table 2. Summary of the characteristics of selected U-FTT processes. Source: Prepared by the authors.

Details of the U-FTT	**Selected U-FTT processes**		
	American University (AU): Public; state university; 2 campuses in Raleigh; 128 years old; over 200 graduate and postgraduate courses. Recognition: land grant; contribution to socio-economic development; innovation.		**Brazilian University (BU):** Public; state; multiple campuses (several cities); 80 years old; 522 graduate and postgraduate courses; Recognition: scientific productivity.
	Processes ALPHA	**Processes BETA**	**Processes GAMMA**
Object of TT	Variety of sweet potato	Discovery of 1 – MCP properties (vegetables, especially fruit)	Variety of ginger
Means of TT	Crop	Patent	Registered with Ministry of Agriculture
Main benefits	Evenness and resistance	Delays ripening (better conservation)	Resistance
Department/Program of origin	Horticulture	Horticulture and Biochemistry	Genetic and vegetable improvement

Concerning data collection, the chosen procedure was the interview (13 in all), with the instrument being the interview script. The subjects who participated in the interviews were: the people in charge of the technology transfer nuclei of universities AU and BU, selected teaching staff involved in U-FTT processes and directors of the recipient organizations of the transferred technology.

Creswell (2014) claims that in a multiple case analysis, a typical format is to proceed first with a detailed description of each case, known as a 'within-case analysis'. This is followed by a thematic analysis across the cases, called a cross-case analysis, in addition to assertions or an interpretation of the meaning of the cases. In the joint analysis, the convergence or non-convergence of the cases was verified, albeit not limited to the previously established propositions and seeking evidence of the positions inherent to each case and highlighting the aspects of the American and Brazilian contexts and their relationship with the cases.

Results and Discussions

Regarding the nature of the technology transfers (Table 3), whether product or process, all were defined as products. However, Beta is an applicable product, integrating a process to delay ripening and is currently applied especially to fruit. Alpha and Gamma are new varieties of plants (vegetables) with superior characteristics, especially in terms of productivity. In the case of Alpha, the new product (a variety of sweet potato) provides higher income through conservation and a more standardized format of sweet potato. This latter characteristic is particularly advantageous for the processing industry, especially for restaurants. The benefits of Alpha extend to the entire production chain, since demand for this type of sweet potato is high, due to its superior characteristics. Concerning Gamma, a new variety of ginger still in the experimental stage, its primary benefit lies in its resistance to pests. This aids the economic activity of small farmers who wish to grow it or return to growing this crop, thus providing more business for Gamma.

The creation of new enterprises (spinoffs and startups) or new businesses from Alpha's TT occurred indirectly, but in the long term, with new second-generation products, enabling some farmers to expand and supply new markets. Alpha's TT favored the creation of products such as vodka, also called Alpha, and purified sweet potato mash, which led to the opening of a new company. In the case of Beta, the technology, initially adapted to the flower market, led to the creation of the Florabloc product, when the recipient, the object of this study, created a new subsidiary because of this technology. With the newly adapted technology, the BetaFresh product was created, for application to a range of fruits, creating differentiated products in its application and with adaptation to other fruits and regions, with incremental innovations in the USA and the rest of the world. As for Gamma's TT, it is not possible to make accurate predictions, but there is the possibility of supplying natural and processed ginger to the Brazilian market and even overseas. It is believed that small farmers, with incentives and support from private and public programs, can develop new businesses (Table 3)

The TT aspects of the empirical cases in question are summarized in the following table:

Table 3. Aspects related to the object of TT in the three cases.

ASPECTS	*ALPHA*	*BETA*	*GAMMA*
Result: product or process	PRODUCT. Creation (invention): crop Alpha, variety of sweet potato. Crop (patent). Higher income, quality and longer shelf life	PRODUCT. Discovery: Component 1-MCP Applicable to vegetables and flowers. Patent. Delays ripening and prolongs shelf life, preserves and reduces waste	PRODUCT. Creation (invention): Beta crop, variety of ginger. Crop (registered with Agriculture Ministry). Resistant to fusarium, adapted to local conditions
Sector of application	Agriculture, horticulture, farmers, crops, plants, genetics, classical improvements, participative improvements, cultivar, sweet potato	Postharvest; horticulture; biochemistry; food; vegetables; fruit; vegetables; ripening; conservation	Agriculture; food; medicinal use; farmers; crops; participative improvement; cultivar; ginger; genotypes; resistance; fusarium fungus; neglected culture
Field of knowledge and subfields	Department of Horticulture Horticulture, genetic improvement of plants, especially sweet potatoes. Genetic and improvement programs for potatoes and sweet potatoes	Departments of Horticulture and Molecular and Structural Biochemistry, both belonging to the CALS. Horticulture; physiology in postharvest of fruit; biochemistry; botany; plant physiology	Department of Genetics of the Postgraduate program in Genetics and Plant Improvement, Genetics and participative improvement in neglected cultures. Lab. of Genetic Diversity and Improvement – Genetic Diversity and Improvement PG
Stage of PLC on the market	When launched: birth; Current: growth – International expansion	When launched: birth. Current: between growth and maturity (internationally)	After registration: birth. Later: growth
Type of innovation	Incremental, with superior performance and characteristics	Radical, with far superior characteristics and performance over technologies with similar purposes	Incremental, with superior characteristics and performance in terms of resistance to fusarium
Type of innovation (origin)	Applied research. Market pull.	Not applied: Market push	Applied research. Market pull
New of pre-existing project of the recipient	Does not integrate, but has strong ties with previous projects	No. No relationship	Does not integrate, but has ties with previous project
Generation of new companies/businesses	Not directly, but in the long term with second generation products	Yes, creation of a company subsidiary	Might contribute

Concerning the three cases of technology transfer analyzed at AU (TT processes of Alpha and Beta) and BU (TT process of Gamma), in the following table, the means adopted for TT are summarized, along with the reasons for choosing the means, the elements involved (people and organizations), the time involved and the sources and amounts of resources (Table 4).

Regarding the means: Case Alpha is a patented crop, whereas Gamma is an unpatented crop that is only registered at the Ministry of Agriculture, as there is no commercial interest (in commercial gain through marketing) on the part of the TT agent, BU. Both Alpha and Gamma use participatory improvement as a means, as the primary user is actively participating. Therefore, efforts regarding technology are pre-directed. In the case of Beta, the discovery of the component (Beta technology) was a random one, when combining a research project with another purpose (Table 4).

Concerning the motives for choosing the means, for both Alpha and Gamma, as they are a new variety of plant, the means is the crop. In the case of Alpha, the "patenting of the variety" was considered a pioneer step by the agent and the recipient, who had worked without patents and licensing. These were motivated by legislation, but also by the need for further resources to continue research. AP2 mentioned that without the resources earned from licensing, with the withdrawal of public funding, the research programs would not be as advanced as they are (Table 4).

Concerning the source and amount of resources, in none of the cases was the sum invested in the development of the technologies up to the 'point of marketing' revealed. State investments were included in all cases either directly (case Alpha) or indirectly (Beta and Gamma). In the case of Alpha, the farmers, officially organized into a Commission, invested directly in the technology, which also occurred when Beta was marketed, but with the necessary adaptation to the market. In the case of Gamma, the technology cost less and the resource required was the soil for planting (location of the field experiment). The other resources were acquired from the physical structure of BU and the departmental resources and doctorate scholarship. The American researchers in the cases of Alpha and Beta mentioned their salaries as part of the investment, while the Brazilian researchers made no reference to this (Table 4).

Table 4. Aspects related to the means of TT in the three cases.

ASPECTS/ AGENTS OF TT	*ALPHA (AU – Commission)*	*BETA (AU-BetaFresh)*	*GAMMA (BU-GAMA)*
Means adopted	Formal TT: crop. Non-exclusive license – international Participative Improvement Project for Farmers (Sweet Potato Improvement Program of AU)	Formal TT: exclusive licensed patent – international Research project funded by the US Dept. of Agriculture (other purpose)	Informal TT: crop (Ministry of Agriculture). No license. North coast of São Paulo. Research Project (doctorate) Participative improvement of ginger
Reasons for choosing means	Variety of plant. Non-exclusive license: available to many farmers	Technology applicable to plants. Exclusive license. The size of the second company may have further enabled the exclusive use as it is an active multinational	Variety of plant. Crop only registered, no commercial interest of researchers; alternative income for small farmers Lacks BU structure for quicker process
Elements involved (people and organizations)	Permanent: Two researchers, one a professor, the other not (improvers) of AU (Department of Horticulture) Commission of farmers. Not permanent: other researchers of the AU; laboratory technician; farmers; state extension agents; ETT external office (legal area); Board of Directors of the CALS	Permanent: two researchers/professors at AU (Departments of Horticulture and Molecular and Structural Biochemistry). Not Permanent: Post-doctorate candidate; ETT; Flowers; TT facilitators; colleague from the department and Flowers; Agrobeta	Permanent: doctoral researcher and two researchers/professors. Post-graduate project in Genetics and Plant Improvement; owner of Gamma; farmer at Gamma. Not permanent: extension agent from research institute, other farmers
Time involved	Launch: between 2005 and 2006 Crop registered in 2008. Immediate use: farming commission	Development and launch: early 1990s. Patent granted: 1996. Uses: 1999 – decorative plants – Flowers; 2002 – apples (EPA) – by AgroBeta	Development: from 2012 to 2016 (GP3). Launch and registration (2016). Use: Gamma and farmers in the region
Source and amounts of resources involved	Sources of resources. Participative Improvement of Farmers Project. CBDCN Association of Development for the harvest run by the State. State (stations) AU structure (physical and salaries). Amount of resources: not informed	Sources of resources: research project (US Department of Agriculture for another purpose); AU structure (physical/salaries). Amount of resources: not informed	Source of resources: CNPq Scholarship Department – Doctorates. BU structure (physical). Amount of resources: not informed

Discussions related to aligning the object and the means of technology transfer

The following table summarizes the theoretical assumption regarding the object of TT and the empirical cases:

Table 5. Theoretical assumptions related to the object of TT in the three cases.

THEORETICAL ASSUMPTIONS	*ALPHA*	*BETA*	*GAMMA*
Great impact of tacit knowledge on the effectiveness of production (process) technology transfer (Grant & Gregory 1997; Comacchio e*t al*., 2012)	Yes, but product TT. Tacit knowledge: agent and recipient	Yes, but product TT. Tacit knowledge: agent and recipient	Yes, but product TT. Tacit knowledge: agent and recipient
A technology may be characterized by more than one useful purpose, which the author calls dual use (Watkins, 1990)	Yes, immediately and in the long term. Support: Agent and recipient.	Yes, immediately and in the long term. Support: Agent and recipient.	Yes
There is strong interaction between the sector of use, the process and technology of the product and the types of learning necessary to implement a technology, showing that the stronger the interaction, the greater the chances of success (Cowan & Foray, 1995)	Yes, various forms of interaction and integration	Yes	Yes
Federal funding of the development of certain fields is positively reflected in TT (O'Shea *et al*., 2005)	Yes, but with state funding	There was no direct federal funding	It is presumed, if there is future funding
Interaction linked to the product lifecycle on the market. The more mature the technology, the greater its transferability. (Cowan & Foray, 1995)	Yes	Yes	Insufficient data
Most licensed inventions could not be developed independently by any inventor or company, reinforcing the role of university research in technological innovation (Jensen & Thursby, 2001)	Yes	Yes	Yes
Companies' internal R&D, which used to be a strategic asset, has given way to cooperation with universities (Chesbrough, 2003; Park & Lee, 2011)	Yes	Partially	Yes
The universities have steadily increased their share in the creation of companies based on creating new technologies originating from academic research (Etzkowitz, 2003; Srivastava & Chandra, 2012; Costa & Junior, 2016; Ruiz et al., 2017)	Partially	Partially	Insufficient data

Regarding the strong impact of tacit knowledge on the effectiveness of production (process) TT, in accordance with Grant and Gregory (1997), in all the cases, the answer was yes. However, it was also attributed to production TT by the agent and recipient (Table 5).

Of the three cases, Alpha has the greatest contribution in terms of tacit knowledge of the agent and recipient. The university (agent) contributes the improvement technique and the development of varieties and the experience it has accumulated in several projects It also contributes with the researchers' expertise. The commission (recipient) has knowledge of the crop and the need to solve problems regarding agriculture, the crop and the consumer, as well as the requirements of the market. The ability of both sides to interact is also part of the tacit knowledge, resulting from previous interactions between them and with other organizations, aided by the participative improvement technique. The tacit knowledge of other actors is also included, albeit with more limited participation (Table 5).

In the case of Beta, the initial support of the researchers who discovered the AgroBeta component in the early stages of 'absorbing' the technology was especially important, as was the tacit knowledge of those at the company to adapt and improve the technology for the market. The process went through the following stages: (1) stabilizing the chemical compound, (2) having the product approved by the EPA and (3) improving the invention for work in real life conditions (Table 5).

In the case of Gamma, the university (agent) provided continuous learning for the main researcher (GP3) through the tacit knowledge of GP1 and GP2 (with more experience) and the recipient (company and farmers) and another element, the partner (research institute). GP3 highlights greater knowledge of the market and the development of interaction capabilities with the company, with farmers and the research institute, as well as learning the use of different laboratory techniques at the vegetation house and achieving classical and participative improvements. GRT highlights the scientific knowledge provided by the researchers with new techniques, and because participative improvement involves information exchanges (Table 5).

Tacit knowledge is important for the effectiveness of TT, both on the part of the agent (university) and the recipient, as well as the partners involved, emphasizing in addition to knowledge exchanges, the interaction capability of all parties involved (Table 5).

Regarding the technology characterized as dual use (Watkins, 1990), in all the cases, there is evidence of this. In the case of Alpha, the Commission and the University are looking at the different uses for sweet potatoes. The recipient does this directly, publishing recipes for new dishes with sweet potatoes and creating new products such as Alpha Gourmet Vodka. The agent does it indirectly and in the long term, including researchers from another department of AU to develop new forms of processing sweet potatoes, creating a new product such as 'purified sweet potato mash'. In the case of Beta, it occurs directly, with the recipient striving to use the technology in different fruits in different regions. The AU agent does so with recent research involving the possible use of the technology on a smaller scale for small farmers. In the case of Gamma, advances were forecast for the new variety, with great chances of increased ginger production, new commercial partnerships and partnerships with the university, as well as the return of former farmers and the involvement of new ones in expanding the trade of natural and processed ginger by Gamma (Table 5).

The premise of Cowan and Foray (1995) is confirmed, claiming that there is strong interaction between the sector of use, the process and the technology of the product and the types of learning necessary to implement a technology. They highlight that the stronger the interaction, the greater the chances of success. In the case of Alpha, strong integration, growth and consolidation of sweet potato production was confirmed. Institutions (government, university and recipients) worked in partnership, integrating the links of the production chain, expanding quantitatively and qualitatively. In the case of Beta, the AgroBeta business was consolidated based on transferred technology, benefitting the entire production chain. Beta is also investing in and marketing equipment for the application of Beta (BP) and other postharvest and pre-harvest products with similar purposes to those of Beta. In the case of Gamma, it is assumed that the domination of GRT in the production chain will mean greater success in ginger-related activities, expanding the business in terms of both quality and quantity, despite GRT already leading the TT process (Table 5).

The arguments of O'Shea *et al.* (2005), that federal funding for the development of certain fields is positively reflected in TT, is confirmed only for Alpha, but only in the case of state investments. Investment in research and the extension of sweet potatoes, especially by the state government, is of national prominence, greater than in other states that produce this crop. One aspect of state investment is the AU itself, which is a state university. This investment strengthens research and sweet potato production in the state. In the long term, it involves academia and farmers, providing benefits that extend to the production chain. In the case of Beta, this premise cannot be identified because the research that led to the component had another purpose. In the case of Gamma, it is assumed that federal or state incentives for small ginger farmers mean further advantages for business after the production of the new variety (Table 5).

When linking interaction to product lifecycles on the market, the claims of Cowan and Foray (1995), that the more mature a technology is, the greater its transferability, is confirmed for Alpha and Beta, that the more advanced the stage of the lifecycle, the greater its expansion. It is important to highlight the report of ETT1 at AU regarding the need to work on discoveries and inventions for the market, which is one of the main challenges at AU. In the case of Alpha, with applied research and participative improvement, this maturity is easier to achieve. In the case of Beta, efforts were made to market the Agro-Beta technology, seeking the involvement of researchers from AU. In the case of Gamma, it is not yet possible to evaluate the behavior of the technology with regard to the assumptions of Cowan and Foray (1995) (Table 5).

The claim by Jensen and Thursby (2001) that most licensed inventions could not be developed by any inventor or company independently, reinforcing the role of university research in technological innovation, is evident in these cases (Table 5).

Chesbrough's (2003) claim that a company's internal R&D used to be a strategic asset that has now given way to cooperation with universities can be confirmed in the case of Alpha and Gamma. With regard to Alpha, the recipient, the Commission, a non-profit organization, presents a cooperation strategy with AU for innovation, with no internal R&D structure. For Gamma, it was seen that the micro enterprise that acts as the technology recipient is open to partnerships with other organizations as a source of R&D and, consequently, innovation, as it is an 'open organization' (Table 8). In the case of Beta, this is partially confirmed, as the knowledge applied by the company with a team of researchers was fundamental in making the technology feasible and diffusing it later (Table 5).

Regarding the claims of Etzkowitz (2003), that universities have constantly increased their level of participation in the creation of companies to create new technologies through academic research, this is partly the case for Alpha and Beta. It is partly the case for Alpha because, in the long term, new businesses have been developed in the production chain, including some with the support of AU, although it originated at other departments. It is partly true for Beta because it did not occur directly. The company was created to market the technology that was expanded, leading to the product being applied to other fruit and the international market. Furthermore, as there were benefits to elements of the production chain, it is possible that new businesses were created. A new job was also created, the 'Beta applicator', along with equipment for this activity. There are insufficient data on Gamma to confirm the authors' arguments (Table 5).

In none of the cases was there participation or influence from a science park (Bozeman, 2000), research consortium (Aldrich *et al.*, 1998) or cooperative research center (studied by Gray, 2008 and Boardman & Gray, 2010). In the cases of Alpha and Gamma, pre-existing relationships influenced the effectiveness of the TT, while in the case of Beta, it was only through the first company, which acquired the technology and as an entrepreneur glimpsed an opportunity in the apple market, and sought to market it, which resulted in the license to DD Chemicals (Table 6).

Informal means (Grimpe & Fier; 2010 and Bradley, Hayter & Link, 2013) were identified in the case of Alpha prior to the TT and in Beta after the TT, in the case of Beta when there was cooperation between researchers and DD Chemicals to adapt the technology to the 'point of marketing'. In the case of Gamma, the TT was informal, considering that there is no licensing (Table 6). The relationship between the theoretical assumptions of TT means and the empirical cases is summarized in the following table:

Table 6. Theoretical assumptions related to TT in the three cases.

THEORETICAL ASSUMPTIONS	*ALPHA*	*BETA*	*GAMMA*
Science Park (Bozeman, 2000), Cooperative Research Center (studied by Boardman & Gray, 2010) and/or Research Consortium (Aldrich et al., 1998) with links to TT	No	No	No
Informal means of TT identified by Grimpe & Fier (2010) and Bradley et al. (2013)	Sim. Before.	Yes. Later.	Yes. The TT is informal
Rhan (1994) on the importance of researchers spanning for TT and for companies	Yes.	Yes, only for the first company.	Yes.
Stages of the licensing process presented by Thursby & Thursby (2002)	Yes.	Sim	Not applicable.
Registering the patent and the licensing process do not guarantee the success of the TT (Fugino & Stal, 2007)	Yes.	Sim	Not applicable.
Importance of patenting and licensing norms (Stal & Fujino, 2005; D'este & Perkmann, 2011)	Yes.	Yes.	Not applicable.

In all the cases, the researchers were characterized as spanning (Rhan, 2000), but in the case of Beta, only in the case of the first company that led to TT later to DD Chemicals (Table 6).

As for compliance with the stages of licensing identified by Thursby and Thursby (2002), in the case of Alpha and Beta, these stages are identified, but in greater detail. This does not apply to Gamma, as the TT is informal (Table 6).

The claim that patenting and licensing are not synonyms of successful TT (Fugino & Stal, 2007) is valid for Alpha and Beta. It is not applicable in the case of Gamma, as its TT is informal, only requiring registration with the Ministry of Agriculture. The importance of patenting and licensing norms (Stal & Fujino, 2005) is evident in the cases of Alpha (patent itself) and Beta (specific patent of a variety of vegetable, known as a cultivar), but does not apply to the case of Gamma, as its TT is informal (Table 6).

Conclusion

Considering the peculiar aspects of National Innovation Systems in each country, in Brazil and the USA an attempt was made to analyze the agriculture schools of Brazilian and American universities. The study of these cases enabled a detailed description of the alignment between the object and means of U-FTT and a discussion of theoretical assumptions (Tables 5 and 6). Thus, it was possible to conclude that the U-FTT model is contingent, i.e., the object and means of U-FTT are in continuous alignment and construction. Therefore, they are open to new contributions and theoretical assumptions, as summarized in the following table.

Table 7. Theoretical assumptions related to the object and means of TT in the three cases.

VARIABLES	*ASSUMPTIONS*
TT object	(1) Federal funding for the development of certain areas reflects positively on TT (O'Shea *et al*., 2005); (2) Most licensed inventions could not be developed independently by any inventor or company, strengthening the role of university research in technological innovation (Jensen & Thursby, 2001). (3); Companies' internal R&D used to be a strategic asset, but has now given way to cooperation with universities (Chesbrough, 2003; Park & Lee, 2011); (4) Universities have constantly increased their participation in the creation of companies based on the creation of new technologies that originated in academic research (Etzkowitz, 2003; Srivastava & Chandra, 2012).
TT means	(5) The participation of the university in Cooperative Research Centers serves as a mechanism for national and state governments and private companies to achieve social and economic results with science and technology, as well as scientific results (Boardman & Gray, 2010); (6) Informal TT means identified by Grimpe & Fier (2010) and Bradley *et al.* (2013); (7) Stages in the licensing process presented by Thursby & Thursby (2002); (8) The registration of patents and the licensing process do not guarantee the success of TT (Fugino & Stal, 2007); (9) The importance of licensing and patenting norms (Stal & Fujino, 2005).

Based on the existing studies on U-FTT (Bozeman, 2000; Hendriks, 2012; Susanty *et al.,* 2011; Roper, Gormley & Hewitt-Dundas, 2013), the present study differs and makes significant contributions through the following factors: (1) it concentrates on TT from the perspective of agriculture schools of public universities for food products; (2) its analysis is aligned with the object and means of U-FTT, considering the perspectives of the agents and recipients of the technology and theoretical assumptions; (3) it investigates the phenomenon of U-FTT in terms of formal and informal means; and (4) it is an interinstitutional and international study, considering aspects of the macro context, especially characteristics of national innovation systems in each country.

A suggestion for future studies would be to look at the effects of TT considering the assumptions raised and validated in this study. Other studies could focus on the expansion of the original TT to other regions by the recipient, or to other countries, adapting it to other cases of food.

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Exploring Knowledge Transfer at UC Engineering School

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Abstract: I explore the degree to which patents represent magnitude of knowledge transferred from University to Industry. Building on the Agrawal & Henderson (2002) framework, I compare two MIT engineering departments and the School of Engineering of the Pontificia Universidad Católica de Chile (UC Engineering). Based on quantitative and qualitative data I estimated the relative importance of patenting as a knowledge transfer mechanism. I found that in UC Engineering patenting and publishing activity have increased steadily, in line with faculty size increase. However, patenting is perceived by academics as a relatively less important technology transfer channel, and in terms of production counting it appears much less relevant. Although in terms of relative importance of publishing over patenting as a technology transfer channel both are relatively similar, in the perception of faculty; in terms of production counting there is a substantial difference. I suggest some plausible explanations, proposing new avenues for research.

Keywords: knowledge transfer; academic patenting; scientific publication.

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Introduction

In the absence of better innovation data, patents have frequently been used as indicators of industrial innovation (Kleinknecht & Jan Reinders, 2013). Patenting, however, is only one of more than 20 different knowledge transfer mechanisms between universities and industries (Bekkers & Bodas Freitas, 2008). Estimating the nature and magnitude of the different knowledge transfer channels and its impact on industry remains difficult, although this is important for academics, universities and governments. University professors might be evaluated or provided incentives for knowledge transfer; yet defining a metric for calculating these incentives is difficult and might be counterproductive if important knowledge transfer channels are neglected. Universities are pursuing a 'third mission' by fostering links with knowledge users and facilitating technology transfer to society, thus knowing which channels are utilized can provide information on how to manage the collaborations with external partners. Governments, in trying to stimulate economic growth and solutions to public problems, encourage universities to transfer knowledge and to develop institutions that enable the "third mission"; yet in the absence of indicators it's hard to allocate resources. Thus, this matter is of great relevance for policy-makers who attempt to stimulate the diffusion of university-generated technologies within the wider economy.

In this paper, I explore the degree to which patents are representative of the magnitude and impact of the knowledge transferred from University to Industry. I build on the framework developed by Agrawal & Henderson (2002) who used quantitative and qualitative data to estimate the relative importance of patenting as a mechanism for knowledge transfer from two selected engineering departments at MIT. Johnson sustains that some important groundbreaking technologies have stemmed from university-based work, but evidence suggests that many of these have been the products of only a few entrepreneurial universities with engineering schools such as at MIT and Stanford (Johnson, 2011). The US ranked second in intellectual property filing activity by origin in 2016 (World Intellectual Property Organization, 2017). Within the US, the MIT was the second university to which more patents (278) were granted in 2016 (National Academy of Inventors, 2017). I replicated to some extent the already mentioned study, focusing on a particular setting: the School of Engineering (hereafter UC Engineering) of the Pontificia Universidad Católica de Chile (hereafter UC), one of the Chilean leading higher education organizations. Drawing on a survey questionnaire applied to the faculty of the UC Engineering ten departments; together with quantitative information about each faculty member´s patenting and publication record, I consider to what extent patents are perceived in terms of magnitude and impact, compared to other channels, of the knowledge transferred from UC Engineering to industry. Data available was scarce and contemporary, due to the recent organization and strengthening of intermediation structures in the UC and UC Engineering.

I found that patenting is an activity undertaken by a small portion of the faculty members at UC Engineering. In addition, although in terms of relative importance of publishing over patenting, as a technology transfer channel, they are relatively similar in the perception of UC Engineering and MIT faculty, in terms of production counting strong differences are shown. This is the biggest difference that I found. In respect to the exploration about the degree to which patents are representative of the magnitude of the knowledge transferred from university to industry, I found that in UC Engineering, in general, during the last 10 years patenting and publishing activity have been increasing steadily in line with faculty size increase. However, patenting is perceived by academics as a relatively less important technology transfer channel, and in terms of production counting, it appears much more less relevant.

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I speculate that, with the aim to achieve a more straightforward transfer of academic knowledge into the industrial domain, enabling elements are funding availability, organizational attention to academics productivity in terms of academic entrepreneurial culture and career promotion rules, and alignment to strategic objectives. In particular, the latter on the objective of helping domestic economy to find its future and sustainable competitive advantage.

This paper contribution lies in a deeper understanding of the degree to which patents are representative of the magnitude of the knowledge transferred from university to industry. First, uncovering particulars of patenting and publishing at UC Engineering. Second, analyzing and comparing them to previous research looking at the MIT. Third, paying attention to the extent to which patents are complementary or substitute for publications in the university context. Finally, speculating about the enablers for a more thorough knowledge transfer. To sum up, effective and sustainable knowledge and technology transfer from university to industry requires evidence about the nature and magnitude of different technology transfer channels. This work contributes to a richer understanding of the complex nature of technology transfer activity in a university setting. In particular, this research look at faculty in a developing country, in a specific engineering school, allowing to look at a 'local' social environment, thus minimizing the heterogeneity of a broader context.

The exploratory nature of this study builds on the broad, but still fragmented and at times contradictory, literature on technology transfer from university to industry. Also, on the very few studies that consider engineering academics or the context of a developing country, and few pieces of research that look at engineering settings. The paper is organized as follows; section 1 introduces the aim of exploring knowledge transfer in the specific setting. Then, section 2 considers gradually the notion of knowledge transfer channels, patenting and publishing. Subsequently, section 3 presents the data and the methodology used. Finally, section 4 discusses the results and concludes the paper.

The nature of knowledge and technology transfer channels, patenting and publishing

Valuable technological capabilities are built incrementally over time. Petralia et al found that having capabilities in related technologies is important for a country when entering into a new technological domain, the likelihood a new technological capability will emerge is higher the closer that technology is with respect to the profile of existing capabilities of the country (Petralia et al, 2017). This effect diminishes as countries develop as results show that diversification in unrelated technologies is less likely to occur at early stages of development (Petralia et al, 2017). They found a significant and positive reinforcement of having developed related capabilities, implying that technological production tends to cluster in the technological space. Furthermore, according to their findings, the likelihood of specialization increases for complex and valuable technologies as countries develop (Petralia et al, 2017). In short, countries climb the ladder of technological development gradually, changing patterns as countries develop. In any case, in the global value chain, countries that innovate are able to capture a larger share of the value added, while others are trapped in less profitable activities (Petralia et al, 2017).

Technology transfer can be considered a complex and systemic phenomenon. Knowledge transfer is not a single homogenous concept, it can occur through a number of routes, both formal and informal, referred to as "research commercialization" such as patents, licenses and spin outs, or "academic engagement", with the most popular being contract research, collaborative research and consulting (Sengupta & Ray, 2017). As a whole, Bozeman et al suggest that technology transfer activity is one significant event in a multi-casual chain of events (Bozeman et al, 2015). Further, Landry et al maintain that there are complex interactions among multiple forms of mutually reinforcing knowledge transfer activities that lead to enhanced performance in the knowledge transfer of individual academics, representing a knowledge transfer system made up of interdependent and mutually reinforcing activities (Landry et al, 2010). Moreover, Perkmann et al argue that this transfer is a multi-level phenomenon, in the sense that is determined by both the characteristics of individuals as well as the organizational and institutional context in which they work (Perkmann et al, 2013). Similarly, regarding portfolio management of knowledge transfer activities, decision makers have to manage complex social systems whose constituents and interactions are usually incompletely understood and whose benefits only become apparent post hoc (Landry et al, 2010). In practice, academics may make joint decisions for multiple knowledge transfer activities rather than treating them independently, due to the presence of complementarities that arise from interrelated knowledge transfer activities, allowing exploiting opportunities for cost saving, as well as drawing on tacit interrelated skills (Landry et al, 2010). Regarding the factors which determine the propensity of academic scientists to engage themselves in commercialization activities, Arvanitis et al suggest that there exists some kind of trade-off between financial motives because of the perspective of additional income, the inherent motives of a scientist who primarily pursues research goals and the reputation associated with research achievements (Arvanities et al, 2008). Johnson suggests that tying the outcomes of the innovation venture to the reward structure of the scientists involved in the university – industry technology transfer process may be an effective way of motivating innovative behavior (Johnson, 2011). Thus, technology transfer activity is seen as a complex, multi-level phenomenon, made up of interdependent activities.

Technology transfer channels must be carefully considered because they are not completely understood yet. Bekkers & Bodas Freitas suggest that the perceived relative importance between technology transfer channels hardly differs between industry and university; still, differences in importance of various channels of knowledge transfer are not related to industrial sectors if not rather by basic characteristics of the knowledge in question, disciplinary origin of the knowledge involved, and, to a lesser extent, to individual and organizational characteristics of those involved in the knowledge transfer (Bekkers & Bodas Freitas, 2008). Regarding more granular literature on technology transfer channels, they noted that a few studies have shown that differences exist in the forms of knowledge transfer across different disciplines and industrial activities; however, the patterns of knowledge transfer from university to industry still have to be explored systematically across sectors with different learning patterns and different level of technology opportunities, to find explanations underlying these patterns (Bekkers & Bodas Freitas, 2008). Moreover, they found no consensus on the channels through which knowledge flows between university and industrial firms. Some authors argue that firms consider codified output, such as publications and patents, the most important form of accessible knowledge that is being developed by a university, whereas others contend that the most important channels for universities to have an impact on industrial R&D are published papers and reports (Bekkers & Bodas Freitas, 2008). In any case, Van Looy et al found no evidence of any trade-off between the different technology transfer mechanisms (Van Looy et al, 2011). Bekkers & Bodas Freitas summarize their findings about knowledge transfer channels related to industry sectors in existing literature through four ideas. First, publications, participation in conferences and collaborative research are particularly important in R&D-intensive industrial activities. Second, influx of students, contract research and collaborative research are expected to be specially important in the engineering field. Third, patents, spin-offs and collaborative research are expected to be of major importance for firms active in science-intensive industries. Finally, informal contacts are not expected to differ significantly across sectors (Bekkers & Bodas Freitas, 2008). To sum up, there is no consensus on technology transfer channels relative importance and patterns.

The growing relevance of technology transfer has brought new concerns. In a knowledge economy, science is exerting an increasingly large influence on innovation, especially in fast-growing knowledge-intensive industries (Arvanitis et al, 2008). The intensity and variety of activities at the University – Industry interface is growing and it is crucial to improve our understanding of which university researchers are interacting with firms (Giuliani et al, 2010). In addition, universities are becoming increasingly proactive managers of their collaborations with industry, seeking to create valuable intellectual property to foster technology transfer (Bruneel et al, 2010). In this respect, government agencies and universities themselves have made concerted efforts to increase the transfer of academic knowledge into the industrial domain, for reasons ranging from generating societal legitimacy for publicly subsidized scientific research, stimulating economic activity, to raising revenue for universities (Perkmann et al, 2013). Research demonstrating the potential of universities to contribute to regional economic growth and to be instrumental in the formation of new industries has led to a greater policy focus on the role of universities in engaging with businesses and undertaking knowledge transfer activities (Hewitt-Dundas, 2012). Overall, some authors argue that the 'third role' played by universities conflicts with research and higher education in the absence of adequate resources (to be devoted to this specific aim) and of indicators of this type of output, which are taken into account to assess the advancement of scholars' careers (Maietta, 2015). In particular, capabilities, in the broad context of university commercialization of research results, are built over time and cannot be implemented simply by setting up structures and policies (Rasmussen & Borch, 2010). Specifically, bottom up processes from within the university can be important in developing these capabilities (Rasmussen & Borch, 2010). Consequently, to foster technology transfer, a clearer understanding of this activity in itself is necessary.
An engineering setting can pose an attractive context for technology transfer. Arvanitis et al found that institutes of economics and business administration, natural sciences, engineering and medicine are stronger involved in knowledge and technology transfer activities than institutes of mathematics and physics (Arvanitis et al, 2008). Further, Perkmann et al suggest, on the institutional level, strong association between transfer and affiliation to engineering; as well as support for the notion of transfer of academic knowledge into the industrial domain as complementary to traditional academic science in research looking at engineering faculties (Perkmann et al, 2013). In this respect, Crespi et al found evidence of a subtle scientific field effect where computer sciences and engineering showed a crowding-in effect between patenting and publishing; however, they also found indications that beyond a certain threshold, a continuing focus on patenting can result in a negative effect on other channels of knowledge diffusion such as publishing (Crespi et al, 2011). Some authors argue that academic engineering faculties are specially positioned to undertake technology transfer, but research is needed to explain some inconsistencies drawn from evidence.

There are a number of avenues open for research on technology transfer. Overall, Perkmann et al suggest that research published on the transfer of academic knowledge into the industrial domain remains relatively fragmented and tentative (Perkmann et al, 2013). In addition, Bodas Freitas et al maintain that despite there is an extensive body of literature on University – Industry collaboration in developed and newly industrialized countries, no work has been published on whether and how the establishment, content and organization of University – Industry collaboration differ between emergent and mature industries (Bodas Freitas et al, 2013). In this respect, explaining why academics become involved in entrepreneurial ventures is a domain that has received increased levels of interest from academics and practitioners (Clarysse et al, 2011). A number of authors suggest that the sparse pertinent literature claim for further research on technology transfer, to understand how universities can foster University – Industry links, in order to facilitate this activity. This knowledge is highly relevant for universities and policy makers seeking to increase the impact on the industrial domain, and subsequently economy and people.

Patenting and publishing

Patenting and publishing are important to this research because of the potential complementary or competing relationship amongst them. Landry et al suggest that publications, patenting, spin-off creation, consulting and informal knowledge transfer are complementary activities (Landry et al, 2010). Moreover, generally speaking, complementarity effects among patenting, spin-off formation, consulting, informal knowledge transfer and publications emerge under four conditions: finance linked to private funding, the degree of novelty of research findings, network assets, and organizational assets linked to the size of research units and the research intensity of the universities (Landry et al, 2010). In this respect, Crespi et al maintain that academic patenting may be complementary to publishing at least up to a certain point, after which there would be a substitution effect (Crespi et al, 2011).

Patents are widely used in the innovation literature because they provide a systematic and quantitative measure of new technological inventions, but they are also criticized because they only capture some specific types of innovation and technologies (Petralia et al, 2017). Many generic forms of innovation, especially in developing countries, won't show up in patent data (Petralia et al, 2017). Conversely, the use of secrecy over patenting as a method of protection cannot be measured unless a firm-level survey spanning different technological domains is conducted (Petralia et al, 2017). In any case, a long period is necessary to ascertain the effects of collaboration between national systems of innovation's actors and industry, after accounting for cross-sectional and time heterogeneity (Maietta, 2015). In coherence with this view, looking for accuracy in metrics based on activity, Bozeman et al suggest that measures need to be tracked over time. They point out that the US Department of Energy, rather than simply reporting the number of patents, report the ratio of patents in a given year to patent applications filed for a three year base period, using a rolling three-year average (Bozeman et al, 2015). Nevertheless, they emphasize that for any valid inference about effectiveness, activity measures must relate to resource measures (Bozeman et al, 2015).

Crespi et al argued that findings are mixed with regards to the relationship between patenting and publishing among academics. While there is some statistical evidence of a complementary effect (co-occurrence) between publishing and patenting, there is also qualitative and quantitative evidence of crowding out, highlighting the presence of non-linear relationships between patenting and publishing (Crespi et al, 2011). It is also suggested that patents and publications can result from one and the same underlying research effort, showing a positive relation at the individual professor and scientist level (Van Looy et al, 2011). Both activities share the objective of advancing knowledge and the state-of-the-art, in science and technology, respectively (Van Looy et al, 2011). In any case, Van Looy et al found that the level of scientific productivity is the only variable consistently (and positively) related to levels of entrepreneurial activity (Van Looy et al, 2011). In consistency with this view, Perkmann et al suggest that academics who generate high numbers of publications in peer-reviewed journals also excel at patenting and academic entrepreneurship, although compared to alternative channels of interaction patenting and academic entrepreneurship are only moderately important (Perkmann et al, 2011). To sum up, patenting is commonly used as a measure of innovation or technology transfer. Although as Bruneel et al maintain, it is unclear whether the changes that have occurred in university patenting activity are a direct consequence of technological changes or of policy (Bruneel et al, 2010).

As a final point, it is important to underline the increase of Chilean policies and incentives aimed at stimulating R&D and technological transfer from academia to the industrial domain. This, since the introduction of an industrial property law (1991) and the tax incentive for R&D investment law, enacted in 2008, has generated growing interest in the magnitude and impact of patenting in terms of the knowledge transferred from university to industry.

Data and methods

UC Engineering was selected in this work because the author works in DICTUC SA, a company affiliate to the UC, dedicated to transfer knowledge and technology generated by UC Engineering, so as to place it at the service of the community, through individual or multidisciplinary services (Pontificia Universidad Católica de Chile, 2016). DICTUC links academia and research to productive sectors of the country, providing multidisciplinary engineering services to solve specific problems and developing large, relevant and diverse projects, in order to positively impact people, by giving concrete solutions to the challenges of society (DICTUC, 2016). Another reason is because the university is one of the premier higher education organizations in Chile. The university obtained the first place of Latin American universities in the QS 2018 ranking, after being third in the 2017 ranking. Furthermore, MIT ranked UC Engineering in the fourth position of its 2017 global ranking of emerging engineering institutions with a better projection for the coming years. UC Engineering was behind the University of Technology and Design of Singapore, which ranked first, Olin College of the US (second) and University College London (third). This is important in respect of technology transfer as those universities with highest research quality will be most likely to engage in knowledge transfer (Hewitt-Dundas, 2012). Besides, the university was the Chilean organization that filed most patent applications for invention in Chile in 2015. Within the UC, the areas with the highest number of patent applications are life sciences, with more than a third, followed by engineering and construction, and the rest are divided into design, food, chemical processes, and others. Finally, UC Engineering's leadership highlights the critical role that applied disciplinary and interdisciplinary research will play in helping economy find its future and sustainable competitive advantage to tackle the increasingly complex shared concerns of Chilean people and society (Pontificia Universidad Católica de Chile, 2016). In summary, UC engineering is committed to become a world-class school of engineering, recognizing that a critical path in this realm has to do with orchestrating capabilities that finally use knowledge and technology as a vehicle to impact society as well as global markets. As a result, this specific setting seems well suited to explore the nature of knowledge and technology transfer at UC Engineering with focus on publishing and patenting behavior of faculty members.

The data for this work is based on the population of professors who were on the faculty on December 2017 and who generated at least one paper or patent during the period January 2008 -– December 2017. This added up a total of 111 professors. I chose to focus on this period because publication and patenting data were available for those years. Our final data set includes information about 47 patents and 2,090 papers, allocated to the sample faculty. Paper data was collected from Dimensions of National Scientific Production, the Scientific Information Program CONICYT (DataCiencia), (CONICYT, 2017) for some selected universities chosen, and the records of the UC Engineering's Directorate of Innovation and Research for UC Engineering. Patent data was collected from the Chilean National Institute of Industrial Property (INAPI) for the selected universities, and the records of the UC's Direction of Transfer and Development for UC Engineering. The year of the patent is the application year, which is the more closely approximating the invention date. Publications have been dated in the year of publication because that is the only date available in a reliable manner.

This work resorts to both qualitative and quantitative data. Due to the exploratory nature of this effort, I focus on a single university and in particular, one engineering faculty made of 10 departments. The core of this work is the consideration of the professors currently working on a full time basis at UC Engineering. I have to highlight the originality of this research, in the setting of one engineering school in a developing country. In this particular context, literature regarding technology transfer from university to industry in general, and from an engineering school in particular, is almost inexistent.

I supplemented quantitative data with a survey questionnaire aimed to collect quantitative as well as qualitative data. I requested every faculty member to answer a survey questionnaire during the two-day´s UC Engineering strategic planning workshop held on January 2018. To develop the questionnaire, I conducted a few interviews with academics and reviewed the literature. The survey asked about academics' demographics as well as perceptions on their research and on channels of knowledge transfer. Of the faculty members, 66 % agreed to answer, resulting in a sample size of 73.

Results

Sample characteristics

Table 1 presents basic descriptive statistics for professors that were faculty members in December 2017 who generated at least one paper or patent application, contrasted with the faculty members who had filled at least one patent application between 2008 and 2017 (Academic inventors). The academic inventors published about 50% more than the population mean and patented a great deal more (over 5 times) and were active over 50% more time during the period considered (longer tenure).

Table 1 Descriptive statistics for the total population and Academic inventors

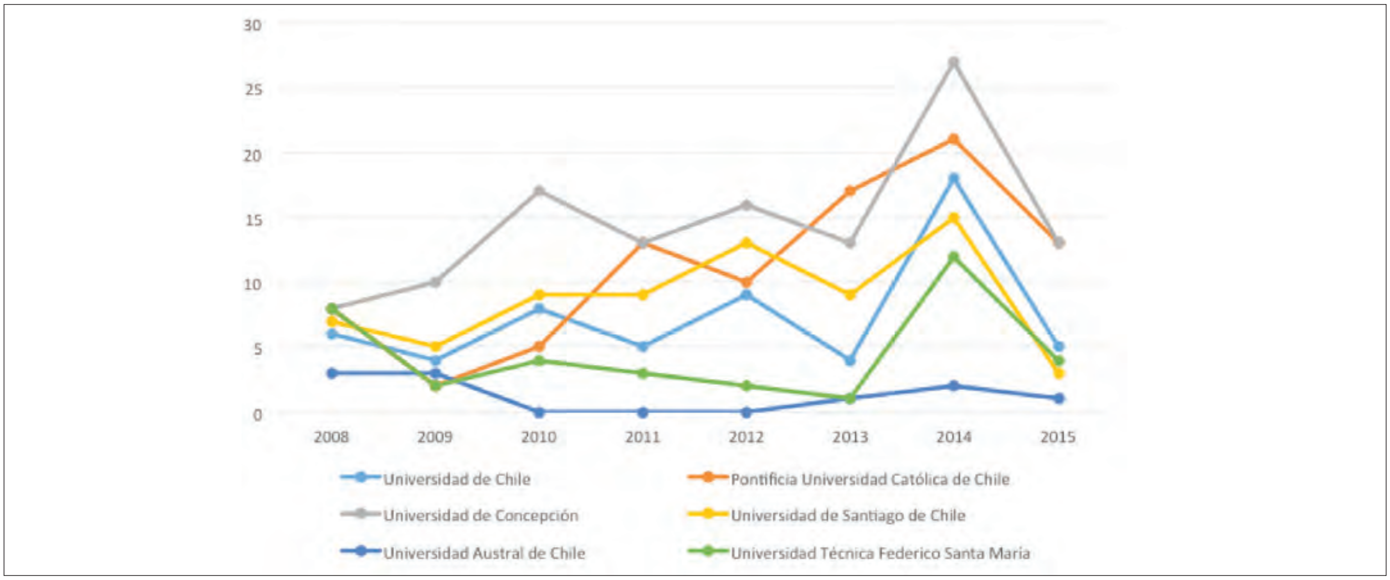
	Total population	**Academic inventors**
N	**111**	**22**
Publications		
Mean	18.8	28.1
Standard deviation	15.2	18.4
Median	15	24.5
Maximum	79	79
Minimum	1	4
Patents		
Mean	0.4	2.1
Standard deviation	1.1	1.4
Median	0	1
Maximum	6	6
Minimum	0	1
Years at UC Engineering		
Mean	13.4	20.6
Standard deviation	10.5	9.5
Median	11	21
Maximum	43	43
Minimum	1	4

Source: Records, Directorate of Transfer and Development Pontificia Universidad Católica de Chile, December 2017 (Patents); and Records, Directorate < of Innovation and Research, School of Engineering, Pontificia Universidad Católica de Chile, December 2017 (Publications).

Patenting and publishing, two channels for technology transfer

A increase in scientific publication and patenting has been recorded during the last few years in Chile. Figure 1 shows total patents assigned to six selected universities in Chile between 2008 and 2015. Between 2008 and 2014, despite fluctuations from year to year, the universities increased significantly the number of patents granted, between 50% and 238%, with the exception of the Austral University, with a decrease of 33%. For example, while the UC was granted eight patents in 2008, in 2014 the figure reached 21, a 163% of increase. Further explanation requires the sudden decrease in activity in 2015, for all of the universities in the sample, possibly due to incentives in 2014 that boosted a specific year, restrictions of public resources for R&D in the immediately preceding years, or an economic slowdown during these years. A supplementary explanation could be recent incentives to universities for technology transfer facilitation, which resulted in the patenting peak observed in 2014.

Figure 1 Selected universities patenting over time

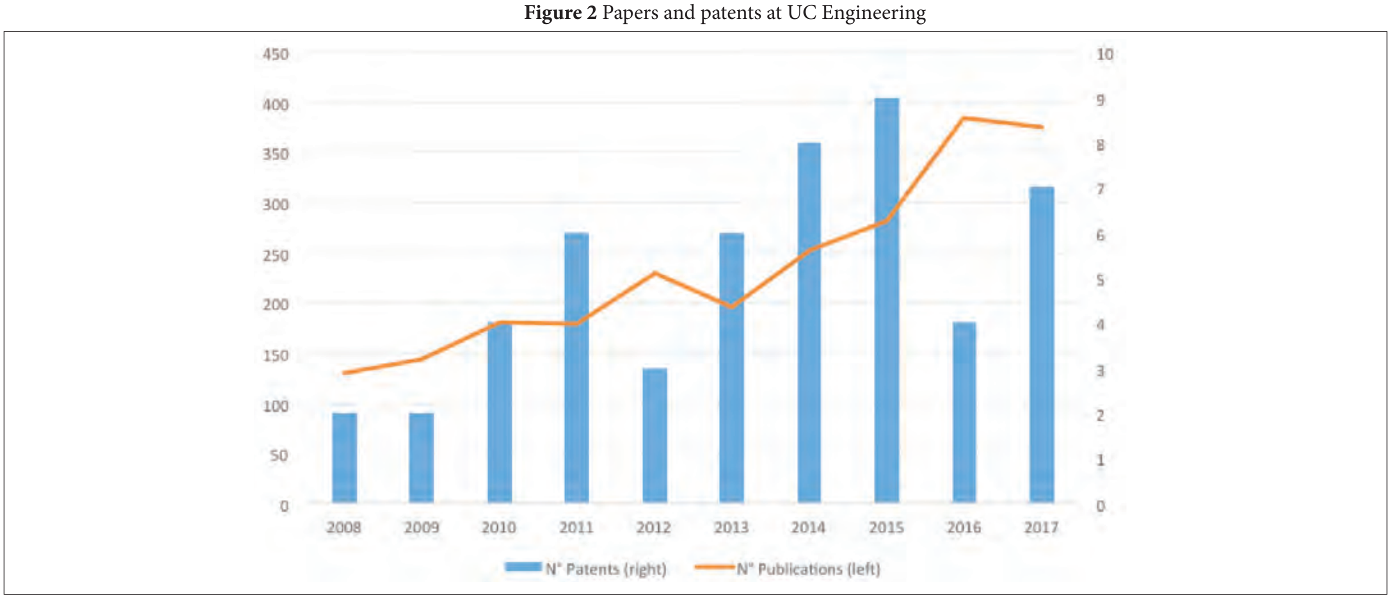


Source: National Institute of Industrial Property (INAPI) records for patent applications, November 2017.

Figure 2 shows patenting and publishing data over time for the academics of UC Engineering that patented or published at least once between 2008 and 2017. On the one hand, a clear upward trend can be seen regarding publications, which increased by 189 % in the period. On the other, patents showed an upward trend, with a decrease in 2012, and a sudden fall in 2016 with a swift recovery in 2017. The difference in patenting in 2015 between Figure 1 and Figure 2 (i.e. between selected universities and UC Engineering), where the selected universities had a sudden decrease in 2015, whereas UC Engineering experienced a fall in the following years could be, allegedly, attributed to recent work to speed up patenting applications at UC Engineering that was completed in 2015. Figure 2 also shows that publication counting is much more higher than patenting. It is much more important, at least measuring counting data. While the average faculty member publishes a ratio between 2.3 and 3.7 papers per year, they produced between 0.03 and 0.09 of a patent. Notwithstanding, it is relevant to note that the number of academics increased steadily from 56 to 111 during the period. To sum up, for UC Engineering in the period considered, publishing rates increased in a threefold manner, the number of academics doubled, and patenting fluctuated with a slightly upward trend that fell in 2016 but recovered in 2017.

There is a potential limitation in respect of possible survivorship bias, a common type of sample selection bias; because our population consists of professors that were in the faculty in December 2017, thus faculty that left over the period has been systematically excluded. It is possible that our results would be distorted if “weak” faculty left.

Figure 2 Papers and patents at UC Engineering



Source: Records, Directorate of Transfer and Development, Pontificia Universidad Católica de Chile, December 2017 (Patents); and Records, Directorate of Innovation and Research, School of Engineering, Pontificia Universidad Católica de Chile, December 2017 (Publications).

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Note that the ratios for data presented in Figure 2 considered the number of full time academics that have published or patented at least once in the period considered. The ratios considered the number of academic tenured each year because faculty increased progressively every year, from 56 in 2008 up to 111 in 2017. It has not been taken into account academics that entered and left faculty between these years.

Table 2: Average publications and patent rates per academic per year

	Publications	Patents	Period
UC Engineering	2.9	0.06	2008 – 2017
MIT, two Engineering Depts.	1.8	0.25	1983 – 1997

Source: Agrawal & Henderson. Putting Patents in Context: Exploring Knowledge Transfer from MIT. Management Science Vol. 48 N°1, January 2002 (MIT Publication and Patents). Records, Directorate of Transfer and Development, Pontificia Universidad Católica de Chile, December 2017 (UC Engineering Patents); and Records, Directorate of Innovation and Research, School of Engineering, Pontificia Universidad Católica de Chile, December 2017 (UC Engineering Publications).

When these averages for faculty members are compared to data gathered by Agrawal & Henderson (2002) in his work focused on two MIT engineering departments (See Table 2), the ratios are 1.5 and 2.0 (average 1.8) for publishing and about 0.25 for patents. This situation suggest a much higher relative importance of publishing over patenting in UC Engineering when compared to the sample from the MIT. An alternative explanation could be that publications do not refer to technologies that could be patented.

It is essential to underline that this comparison is anecdotal. There is a gap in time of about 10 years between the two populations considered, and they are not comparable in a straightforward manner, as UC Engineering is a complete faculty, comprised by ten departments, covering a broad array of engineering disciplines, compared to the MIT's departments of Mechanical Engineering, and Electrical Engineering and Computer Science. In addition, the 2017 Chilean National Innovation Strategy for Development points out that the complete set of national science corresponds to that of a good medium-sized US research university (Consejo Nacional de Innovación para el Desarrollo, 2017).

Table 3 shows the average paper-to-patent ratio of the total population of full time academics, along with the academic inventors, for the ten years for which data could be gathered. There is a clear systematic difference between the ratios for the total population and the group of patenting academics. Above all, only a small fraction of the faculty members (0.20) patent at all. Twenty-two professors have patented between 2008 and 2017, seven of them have between two and six patents in total.

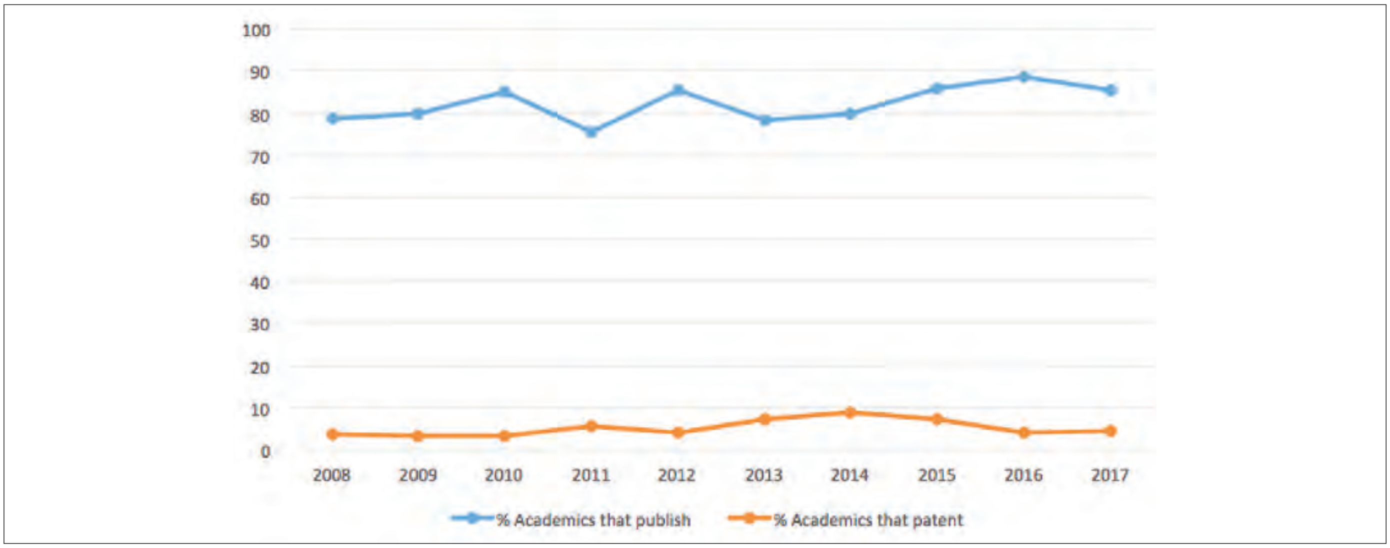
Table 3 Comparative paper to patent ratios, total population and patenting academics

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Total population (Full time academics that publish or patent)	56	60	66	73	76	83	90	99	104	111
Academic inventors (Academics that patent)	2	2	2	4	3	6	8	7	4	5
Academics publishing at least one paper	44	48	56	55	65	65	72	85	92	95
Paper-to-patent ratio (Total population)	65.0	72.0	45.0	29.8	76.3	32.7	31.6	31.3	96.0	53.7
Paper-to-patent ratio (Academic inventors)	16.5	18.0	10.3	7.8	20	7.7	7.4	6.2	17.0	10.0

Source: Records, Directorate of Transfer and Development, Pontificia Universidad Católica de Chile, December 2017 (Patents); and Records, Directorate of Innovation and Research, School of Engineering, Pontificia Universidad Católica de Chile, December 2017 (Publications).

Figure 3 presents the percentage of faculty members who published or patented every year between 2008 and 2017. In consistency with paper-to-patent ratios (Table 3), patenting shows up as a minor activity compared to academic publications. On average, only 5.1% of the faculty patent in any given year. Conversely, over 80% of the faculty publish as a minimum one paper in any given year.

Figure 3 Percentage of faculty members publishing and patenting



Source: Records, Directorate of Transfer and Development Pontificia Universidad Católica de Chile, December 2017 (Patents); and Records, Directorate of Innovation and Research, School of Engineering, Pontificia Universidad Católica de Chile, December 2017 (Publications).

Figure 4 delves into this aspect by presenting the distribution of professors in terms of publishing (4a) and patenting (4b) frequency between 2008 and 2017. It is noteworthy the difference between both distributions. In coherence with Figure 3, the distribution of patenting faculty is highly skewed to the left. About 80% of the professors have never filed a patent application; only 6 faculty members have filed more than 2 applications with a maximum of 6. Distribution of publishing faculty is also skewed to the left, although it has mass up to about 25 papers published, with three prolific authors producing over 40 papers in the period. 72% of the faculty members have published up to 20 papers, 14% more than 30 papers, while 9% have published 35 or more.

In a diagnostic report on academic entrepreneurship at UC Engineering, it was found that more than half of the professors are interested in undertaking academic entrepreneurial activities (Pontificia Universidad Católica de Chile, 2017). However, the main barrier, mentioned by the respondents to a survey, was lack of time to devote to this sort of activity, considering the framework for academic career assessment. Regarding potential proposals for actions to encourage academic entrepreneurship, the most important aspect, in the view of the respondents, was the possibility of having a comprehensive assistance process to support the development of academic entrepreneurial initiatives (Pontificia Universidad Católica de Chile, 2017). However, the idea that organizational support for knowledge transfer may significantly affect the performance of this activity has found limited support; despite similarity in the presence, staffing and capability of TTOs across universities, significant differences have been found in the scale and scope of knowledge transfer activities (Hewitt-Dundas, 2012). In any case, Hewitt-Dundas suggests that capability is less important in shaping knowledge transfer activity than the strategic priorities for knowledge transfer, arguing that even where capability is established, this will not directly generate activity if there is a 'disconnect' between the organizational supports and strategic priorities (Hewitt-Dundas, 2012).

Figure 4a Publication frequency

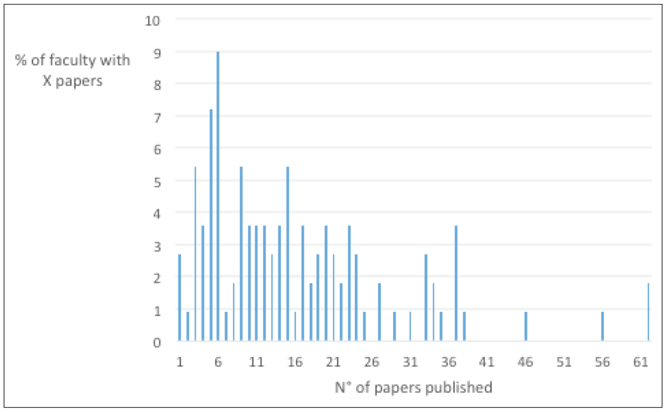
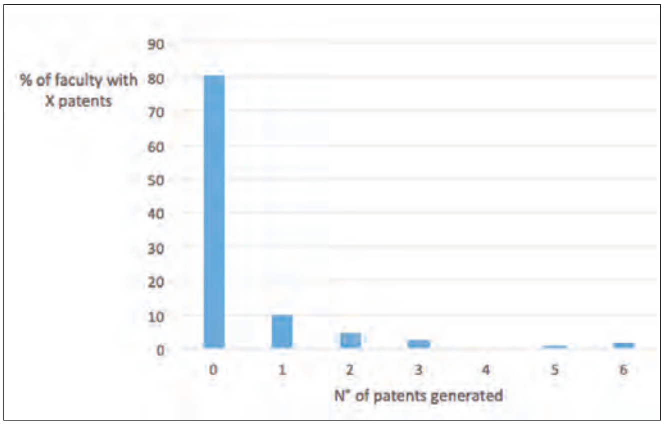


Figure 4b Patent frequency



Source: Records, Directorate of Innovation and Research, School of Engineering, Pontificia Universidad Católica de Chile, December 2017 (Publications); Records, Directorate of Transfer and Development Pontificia Universidad Católica de Chile, December 2017 (Patents).

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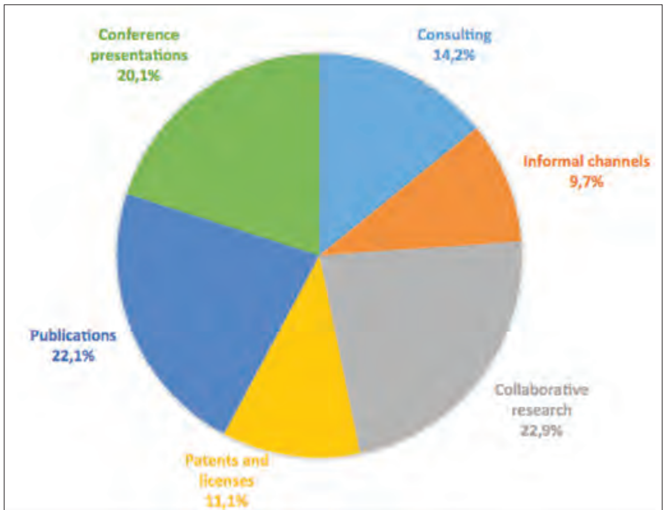
Another piece of evidence, about the relevance of patenting in the transfer that reaches industry, is provided by the answers to the survey. The objective of the survey was to understand the UC Engineering's faculty members' perspective in respect of knowledge and technology transfer and its channels relative importance. Figure 5 shows the response to one of the questions, the relative importance credited to nine different channels of technology transfer. Respondents classified important or very important every channel, ranking collaborative research (22.9%) as the most important knowledge and technology transfer channel to industry, followed closely by publications (22.1%). Only informal channels (ex.: conversations) was ranked below patenting and licensing which reached 11.1%.

Figure 5 Perception of relative importance of knowledge and technology transfer to industry



Source: Survey to UC Engineering faculty, January 2018.

Table 4 presents our survey results and compares them with Agrawal & Henderson (2002). It is noticeable the relatively low importance that UC Engineering faculty members assign to patenting and licensing. It was deemed important or very important as a knowledge and technology transfer channel by 11.1% of the respondents. Both sets of results rank patents and licensing as relatively unimportant (11.1% versus 9.0%), while both sources view consulting, publishing and collaborative research accounting for 59.2% versus 76.3% as important or very important channels. All in all, these results show the relatively low importance that UC Engineering academics assign to patenting and licensing, and is consistent with the hypothesis formulated by Agrawal & Henderson (2002) that patenting constituted a relatively small channel for the transfer of knowledge form university to industry. There are potential limitations associated with the fact that I asked about perceptions of relative importance of knowledge and technology transfer channels, which may be influenced by the channels that involve more interaction with firms that use individual academics' particular knowledge. Faculty might overestimate the relative importance of channels that involve more interaction with firms that use their particular knowledge, and to underestimate the importance of other channels. In addition, I considered only those faculty members that have published or patented at least once. It could be expected that this group overestimate, to some extent, the importance of publishing as over 80% have published as a minimum one paper in any given year; and underestimate patenting and licensing importance, as about 80% of the academics have never filled any patent application.

Table 4 distribution of perceived importance of channels of knowledge and technology transfer to industry

	What is your perception of relative importance of the following knowledge and technology transfer channels (UC Engineering, 2018):	Estimate the portion of the influence your research has had on industry activities, including research, development and production that was transmitted to each of the following channels (MIT, 2000):
	% Total that responded at least "important" (4 on 5-point Likert scale) Normalized to equal 100	% Total Normalized to equal 100
Consulting	14.2	34.4
Informal channels (ex. conversations)	9.7	8.6
Collaborative research	22.9	16.6
Patents and licenses	11.1	9.0
Publications	22.1	25.3
Conference presentations	20.1	7.1

Source: Agrawal & Henderson. Putting Patents in Context: Exploring Knowledge Transfer from MIT. Management Science Vol. 48 N°1, January 2002 (MIT, two engineering departments). Survey to UC Engineering faculty, January 2018 (UC Engineering).

As a whole, all these results are consistent with the idea that patenting and licensing represent a relatively small channel for the transfer of knowledge from academia to industry. It is remarkable, despite the anecdotal nature of the comparison, the extreme importance of publications over patents in terms of production, when comparing UC Engineering to MIT's engineering departments. Average publications per academic are more than 50% more frequent, and patenting per academic over four times less frequent, at UC Engineering, as shown in Table 2. In terms of academic perceptions of the relative importance of knowledge and technology transfer channels, however, patenting and publishing results are much closer in terms of order of magnitude as seen in Table 4. Although UC Engineering academics found relatively more important publication over patenting in a ratio of 2:1, versus 2.8:1 gathered by Agraval & Henderson; in terms of average production of papers per patent per year, ratios are 48:1 versus 7:1 respectively (see Table 2). Furthermore, despite that UC Engineering academics deemed important or very important publications (22%) over patenting (11%), they publish almost 50 times more than patent.

It is not easy to speculate in respect of these differences about patenting versus publishing in terms of perceptions and production due to the complex and systemic nature of technology transfer activity. Causes could be found in the level of sophistication or "demand" of technology transfer from industry, trust of industry in domestic academia capability to deliver on time and budget, lack of match amongst disciplines or characteristics of the knowledge addressed, academic entrepreneurial culture, incentivation schemes for academics, lack of complementarities with other technology transfer channels, to name some. Alternatively, it might be simply that papers are preferred in the domestic industry context over patents as a channel to gain knowledge from academia. This is a matter that remains unclear.

Notwithstanding, despite the numerous pitfalls it has as a measure, focus on patenting appears to be likely to continue providing a useful lens to consider the impact of a university on the economy, even though patents represent a relatively small portion of total knowledge transferred. Reporting ratios of patents in a given year over three-year average and considering these ratios related to resource measures are suggested measures to increase robustness compared to plain patenting ratios per year.

Relationship between patenting and publishing behavior

I now look at the degree to which these two variables, patenting and publishing, are related. From a quantitative perspective at UC Engineering, Figure 6 shows the plot of total patents versus total publications per academic (6a). Similar to Agrawal & Henderson, there is no clear relationship between the two variables, and the plot represent the strong minority of patenting activity compared to publications. A similar plot is then presented where data has been adjusted to the number of years each academic has been active (6b), paper and patent production has been divided by the number of years each professor has been working at UC Engineering during the period investigated. Again, no clear relationship is evident. If anything, the plot shows a few academics that publish heavily but does not patent, and that no academic inventor publish more than four papers per year. In any case, it is noteworthy that all academic inventors at UC Engineering publish, and in general, they publish a big deal more than the total population considered. The latter is a difference from Agrawal & Henderson's research as they found a few academics patenting heavily but not publishing.

Figure 6a Papers versus patents output, 2008 – 2017 (n=111)

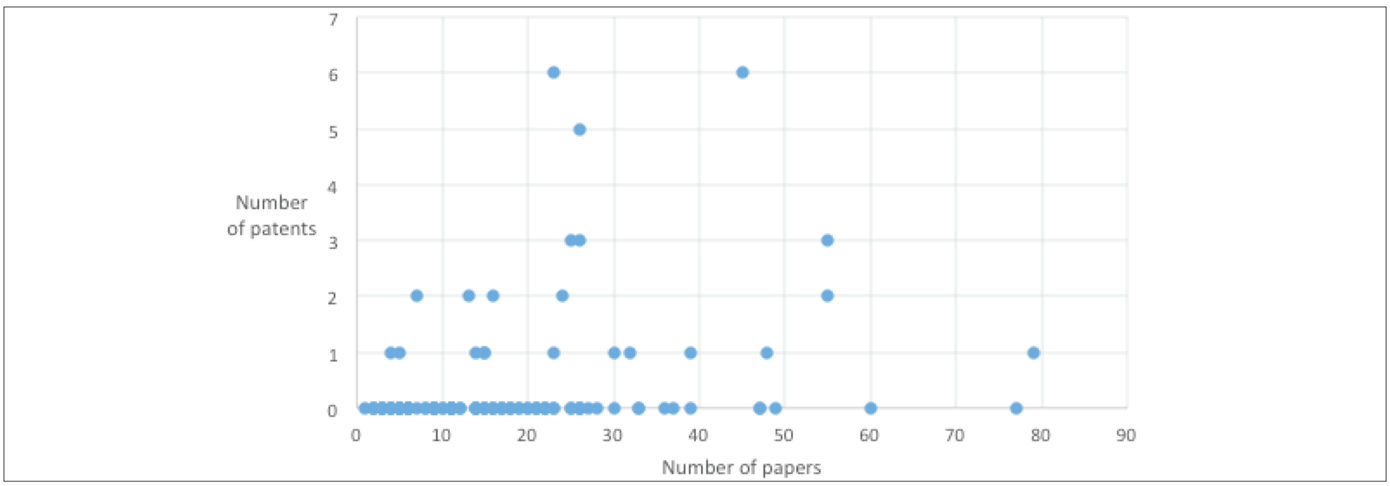
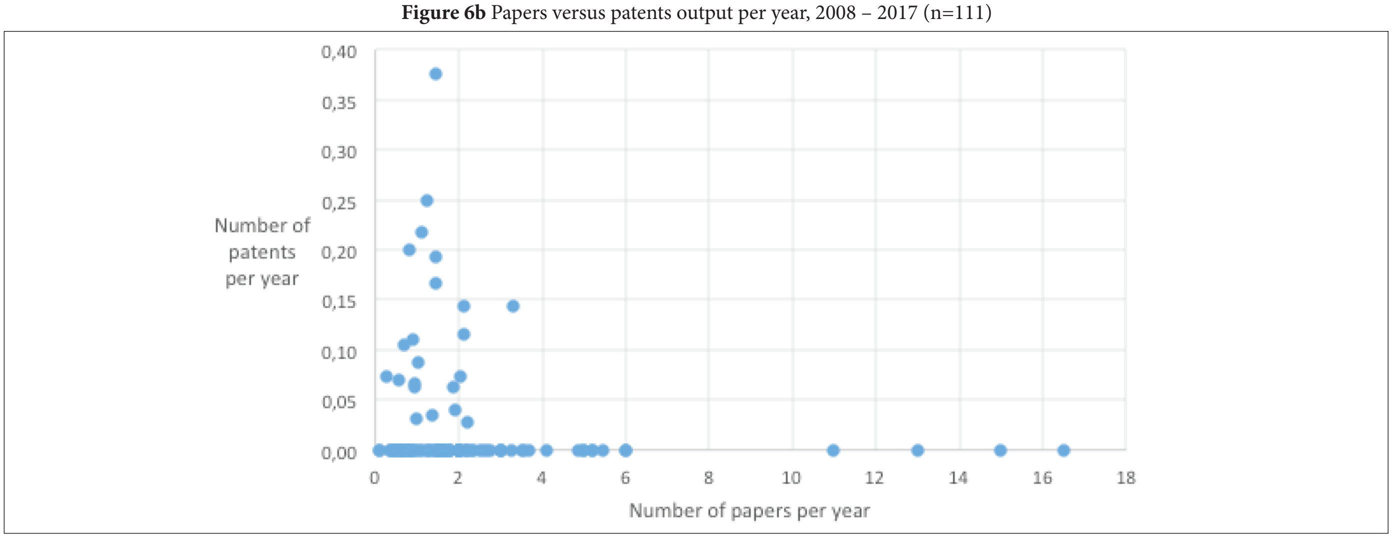


Figure 6b Papers versus patents output per year, 2008 – 2017 (n=111)



Source: Records, Directorate of Innovation and Research, School of Engineering, Pontificia Universidad Católica de Chile, December 2017 (Publications); Records, Directorate of Transfer and Development Pontificia Universidad Católica de Chile, December 2017 (Patents).

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Table 4a presents another step in this analysis looking at academic inventors, showing correlation coefficients for some flow measures of patenting and publishing behavior. Three one-year lag variables have been included to capture any difference arising from the fact that I am using publication and patent application dates. Thus, it is reasonable to assume that a paper and a patent written in the same year would have a difference as publication cycles may last more than one year. First, a low to moderate positive correlation was found across publishing behavior over time (0.37, 0.02, and 0.60 are the correlation coefficients of $Paper_t$ with $Paper_{(t-1)}$, $Paper_{(t-2)}$, and $Paper_{(t-3)}$). Though no clear correlations is evident in respect of patenting behavior over time (-0.02, -0.26, and 0.20 are the correlation coefficients of $Patent_t$ with $Patent_{(t-1)}$, $Patent_{(t-2)}$, and $Patent_{(t-3)}$). Similarly, there is no evidence that patenting and publishing behavior are correlated with each other (-0.19, 0.44, -0.1291 and 0.2531 are the correlation coefficients of $Paper_t$ with $Patent_t$, $Patent_{(t-1)}$, $Patent_{(t-2)}$, and $Patent_{(t-3)}$ respectively).

Table 4a Correlation matrix: patenting and publishing

	$Paper_t$	$Paper_{t-1}$	$Paper_{t-2}$	$Paper_{t-3}$	$Patent_t$	$Patent_{t-1}$	$Patent_{t-2}$	$Patent_{t-3}$
$Paper_t$	1							
$Paper_{t-1}$	0.3745	1						
$Paper_{t-2}$	0.0220	0.4073	1					
$Paper_{t-3}$	0.6026	0.4433	0.2990	1				
$Patent_t$	-0.1948	-0.1785	-0.2126	-0.4609	1			
$Patent_{t-1}$	0.4415	0.0203	-0.0820	0.3080	-0.0199	1		
$Patent_{t-2}$	-0.1291	-0.1904	0.0994	0.1746	-0.2592	-0.0754	1	
$Patent_{t-3}$	0.2531	-0.0168	0.0679	-0.0314	0.1979	-0.0690	-0.3499	1

In short, on the one hand a low to moderate positive correlation was found across publishing over time; on the other, the number of papers written three years ago is not related to the patent applications filed today, or in any of the last three years. The central finding remains, patenting and publishing activity does not appear to be significantly related. This is a difference with Agrawal & Henderson, as they found a clear correlation across publishing and across patenting behavior, but little evidence of patenting and publishing correlation.

Table 4b Correlation matrix: patenting and publishing (Stock measures)

	Total papers	Total patents	Total years	Papers per year	Patents per year
Total papers	1				
Total patents	0.1578	1			
Total years	0.5318	0.3395	1		
Papers per year	0.6044	-0.1102	-0.2162	1	
Patents per year	-0.2254	0.6413	-0.3619	0.0724	1

In a similar manner, Table 4b presents correlation coefficients for stock measures of patenting and publishing behavior for academic inventors, including totals and averages. Although a measure of correlation is present (0.16) between total papers and total patents, this is largely caused by the variance in the numbers of years that the academics have been working at the university. When this factor is controlled for by taking paper and patent output averaged, the coefficient is much smaller (0.07). Again, no correlation is apparent between publishing and patenting behavior.

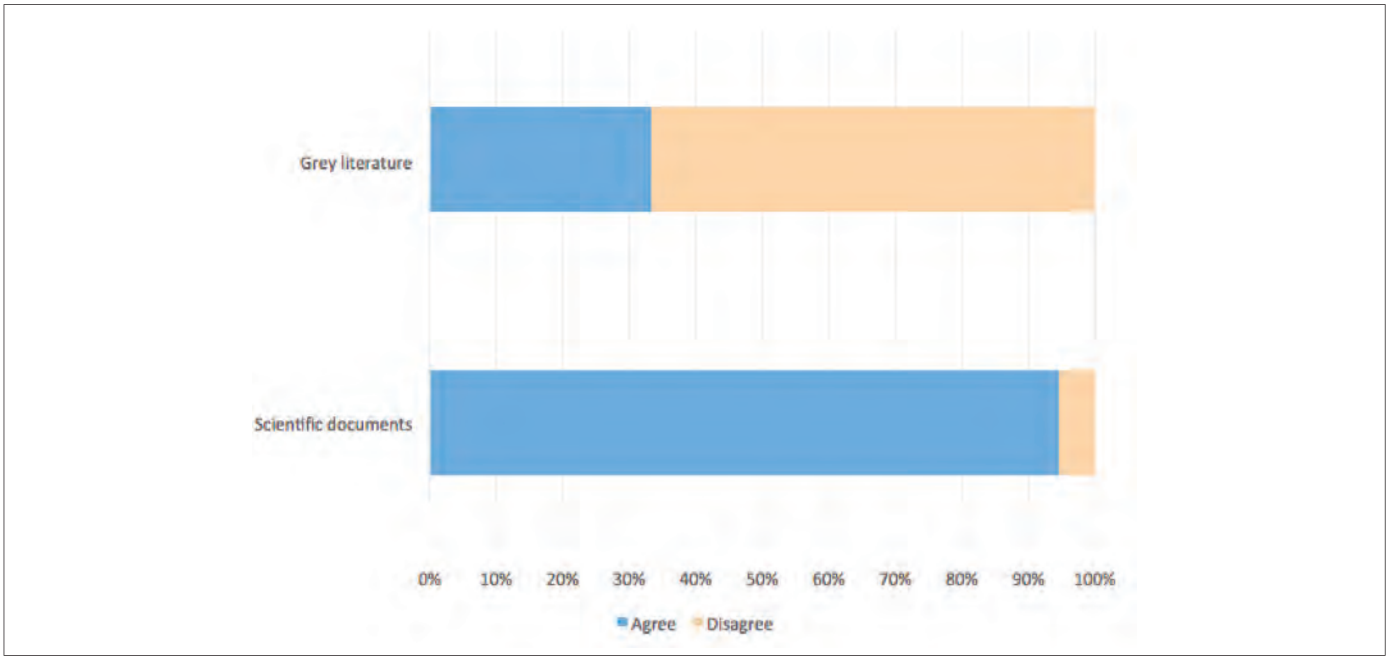
Patens and papers: substitute or complement?

Now, I pay attention to the extent to which patents are complementary or substitute for publications in the university context. As argued in Section 2, some authors suggest a complementary effect whilst others have found evidence of a crowding out effect. So far, our evidence suggest no significant relation amongst them. In this respect, as shown in Figure 7, when UC Engineering academics were asked to what extent knowledge in their individual technological field is primarily expressed in 'scientific documents' (e.g. journal articles, conference papers, and proceedings) or in 'grey literature' (e.g. patents, industrial reports, confidential memorandums, discussion lists), they chose clearly 'scientific documents' over 'grey literature'. Thus, in the academics´ perspective, knowledge in their respective technological field is mainly expressed in scientific documents instead of grey literature. This is consistent with our data that shows the strong prevalence of publishing over patenting.

If patenting activity is a substitute for publishing, it would be expectable publication rates negatively correlated to patent figures. However, correlation coefficients are non significant and even they alternate sign over time (Tables 4a and 4b). Thus, our results suggest that no substitution effect is evident among patenting and publishing activity. By the same token, based on our correlation results complementarity amongst patenting and publishing could be neglected as well. In addition, when publication means of total population and academic inventors are divided by the respective average number of years at UC Engineering (see Table 1), the ratios of publications per year (1.40 and

1.36 respectively) are rather similar. This suggest that seniority would not be an influential factor in terms of average publication production. Conversely, when patenting means are controlled in the same manner (0.03 and 0.09 respectively), the difference is substantial, suggesting that seniority could be an influential factor on patenting behavior.

Figure 7 Primary expression of UC Engineering's academics knowledge



Source: Survey to UC Engineering faculty, January 2018.

Conclusion

What are the findings of this exploratory research? I began this paper by asking to what extent patents are representative of the magnitude and impact of the knowledge transferred from university to industry. This question is highly relevant for policy-makers who attempt to encourage the diffusion of university-generated technologies within the wider economy. Our analysis of UC Engineering has shown some conclusions.

The steady increase in the number of academics at UC Engineering since 2008 until 2017 (56 to 111), has been accompanied by growth in annual publishing (130 to 376) and patenting (2 to 7) outputs at UC Engineering. Patenting is an activity undertaken by a small portion of the faculty members (about 5% in any given year), resulting in a relatively small channel for the transfer of knowledge and technology to industry, in consistency with the widely accepted idea in this respect. Moreover, 80% of the faculty members have never filed a patent application. Despite that UC Engineering faculty members deem publications (22%) more important than patenting (11%) as a channel to transfer technology to industry, I found that they publish, in average, almost 50 times more than patent.

An anecdotal comparison of UC Engineering and two engineering departments at the MIT (Agrawal & Henderson, 2002) suggests a much higher relative importance in terms of production counting, for the former, of publication over patenting activity as a technology transfer channel (48:1 versus 7:1 are the respective average publication to patent rates per academic per year). In average, UC Engineering academics publish more (3:2) but patent a big deal less (1:4) compared to the MIT sample. Neither complementary nor substitution effect was found amongst publishing and patenting. For UC Engineering, only a low to moderate positive correlation was found across publishing behavior over time, but not across patenting. Seniority was not found to be related with publishing behavior, but academic inventors compared to the total group of academics tend to have much longer tenures (20.6 versus 13.4 years in average). The UC is the Chilean university with the higher number of patent applications in country. In this respect, in the US, the MIT is one highly prolific university. However, although in terms of relative importance of publishing over patenting, as a technology transfer channel, UC Engineering and the sample from the MIT are relatively similar in the perception of faculty (2:1 versus 2.8:1); in terms of production counting, the ratios showed a substantial difference. This is the biggest dissimilarity that I found in our comparison. I can only speculate about this situation, suggesting that at the level of knowledge transfer activity portrayed, differences about publishing versus patenting might be related to the complex and systemic nature of technology transfer activity. Also, in the sort of "demand" of technology transfer from industry, weak trust of industry in domestic academia's capability to deliver on time and budget, divergence amongst the characteristics of the knowledge addressed, publication-oriented academic culture, not completely aligned incentivation schemes for academics, lack of complementarities with other technology transfer channels, to name some.

In respect to the exploration about the degree to which patents are representative of the magnitude of the knowledge transferred from university to industry, I found that in UC Engineering, in general, during the last 10 years patenting and publishing activity have been increasing steadily. However, patenting is perceived by academics as a relatively less important technology transfer channel compared to publishing (2:1), and in terms of production counting it appears even less relevant (almost 50:1). It is important to stress that constraints on the data available currently limits our ability to explore this specific type of technology transfer activity in a more granular manner or expand our analysis to consider other technology transfer channels. Notwithstanding, the anecdotal comparison with the MIT lead us to ask if there are some obstacles or barriers impeding a more robust patenting activity; or even hampering other technology transfer channels. Taking into account the magnitude of the differences found, it appears of the utmost importance to detect and overcome obstacles and barriers considering increasing pressures from elements as diverse as societal expectations, fast technological change, firms' innovation needs and market pressures inter alia.

In the broader knowledge and technology transfer context, availability of financial resources to undertake research and organizational attention to academics productivity balancing publishing and patenting activity, appear as essential inputs. The former from public or private sources, and the latter by means of academic entrepreneurial culture and academic career promotion rules. Another key element is alignment to the strategic objective of helping domestic economy to find its future and sustainable competitive advantage. Provided that these fundamentals are in place, a more straightforward transfer of academic knowledge into the industrial domain could be expected. Clearly, there is much to do to advance knowledge. On the one hand, a finer analyses of academic activity. Closer attention to faculty behavior, in respect of multiple technology transfer channels, across departments over time should be enlightening. Building and maintaining robust databases could assist more effective management of academic activity and interaction with industry. On the other, the addition of the industrial counterpart perspective would enable a more comprehensive perspective.

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Calidad de la Relación Universidad-Empresa en una Universidad Pública de Colombia

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Resumen: El presente estudio tiene como objetivo identificar el papel de la función de marketing en los procesos de transferencia tecnológica universitaria, mediante la definición de hipótesis fundamentadas en el conocimiento científico del marketing y basadas en el caso de una universidad pública colombiana. Se ha diseñado un modelo de hipótesis que refleja la calidad de la relación, analizando constructos como satisfacción, confianza, compromiso y lealtad en la relación Universidad-Empresa, mediante un análisis confirmatorio. En los resultados, se evidencian los constructos más relevantes para gestionar y establecer relaciones de largo plazo entre la universidad analizada y las Empresas, lo que permite pasar de una transferencia tecnológica transaccional a una vista desde lo relacional.

Palabras Clave: Relación Universidad-Empresa; transferencia tecnológica universitaria; marketing relacional.

Abstract: ***Title:*** *University-Industry Relationship Quality in a Public University of Colombia*
The objective of this study is to identify the role of the marketing function in university technology transfer processes, through the definition of hypotheses based on the scientific knowledge of marketing and the bases in the case of a colombian public university. It has been designed a hypothesis model that reflects the quality of the relationship, analyzing constructs such as satisfaction, trust, commitment and loyalty in the University-Industry relationship, through a confirmatory analysis. In the results, the most relevant constructs for the management and the long-term relationships between the university and the companies are evidenced, which allows to pass from a technological transaction to a relationship view.

Keywords: University-Industry relationship; university technology transfer; relationship marketing.

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Introducción

El presente estudio desarrolla un análisis que contribuye al reconocimiento de la calidad de la relación entre la Universidad y la Empresa desde la perspectiva del marketing relacional, el cual, se basó en primer lugar, en una revisión de literatura, constituida con argumentos, conceptos y avances actualizados de la literatura académica, y en segundo lugar, en un análisis confirmatorio aplicado en el contexto de una universidad pública colombiana.

En la literatura se ha abordado la relación Universidad-Empresa desde la perspectiva de la innovación, encontrando que un factor determinante para que se dieran de forma cercana y organizada fue principalmente el de las guerras, ya que allí se evidenció la importancia de establecer una sinergia entre las universidades como generadoras de conocimiento, la industria como desarrolladora de tecnología y recursos, y el Estado como generador de políticas y ente regulador de las relaciones (Sábato y Botana, 1968; Zacarías y Martín, 2011).

Diferentes autores han descrito esta relación bajo diferentes modelos (Bozeman, 2000; Cook, Uranga, y Etxebarria, 1997; Leydesdorff, 2012; Leydesdorff y Etzkowitz, 1998; Lundvall, 1997; Sábato y Botana, 1968), dentro de los que se resaltan el triángulo de Sábato (Sábato y Botana, 1968) y el modelo de la triple hélice (Leydesdorff y Etzkowitz, 1998) por su gran acogida.

A partir de la ley Bayh Dole en los 80's hubo se evidencia un incremento en los estudios sobre la relación Universidad-Empresa, fortaleciéndose aún más en los 90´s, interactuando usualmente mediante las patentes, acuerdos de licencia e investigación conjunta (Barcelo, España, y Prieto, 2012). Para facilitar estas relaciones, se crearon las oficinas de transferencia tecnológica que se encargaran del proceso de intermediación para las negociaciones entre la Universidad y la Industria (Martinelli, Meyer, y von Tunzelmann, 2008).

Existen numerosos estudios sobre la relación Universidad-Empresa abordados desde el punto de vista de la transferencia tecnológica, sin embargo la interacción entre estos actores sigue presentando fallas (Cyert y Goodman, 1997; Lee, 2000), por lo que algunos autores han tratado de llegar a una solución abordando el problema desde diferentes perspectivas, como es el caso del enfoque relacional basado en el marketing (Plewa, Quester, y Baaken, 2005). Sin embargo, los aportes en este tema aún son limitados (Rosendo Ríos, 2013).

En Colombia, en materia de transferencia tecnológica aún se está en proceso de estructuración apoyado por el Sistema Nacional de Ciencia, Tecnología e Innovación, SNCTI que se crea a través del Departamento Administrativo de Ciencia, Tecnología e Innovación, Colciencias, con el fin de "promover y consolidar mecanismos de inversión en las actividades de investigación y desarrollo y la formación del capital humano en CTI como instrumentos determinantes del desarrollo económico, social y ambiental" (DNP, 2009).

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El SNCTI permite diferentes procesos de vinculación y actividades conjuntas entre las universidades y las empresas, los cuales, se dan en varias ocasiones, gracias a las convocatorias y diferentes iniciativas que el Estado hace para propiciar la transferencia de conocimiento, generando su impacto en el creciente trabajo entre la academia y la industria (Bozeman y Gaughan, 2007), aunque el escenario ideal sería que las Empresas incrementen su compromiso de invertir en generar nuevos desarrollos e investigaciones conjuntas con las Universidades, sin esperar la intervención del Estado.

Es por esto, que este estudio pretende realizar un acercamiento de tipo exploratorio y descriptivo para entender las relaciones Universidad-Empresa desde el punto de vista relacional, identificando el papel de la función del marketing en los procesos de transferencia tecnológica universitaria, mediante la definición de hipótesis fundamentadas en el conocimiento científico del marketing, y basadas en el contexto de una universidad pública colombiana.

Marco teórico y desarrollo de hipótesis

La literatura sobre transferencia tecnológica en el marco de la relación Universidad-Empresa se ha enfocado principalmente desde un punto de vista transaccional más que de uno relacional (Guerin, 1999; Plewa et al., 2007), lo que podría deberse a la tradicional perspectiva de hacer énfasis en el rol de las Universidades que solo transfieren sus resultados de investigación a otros actores como la sociedad y la empresa (Azagra-Caro, Gutiérrez-Gracia, y Fernández-de-Lucio, 2006; Castro, Cortés , Gelench, y Costa, 2005; Gunasekara, 2005; Necoechea-Mondragón, Pineda-Domínguez, y Soto-Flores, 2013).

Sin embargo, la relación Universidad-Empresa toma diversas formas, como es el caso de actividades en conjunto de I+D, teniendo una relación mucho más estrecha que la tradicional generada por la transferencia de resultados de investigación y comercialización (Perkmann y Walsh, 2007). En el contexto de esta relación, la universidad y la empresa crean una red organizacional colaborativa donde ambos actores realizan tareas en conjunto con objetivos diferentes, pero con una alta dependencia el uno del otro para lograr los resultados esperados, lo que implica la necesidad de un enfoque que ayude a gestionar estas relaciones cada vez más complejas (Mora-Valentin, Montoro-Sanchez, y Guerras-Martin, 2004; Perkmann y Walsh, 2007; Plewa et al., 2013).

Por lo anterior, es claro que el papel del marketing en la transferencia tecnológica es crucial, permitiendo a las universidades, además de la docencia y la investigación, jugar un rol activo en la sociedad mediante el establecimiento de relaciones con las empresas, ayudando a reducir la brecha entre la comunidad académica y empresarial (Frasquet et al., 2011; Lantos, 1994).

Desde el marketing se ha abordado la relación Universidad-Empresa desde la perspectiva del marketing relacional (Frasquet et al., 2011; Helgesen, 2008; Marzo-Navarro, Pedraja-Iglesias, y Rivera-Torres, 2009; Plewa et al., 2005), conocida como el proceso de identificar, establecer, mantener, mejorar, y cuando sea necesario terminar las relaciones con los clientes y otros stakeholders, de forma rentable, de tal manera que se cumplan los objetivos de las partes interesadas (Grönroos, 1997), ya que lo que se busca es definir qué factores son determinantes para generar relaciones duraderas entre estos actores. El marketing relacional ha representado un cambio significativo en la concepción del marketing desde un punto de vista meramente transaccional a uno enfocado en establecer relaciones de largo plazo (Lee, 2000; Mora-Valentín et al., 2004; Plewa et al., 2007), mismo cambio que se espera se genere en la relación Universidad-Empresa.

Siguiendo la perspectiva del marketing relacional, se identificaron cinco constructos que pueden ser útiles para explicar la relación Universidad-Empresa con un enfoque académico y profesional, como son la satisfacción, la confianza, el compromiso y la lealtad, los cuales influyen en la construcción de relaciones duraderas (Chenet, Dagger, y O'Sullivan, 2010; Gil-Saura, Frasquet-Deltoro, y Cervera-Taulet, 2009; Huntley, 2006).

En primer lugar, el valor percibido es definido por como la evaluación global por parte del consumidor de la utilidad de un producto, basada en la percepción de lo que se recibe y de lo que se entrega (Zeithaml, 1988). Así mismo, se define como todos los factores cualitativos y cuantitativos, subjetivos y objetivos inmersos en todo el proceso de compra (Schechter, 1984).

En segundo lugar, la satisfacción es considerada como la evaluación de las expectativas percibidas sobre un producto o servicio y la realidad (Oliver, 1999)

En tercer lugar, la confianza es vista como una creencia, sentimiento, o la expectativa sobre la confiabilidad de un compañero de intercambio que resulta de la experiencia de la pareja, la fiabilidad o la intencionalidad (Blau, 1964; Moorman, Zaltman, y Deshpande, 1992; Pruitt, 1981; Rotter, 1967).

En cuarto lugar, el compromiso se concibe como la intención de establecer y mantener relaciones de largo plazo (Moorman et al., 1992). Esta intención es demostrada con promesas implícitas o explícitas de beneficio para las partes involucradas, adicionalmente, es necesario hacer sacrificios para obtener dichos beneficios (Marzo-Navarro et al., 2009).

En quinto lugar, la lealtad es vista como la cantidad de re-compras que se hace a la misma empresa, considerando solo esa oferta y no haciendo ninguna búsqueda relacionada con la misma (Newman y Werbel, 1973; Oliver, 1999).

Con la definición de las hipótesis, se busca evidenciar desde la literatura del marketing relacional cómo se comportan los constructos planteados en la relación Universidad-Empresa, analizando el caso específico de la Universidad de Antioquia.

En la literatura del marketing, la satisfacción es considerada como constructo influenciador de la confianza (Oliver, 1999; Zeithaml, Berry, y Parasuraman, 1996), ya que un cliente puede generar confianza tras una acumulación de satisfacción en la experiencia del servicio.

Por otro lado, diferentes autores toman la satisfacción como constructo influenciador de la lealtad (Gil-Saura et al., 2009; Jones y Sasser, 1998; Morgan y Hunt, 1994; Oliver, 1999), ya que la lealtad sin satisfacción difícilmente se da.

H1: La satisfacción influye positivamente sobre la confianza en la relación U-E

H2: La satisfacción influye positivamente sobre la lealtad en la relación U-E

Del mismo modo, se ha abordado la confianza como influenciador del compromiso (Achrol, 1991; Hrebiniak, 1974; McDonald, 1981; Moorman et al., 1992; Morgan y Hunt, 1994; Rotter, 1967), ya que la confianza es un factor importante para quienes quieren llegar al compromiso (Hrebiniak, 1974). Existe una relación directa entre la confianza y la lealtad (Umar y Bahrun, 2017; Setyawati y Raharja, 2018), sin embargo, algunos autores como Gil, Frasquet, y Cervera, (2009); Tian et al., (2008) encontraron relación significativa por medio de un efecto indirecto a través del compromiso.

H3: La confianza influye positivamente sobre el compromiso en la relación U-E

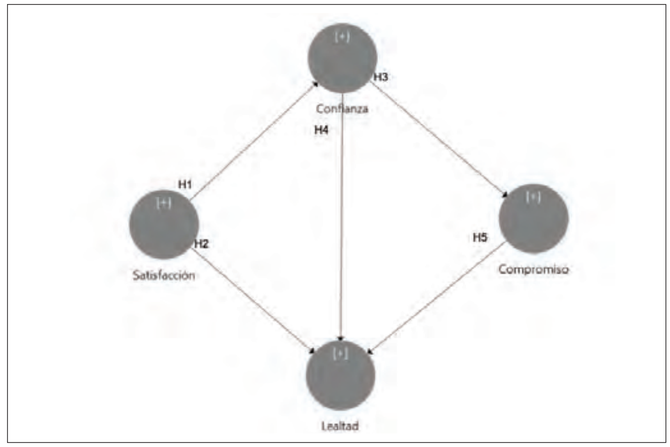
H4: La confianza influye positivamente sobre la lealtad en la relación U-E

Adicionalmente, el compromiso en la literatura ha sido identificado como influenciador de la lealtad (Moorman et al., 1992; Morgan y Hunt, 1994; Ulaga y Eggert, 2006), ya que en una relación ante un alto grado de compromiso, es muy posible generar lealtad.

H5: El compromiso influye positivamente sobre la lealtad en la relación U-E

Estas hipótesis se ven representadas en la Figura 1., con el fin de evidenciar las relaciones de forma más clara.

Figura 1. Modelo Conceptual e Hipótesis. Software SmatPLS



Metodología

Este estudio propone un modelo conceptual basado en los cuatro constructos que conforman la calidad de la relación en el contexto de una Universidad pública colombiana, la cual ha estado estructurando su proceso de transferencia tecnológica hace aproximadamente 14 años, buscando siempre el mejoramiento de la relación con las empresas.

Para el trabajo de campo en concordancia con los objetivos y las proposiciones planteadas en el modelo, se logró el análisis de la relación Universidad - Empresa en perspectiva de la calidad de la relación, esto para el caso puntual de los clientes que ha tenido la Universidad en los últimos 8 años.

Para este caso, se realizó una fase de análisis exploratorio compuesto por tres etapas, en la primera se hizo una revisión de literatura exhaustiva para dar cuenta de los antecedentes y estudios previos desarrollados que permitieron la identificación de los constructos adecuados para el planteamiento del modelo. En la Tabla 1 se evidencian los constructos así como las escalas utilizadas para el proceso de medición, las cuales fueron adecuadas al contexto y al objeto de estudio.

Tabla 1. Escalas de medición. Elaboración propia

Constructo	Código	Ítem	Bibliografía
	ST1	Obtener servicios con la Universidad ha sido una buena experiencia	
	ST2	Estamos seguros que fue una buena decisión contratar servicios con la Universidad	
Satisfacción	ST3	Estoy satisfecho con los esfuerzos que la Universidad está haciendo con clientes como nosotros	Oliver (1980); Voss, Parasuraman, y Grewal (1998); Wulf, Odekerken-Schröder, y Iacobucci (2001)
	ST4	Estoy satisfecho con la relación que tenemos con la Universidad	
	CF1	Confío en que la Universidad es honesta	
	CF2	Creo que la Universidad cumple sus promesas	
	CF3	La Universidad tiene experiencia y usualmente conoce la mejor solución para cada situación	Crosby, Evans, y Cowles (1990); Ganesan (1994); Kumar, Scheer, y Steenkamp (1995); Lashley y Morrison (2003)
Confianza	CF4	Creo que la Universidad de es confiable	
	COM1	La Empresa tiene el compromiso de continuar una relación con la Universidad.	
	COM2	La relación entre la Empresa y la Universidad es una alianza de largo plazo.	
Compromiso	COM3	Si la Universidad ofrece otros servicios que la empresa necesite, los contrataría con ésta	Anderson E. y Weitz (1992); Price y Arnould (1999); Tax, Brown, y Chandrashekaran (1998)
	LT1	La Empresa considera a la Universidad como la primera opción para adquirir servicios	
	LT2	La Empresa piensa hacer negocios con la Universidad en los próximos años	
Lealtad	LT3	Las oportunidades de continuar la relación con la Universidad son muy buenas	Auh, Bell, McLeod, y Shih (2007); Bell, Auh, y Smalley (2005); Zeithaml et al. (1996)

En la segunda etapa, se definió el tamaño de la muestra teniendo en cuenta que debían cumplir criterios de ser clientes de la Universidad de Antioquia, haber contratado servicios con la Universidad de Antioquia desde el 2010 hasta la fecha, teniendo como resultado una población finita (Scheaffer, Mendenhall, y Ott, 2007) de 143 empresas, de la cual con un nivel de confianza del 95% se estima una muestra de mínimo 57 empresas para ser representativa.

Además, se construyó una muestra no probabilística a conveniencia de los clientes que contrataron servicios con la Universidad de Antioquia desde el 2010, enviando invitación a participar en una encuesta online a las 143 empresas y obteniendo respuesta de 61 lo que la hace representativa según las condiciones dadas. En la tabla 2 se evidencia la ficha técnica del estudio.

Tabla 2. Ficha Técnica de Trabajo de Campo. Elaboración propia

Lugar	Medellín- Antioquia- Colombia
Tamaño de la muestra	61 organizaciones - muestreo por juicio experto.
Unidad de muestreo	Directores y responsables de los procesos de relacionamiento para actividades de ciencia, tecnología e innovación
Método de la recolección	Correo electrónico, llamada telefónica y visitas personales.
Escala	Likert
Instrumento de recolección	Encuesta estructurada- estudio cuantitativo mediante un diseño descriptivo de corte transversal simple
Método de análisis	Análisis factorial confirmatorio y de ecuaciones estructurales

Por último, se definieron hipótesis con los constructos identificados en la revisión de literatura en la relación Universidad-Empresa, para el caso puntual de la Universidad en estudio, realizando un análisis descriptivo, para dar una explicación al fenómeno mediante el uso de instrumentos de medición estructurados aplicados a la muestra definida.

Resultados

Tras comprobar mediante la prueba Shapiro Wilks, ideal para muestras pequeñas (Razali y Wah, 2011; Shapiro y Wilk, 1965), que los datos no se comportan de acuerdo a una distribución normal, se procedió al análisis mediante el bootstrapping utilizando la muestra de 61 empresas y las respuestas proporcionadas para cada constructo se robustece la información para proceder a correr el modelo y posteriormente realizar el análisis factorial confirmatorio y de ecuaciones estructurales propuesto en la Figura 1 utilizando Smart- PLS 3.0. A partir de esto se determina la validez y la fiabilidad del modelo.

Tabla 3. Cargas Externas. Elaboración propia

		Muestra original	Media de la muestra	Error estándar	Estadístico t	Valor p
C1	Confianza	0,779	0,771	0,068	11,387	0,000
C2	Confianza	0,788	0,791	0,046	17,121	0,000
C3	Confianza	0,716	0,702	0,106	6,770	0,000
C4	Confianza	0,815	0,806	0,062	13,043	0,000
CM1	Compromiso	0,851	0,849	0,042	20,126	0,000
CM2	Compromiso	0,811	0,815	0,054	14,920	0,000
CM3	Compromiso	0,762	0,754	0,064	11,881	0,000
L1	Lealtad	0,706	0,685	0,139	5,064	0,000
L2	Lealtad	0,863	0,858	0,051	16,918	0,000
L3	Lealtad	0,828	0,831	0,048	17,438	0,000
S1	Satisfacción	0,802	0,800	0,055	14,703	0,000
S2	Satisfacción	0,915	0,914	0,020	46,685	0,000
S3	Satisfacción	0,810	0,808	0,053	15,286	0,000
S4	Satisfacción	0,872	0,871	0,029	29,768	0,000

Los resultados de la tabla 3 evidencian la fiabilidad de la escala, lo que indica que las variables son el reflejo de que el constructo existe; los cuatro constructos muestran una fuerza alta hacia la variable y una menor de la variable al error; para todos los casos las cargas son superiores a 0,6 y los valores de p inferiores a 0,05, evidenciando la consistencia entre las variables.

Tabla 4. Alpha de Crombach

	Media	Desviación Estándar	Alpha de Crombach
Confianza	4,160	2,387	0,778
Compromiso	4,071	2,050	0,734
Lealtad	3,814	1,812	0,723
Satisfacción	3,922	2,884	0,872

La tabla anterior confirma la fiabilidad a través del Alpha de Crombach, que en este caso son mayores a 0,7 (Nunnally y Bernstein, 1994). Así mismo, se muestra la media y la desviación estándar de cada uno de los constructos.

Por otro lado, de acuerdo con Hair et al. (2016), para validar los estudios en PLS, es necesario adoptar las siguientes etapas para el análisis del modelo: I) Instrumento de medida para los constructos: evaluando la consistencia interna, fiabilidad, validez convergente y divergente; II) Medida del modelo estructural: Evaluando los coeficientes de determinación y la significancia de las relaciones estructurales. En la tabla 5, se evidencian los criterios mínimos para analizar el modelo construido.

Tabla 5. Criterios mínimos establecidos para indicadores PLS-SEM (Hair, et al. 2016)

Etapas de Validación	Indicadores	Criterios Mínimos
Instrumento de medida para constructos	Consistencia Interna: Alpha de Cronbach (CA)	=>0,7 (Nunnaly y Bernstein, 1994).
	Fiabilidad: Fiabilidad Compuesta (CR)	=>0,7 (Fornell y Larcker, 1981).
	Validez Convergente: Varianza Extraída (AVE)	=>0,5 (Fornell y Larcker, 1981).
	Validez Convergente: Tamaño de cargas y significancia	=>0,6 (Bagozzi and Yi, 1988) y p<0,001; p<0,05; p<0,01.
	Validez Discriminante: Heterotrait-Monotrait (HT/MT)	=< 0,9 (Henseler et al.,2014)
Modelo Estructural	Coeficiente de determinación (Valor R^2)	=> 0,75 y => 0,51 relevante, =< 0,50 y => 0,26, moderado, y < 0,25 débil (Hair et al., 2013)
	Significancia de las relaciones estructurales	p<0,001

A continuación, se presentan los resultados para analizar el modelo propuesto, evaluándolos según los criterios mínimos presentados en la Tabla 5.

Tabla 6. Fiabilidad y validez convergente para constructos

Dimensión	Ítems	Cargas	CA	CR	AVE
Confianza	C1	0,779***	0,778	0,858	0,601
	C2	0,788***			
	C3	0,716***			
	C4	0,815***			
Compromiso	CM1	0,851***	0,734	0,850	0,654
	CM2	0,811***			
	CM3	0,762***			
Lealtad	L1	0,706***	0,723	0,843	0,643
	L2	0,863***			
	L3	0,828***			
Satisfacción	S1	0,802***	0,882	0,913	0,724
	S2	0,915***			
	S3	0,810***			
	S4	0,872***			

***p<0,001

Como se evidencia en la Tabla 6, para este caso se comprueba la fiabilidad y la validez convergente. Adicionalmente, se evidencia que las cargas son significativas con p<0,001.

Tabla 7. Validez Discriminante de los constructos

	CF	CM	LT	ST
Confianza	0,775			
Compromiso	0,486	0,809		
Lealtad	0,558	0,597	0,802	
Satisfacción	0,697	0,364	0,434	0,851

Como se muestra en la Tabla 7, el modelo presenta validez discriminante, mostrando en la diagonal el cuadrado de la varianza extraída (AVE) (Chin, 1998), calculada con el software SmartPLS.

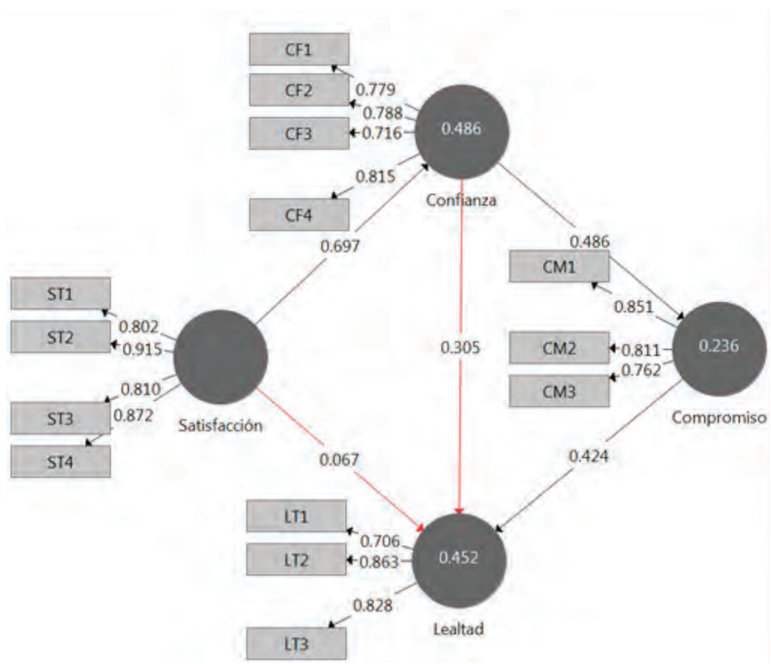
Para evaluar la capacidad predictiva del modelo estructural, se utiliza el R^2, el cual indica qué parte de la varianza de las variables dependientes son explicadas por las variables latentes influyentes (Aldás, 2017). Los resultados arrojados por el software SmartPLS muestran que los constructos confianza (R^2=0,486) y lealtad (R^2=0,452) se evidencian como indicadores moderados, en contraste con el compromiso (R^2=0,236).

Tabla 8. Contraste de hipótesis

Hipótesis	Descripción	Coeficiente de trayectoria	Valor t	Confirmación
H1	Satisfacción-> Confianza	0,697***	10,647	SI
H2	Satisfacción -> Lealtad	0,067	0,367	NO
H3	Confianza -> Compromiso	0,486***	4,390	SI
H4	Confianza-> Lealtad	0,305	1,841	NO
H5	Compromiso -> Lealtad	0,424***	3,911	SI

Indicador de Significancia: p<0,001***

Figura 2. Resultados del modelo estructural



Después de conocer la capacidad predictiva del modelo, se realiza el contraste de hipótesis, utilizando la función de Bootstrapping del software SmartPLS. En la tabla 8, se observan que las hipótesis H1, H3 y H5 fueron confirmadas, pero en contraste, las hipótesis H2 y H4 fueron rechazadas, teniendo en cuenta la significancia de los coeficientes de trayectoria obtenidos. De acuerdo a estos resultados, se evidencia que la satisfacción tiene un efecto positivo sobre la confianza (H1: β=0,697), la confianza hacia el compromiso (H3: β=0,486) y el compromiso hacia la lealtad (H5: β=0,424).

En la Figura 2, se evidencian los resultados del modelo estructural, evidenciando de forma gráfica los resultados obtenidos en el proceso.

Tabla 9. Efectos totales

Descripción	Efectos Totales	Efectos Directos	Efectos Indirectos
Satisfacción-> Confianza	0,697***	0,697***	
Satisfacción -> Lealtad	0,423**	0,067	0,357**
Satisfacción->Compromiso	0,339***		0,339***
Confianza -> Compromiso	0,486***	0,486***	
Confianza-> Lealtad	0,511**	0,305	0,206**
Compromiso -> Lealtad	0,424***	0,424***	

p<0,001***; p<0,01**; p<0,05*

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En la Tabla 9, se pueden evidenciar los efectos totales, los cuales permiten demostrar la existencia de relaciones entre todos los constructos. A pesar que de forma directa ni la satisfacción, ni la confianza presentan efectos directos sobre la lealtad, se evidencia que de forma indirecta presentan efectos de forma significativa con un p<0,01.

Discusión y Conclusiones

El presente estudio contribuye a la literatura del marketing, evidenciando la importancia de establecer relaciones entre la Universidad y la Empresa mostrando particularmente cómo se comportan los factores principales de esta relación en el caso de una universidad pública colombiana para sus procesos de transferencia tecnológica.

Se construyó un marco teórico sobre la relación Universidad-Empresa vista desde el marketing relacional, y se propusieron hipótesis que identifican las relaciones existentes entre los constructos estudiados, validándolo mediante un análisis confirmatorio con base en una muestra empírica de datos, obtenida a partir de encuestas estructuradas enviadas a empresas que han adquirido servicios en la Universidad de Antioquia desde el 2010. Tras el análisis de información se pudo evidenciar que las hipótesis son aceptadas para el contexto de la Universidad de Antioquia en su relación con las empresas.

Los resultados evidenciaron que en la calidad de la relación Universidad-Empresa en el contexto analizado, el principal antecedente de la Lealtad de forma directa es el compromiso (β=0,424***), lo que se encuentra muy acorde con la literatura (Moorman et al., 1992; Morgan y Hunt, 1994; Ulaga y Eggert, 2006). Esto implica que las Universidades deben tratar de construir relaciones sólidas y generar un alto grado de compromiso con las Empresas para lograr relaciones de largo plazo.

Así mismo, se encontró que el principal antecedente de la lealtad teniendo en cuenta tanto los efectos directos (β=0,305; p=0,066), como efectos indirectos (β=0,206; p=0,001) es la confianza (β=0,511; p=0,001), ya que a través del compromiso es que se logra maximizar su efecto hacia la lealtad, esto en concordancia con autores como Tian et al., (2008); Gil, S. I, Frasquet, D. M. y Cervera, T. A. (2009) que encontraron resultados similares en sus estudios. Esto implica que las Universidades no solo deben trabajar en generar confianza entre las Empresas, deben llevarlo más allá, hacia un compromiso que logre convertirse en relaciones de lealtad en el largo plazo.

Algo similar ocurre con la satisfacción, la cual fue una relación que no dio significativa en sus efectos directos (β=0,067; p=0,713) hacia la lealtad, pero teniendo en cuenta sus efectos indirectos (β=0,357; p=0,004) mediada por la confianza y el compromiso, se puede llegar a influir positivamente en la lealtad (β=0,423; p=0,001), lo cual es coherente con resultados encontrados en estudios como los de Hennig-Thurau, T., y Klee, A. (1997); Bowen, J. y Chen, S., (2001) ; Chiou, J. y Droge, C., (2006). Esto implica que las Universidades en una relación de largo plazo deben buscar más que satisfacer en un momento en el tiempo, deben lograr generar confianza y compromiso para llegar a la lealtad.

Todo esto permite concluir que es posible abordar la transferencia tecnológica desde el marketing relacional, generando mayor valor al evidenciar los factores más relevantes para la generación de relaciones de largo plazo con las empresas, permitiendo crear espacios de intercambios de valor que beneficien las partes y a la sociedad en general.

Este estudio tuvo limitaciones en su recolección de datos, ya que fue aplicado para el caso de una universidad pública en específico, lo que no permitiría generalizar los resultados para las Universidades Colombianas. Sin embargo, es un aporte que da cuenta de la importancia de profundizar en la investigación de este tema para lograr generar aportes más significativos para el comportamiento de la relación Universidad-Empresa en general visto desde el marketing relacional.

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Overview Case Analysis Applied to Evaluate Technology Transfer Projects of a Mexican Public University

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Abstract: The objective of this work is to propose a rapid methodology called Overview Case Analysis (OCA) to analyze in a synthetic and simple form, the tremendous amount of information that is created through the years in a technology transfer project. Using OCA analyst can rapidly detect the project highlights along its critical path of the technology transfer project. At the end of the evaluation process, qualification of the project performance is performed using a coarse scale to measure the technology transfer capacity of the participant organizations. To prove the methodology proposed, we explore the economic and social impact results of some technology transfer projects developed by academic groups of the National Autonomous University of Mexico (UNAM, by its Spanish acronym). The conclusion is that in order to have a successful TTP, at least three conditions are necessary: (a) the project must be handled by an efficient technology transfer team *(T^3)*; (b) the technology transferred must be mature; and (c) the technology transferred must have economic and social impacts for the final organization or other users inside the receiver country.

Keywords: technology; transfer; projects; rapid evaluation.

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1. Introduction

In a technology transfer project at least two parts participate, the organization that owns and transfers the technology and the organization who receives it. Both parts must establish a human intellectual capital team who must play many roles as investors, administrators, technologists, technicians and sponsors, among others. Each part also requires the investment of important quantities of money, time and effort. Since this is an intense intercommunication process, it is well known that there are many problems for efficient technology transfer; a frequent one is that stakeholders involved will not be equally motivated to use their resources to transfer technologies, if they perceive that they do not benefit fairly from such transfers. For that reason, the interchange terms must be clearly pointed out and must be negotiated in a range of different forms that goes from the selection of the appropriate payment terms, the interchange of technology-market via joint ventures up to technology interchange. Moreover, the success of a technology transfer project not only depends on the initial agreement terms, but also on some other human, technical, technological and economic variables that we are about to mention.

2. Literature Review and reference framework

Lets start by recognizing that technology is regarded as a key driver for global competitiveness and socio-economic development. For Kondo (2005, pp.155) it functions as the engine of growth. In a few words, technology transfer (TT) is a shortcut to development. It helps the late country entrants to reduce the technology gap quickly (ECOSOC, 2014; cited by Kundu et al, 2015). Likewise, technology transfer has been understood as a series of processes or mechanisms for the rapid transfer of essential core knowledge and skills from one country/region/firm to another. (Shrestha, 1995). Nevertheless, it is a complex process since many authors suggest that effective transfer occurs when technology is requested, transmitted, received, understood, applied, diffused widely and improved. (Ofori, 1994 and UNCTAD, 1990; cited by Shrestha, 1995).

In that sense, far from being a reality in the institutional context and the everyday development experience, technology transfer in developing countries is not well understood among entrepreneurs, academics politicians nor decision makers. However, the idea of the important link between technology transfer, economic development and the role of universities has arisen in practically all economic sectors of Latin-American developing countries.

Therefore, developing countries urgently need to build capabilities in developing and/or applying new technologies in order to enhance cost-effectiveness, make the best use of natural resources, and compete in international markets. (Beukman & Steyn, 2011)

Today, in their struggle to survive, enterprises in developing countries are hurrying to keep abreast with technological advance (Awny, 2005). As the indigenous technological capabilities of developing countries are weak by default, they try to import technology internationally.

Experience has shown that in doing so, a number of obstacles might cause the technology acquisition process be less effective, or even sometimes, turns into a failure economically and/or technically; therefore, *the technical and technological capacities* of the human resources

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of the countries' organizations that receive technology *are a decisive factor* in a successful absorption and technology transfer. Kundu, et al, (2015) point out that the emphasis of the existing literature is on the extrinsic organization factors that affect technology transfer such as technology, market, finance, government, environment, culture and society, which depend on third parties and is beyond the scope and capabilities of transferor and transferee. They indicate that more emphasis is required on the study of the *intrinsic* factors such as goal compatibility, perceptional differences on technology and transfer, environmental differences as well as cultural differences, learning and unlearning, building capabilities, mastering change management, networking, and so on., to make the technology transfer successful.

Accordingly, Roy and Mehnen (2008) consider that continuous improvement of products and the introduction of completely new products are a day-to-day challenge that industry has to face to stay competitive in a dynamic market. They also point out that academia is one of the sources of novel and scientifically well-founded technologies. Furthermore, academia has a rich pool of thoroughly tested methods and well-educated students and professional academics to deliver these methods. Technology transfer between academia and industry, therefore, is a productive way to bridge the gap between 'mysterious' theory and 'plain' practice. Nonetheless, transferring a technology into a new environment means that this technology should be understandable and maintainable over a long time. For industrial applications, this implies training, consultancy and continuous updating of technology and therefore requires well-planned collaboration among participants. In these processes, engineers play a very significant role.

In the past, technology transfer processes occurred normally via local or regional collaborations. For Kondo (2005) today, the participation of developing countries in international networks for the acquisition of technology and to perform the large number of activities needed, ranging from obtaining foreign direct investment (FDI) up to licensing is important. In addition, technology assimilation and domestic diffusion is necessary for full use of acquired technology. Further, domestic networking between industry, universities and public research institutes is necessary to utilize all technological capability for industrial development.

Most technological progress in developing countries stems from the absorption and adaptation of existing technologies, rather than the invention of completely new technologies. Technologies can be sourced, assimilated, and adopted from all over the world to be utilized in high-value added production. In developing countries, technology transfer projects usually aim to introduce new techniques through investment in new plants, improving existing techniques, and generating new knowledge. (Afenyadu et al, 1999; Bischoff, 2003; Saad et al, 2002; World Bank, 2008; cited by Beukman & Steyn, 2011, pp.49)

Technology is not static, but rather implies continuous innovation for increased profitability, growth, sustainability, and competitiveness. Transfer consists of (1) materials, final products, components, equipment, and plants; (2) designs, blueprints, and know-how to create the desired capability; and (3) know-why and information to innovate and to adapt existing technology. Transfer does not only mean knowledge movement from one entity to the next, but also encompasses exchange, cooperation, partnerships, and collaboration. (Beukman & Steyn, 2011, pp.41)

In developing countries like Mexico, the portfolio of sourcing strategies available to a firm in order to access to new technology is: knowledge creation through internal R&D departments, knowledge sharing with suppliers or market relationships, and also transfer from knowledge institutions such as public and private research centers. In this paper, we address the third case recognizing that public universities are a central source of knowledge, but we question the general belief that knowledge is per se flowing between the private and academic spheres through the conduct of university-Industry relationships. (Hermans & Castiaux, 2007). As we will see in the cases overview, it is not always so simple.

Probably the main legal instrument of a technology transfer project (*TTP*) is in most cases, the technology transfer agreement. Which is the legal instrument used in most countries to handover the intellectual property from the part that transfers technology to the one who receives it. Then an efficient *TTP* requires the understanding of the Intellectual Property System and the culture behind it.

In developing countries intellectual property culture is not a problem, Dummond (2015), indicates that since 1787, the US Congress gave to authors and inventors the exclusive right to commercially exploit their respective writings and discoveries. The Second World War catalyzed the growing role of American universities in creating intellectual property through the foundation in the 1970's of the Techno Science System in the USA. By 1978, the General Accounting Office reported that the US government owned 28,000 patents but commercialized less than 5% of them. To solve this problem, the Bayh–Dole Act was adopted in 1980, giving federally funded small businesses and universities the ownership of the patents they file. This led to the creation of Technology Transfer Offices (TTO´s) at many universities. A similar system was adopted in México at the end of last century, currently the intellectual property results of technology development projects financed with public funds belongs to the public universities in which the developments were carried out. Nevertheless, the patenting culture is still incipient, in 2014 there were 16,135 patent applications, and only 9,819 conceded. Notably, 96% of the conceded patents correspond to foreign applicants.

If the heart of the *TTP* is the intellectual property the organization has, the body structure of it is the capability organizations have to adapt and perform a project management methodology. But certainly there must be a range of capabilities to perform TTP's that change from one organization to the other. The same organization could have TTP´s with different levels of efficiency results. Sometimes it could depend on the directives and other stakeholders interest to have a successful project, in other cases financial resources available could be insufficient or the technical and intellectual capital available is not able to provide good results.

The process of technology transfer is complex, and depends on a huge number of variables endogenous and exogenous to the organization, therefore it requires a particularly careful formation of multi and interdisciplinary work teams.

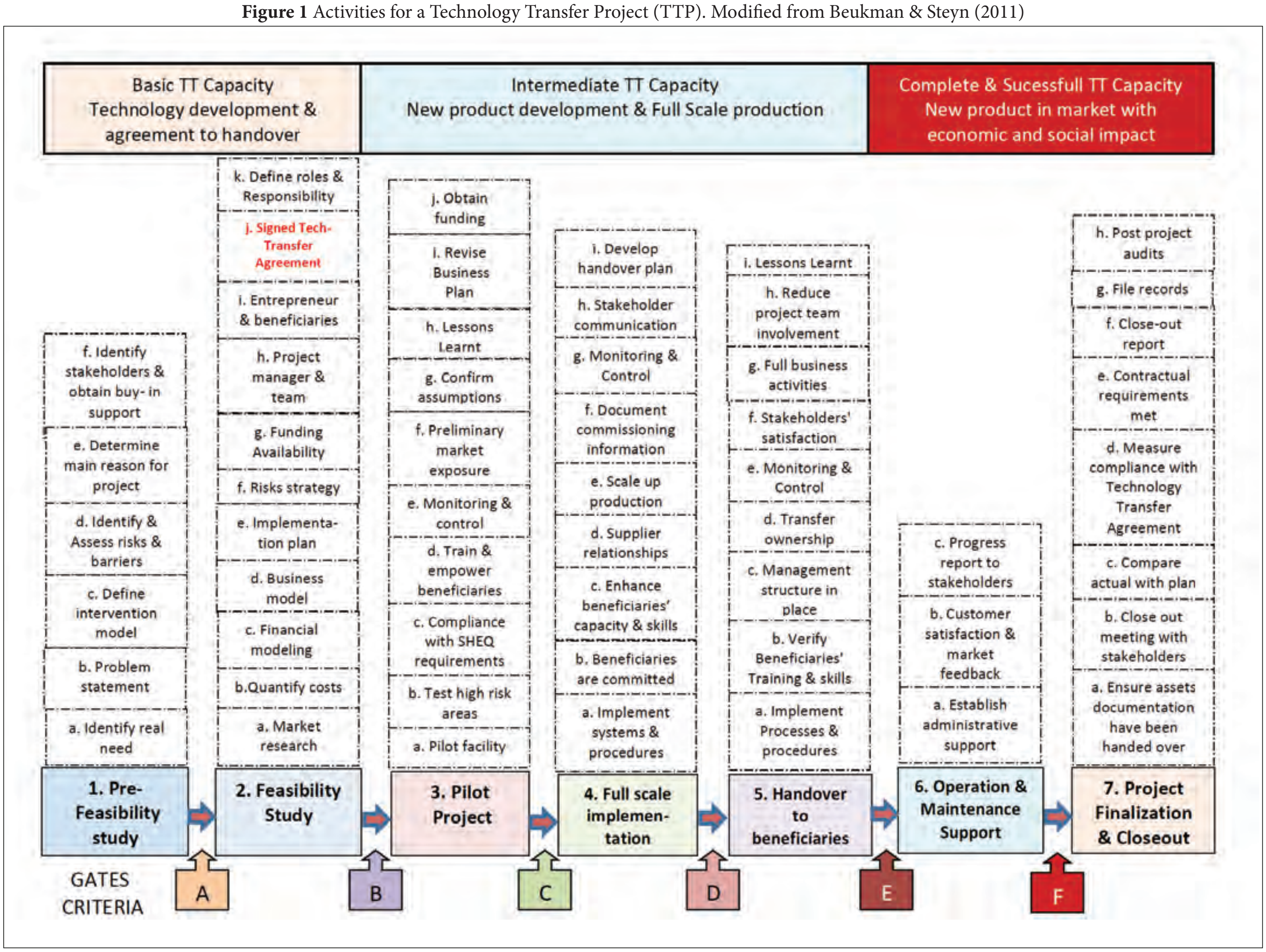
The United Nations Department of Economic and Social Affairs (UNDESA), has established a technology transfer framework specifically for climate change mitigation projects, clearly applicable to any kind of *TTP*. They have defined five key issues for meaningful and effective actions, as follows: (1) human resource development, (2) institutional development, (3) information development, (4) partnership and networking and, (5) collaborative Research and Development (R&D).

UNDESA also found some barriers for technology transfer processes between organizations or individuals, which are: (1) market conditions, (2) the legal system, (3) the physical infrastructure, (4) social and political structures, (5) culture, (5) psychology. Finally, they propose that the framework for TTP requires five well-defined elements, which are: (1) recognition of technology needs and needs assessment; (2) technology information; (3) enabling environment; (4) capacity building; and (5) mechanisms to facilitate institutional and financial support to technology transfer (UNDESA, 2008)

For Klingner (2008), technology transfer can be structured in three phases, namely: pre-transfer, transfer and post-transfer. The objective in pre-transfer is 'search and mutual identification'. The transferor and transferee will study and analyze the organizational goals, objectives, and strategic plan of each other to reach a common beneficial association.

The objective of the transfer stage is planning, transfer and implementation. At this stage, both transferor and transferee will study and act on (1) level of preparedness; (2) barrier analysis; (3) communication channel establishment; (4) trust building, (5) mode of technology transfer; (6) technology transfer agreement, (7) identification of critical activities; (8) implementation plan and project management; (9) building capabilities; (10) training; (11) managing conflicts; (12) review, feedback; and (13) risk analysis.

Figure 1 Activities for a Technology Transfer Project (TTP). Modified from Beukman & Steyn (2011)



The objective of the post-transfer third stage is adoption, adaptation and *innovation*. At this stage the maximum initiative is from the transferee end. They should study and act on technology absorption, fine tuning of the technology, see that diffusion takes place across the organization, technology up-gradation and create spirit of innovation; whereas the transferor will create a support system to augment these plans and activities. On a global scale, it involves the successful diffusion and adaptation of innovations from their initial context to another region or country to achieve economic, social, political, or environmental goals.

Interestingly, all the framework elements of the different institutional and academic visions mentioned above, match to some extent with the gates that allow the passage between the different phases of a technology transfer project, proposed by Beukman & Steyn (2011). As can be seen in Figure 1. Gate A clears the pass from stage 1 Prefeasibility to stage 2. The Feasibility study requires addressing the real need, identifying the stakeholders and to have at least promised funding since these stages are studies that do not require large sums of money. Beyond that, feasibility needs a good project team to be confirmed, at this point, gate B needs to operate to pass from Stage 2 to Stage 3 Pilot Project. This action requires stakeholders support and commitment and to have funding secured and to develop a plan to mitigate risks. Complete technology information, which is point 2 of UNDESA's framework, permits the transition from stage 3, Pilot plant to stage 4, Full scale implementation. Operation of gate C requires stressing the stakeholders support and commitment and to have funding secured that, of course, corresponds to point 3 of UNDESA's framework, enabling environment.

Gate D opens the door from Stage 4 Full Scale implementation to Stage 5 Handover to beneficiaries, this step corresponds to point 5 of the UNDESA framework which are mechanisms to facilitate institutional and financial support to technology transfer because the criteria is to have the business fully operating at full scale production. Naturally, technology equipment is operating and providing financial sustainability. At this point beneficiaries must be satisfied.

Probably, in TTP performed in developed countries, to go from the first to the fifth stage could be enough, and they could skip stages 6 & 7. Of course, the complete model indicates that these stages are required to ensure total success. However, in the *TTP* performed in developing countries Stage 6 Operation & Maintenance Support and Stage 7 project finalization and closeout are particularly important. The reason is that the organization that receives the technology requires backup to establish administrative support and reports to stakeholders, giving enough time to measure compliance of the whole operation with the technology transfer agreement terms.

The above conceptual framework considers the execution of projects when funding is a variable not satisfied initially, that is, investors must be sure of the earnings and the financial benefits that will be received. Stakeholders make project evaluations between stages including technological, technical and financing aspects.

A *TTP* variation occurs when technology transfer is coming from foreign direct investment (FDI) to host regions. This approach integrates firm and regional level analyses using a systemic perspective. In his work, Padilla-Pérez (2008) shows that technology transfer derived from FDI impacts diverse actors of the host region such as local firms, universities, research centers, industry associations, but also that its occurrence is neither automatic nor homogenous across regions.

3. Methodology proposed

If we take as initial premise that a technology transfer project (TTP) is a complex inter-organizational process with a huge number of endogenous and exogenous variables, then, its evaluation becomes a problem of meaningful information management. To carry out the objective of this work, we propose a new methodology called Overview Case Analysis (OCA). It consists of four parts or sections: (a) a Case Data Sheet must be built in the first place. It is a document where the analyst must record general information and the main project characteristics, as available. It should include the name of the organizations involved, project timing, results, and a brief free format description, to capture project details that will permit the later discussion and analysis of the case; (b) using information from the case data sheet, a technology transfer project flow graphic must be implemented; (c) using data elements of the data sheet and the graphical information, the analyst should search for the most valuable results of the project in terms of economic and/or social impacts; (d) finally using all the previous information and results, and the coarse scale of the technology transfer capacity, presented in the previous section, the analyst can qualify the success of the technology transfer project.

3.1 Defining a coarse Scale for measuring an organization's technology transfer capacity

Based on the *TTP* conceptual framework descriptions stated in the previous section, it is clear that technology transfer from one organization to another that looks for benefits from the knowledge that it will receive, in the form of new products, systems, and integrated technology in the form of manufacturing or industrial processes, is not just an action that happens only with the signature of a technology transfer agreement at some point in time. It requires a long range project with many actions and evaluation criteria to evaluate if the project continues or not.

Considering Beukman and Steyn's proposal to perform any technology transfer project by organizations of developing countries, we propose the use of the following coarse scale to measure the capacities an organization has to perform TTP´s.

Grouping the stages and the activities presented in Figure 1, we define that a Technology Transfer Team (T^3) has *Basic TT Capacity* when it is capable of realizing the actions included for Stage 1 Prefeasibility Study and 2 Feasibility Study, ending with the signing of a Technology Transfer agreement.

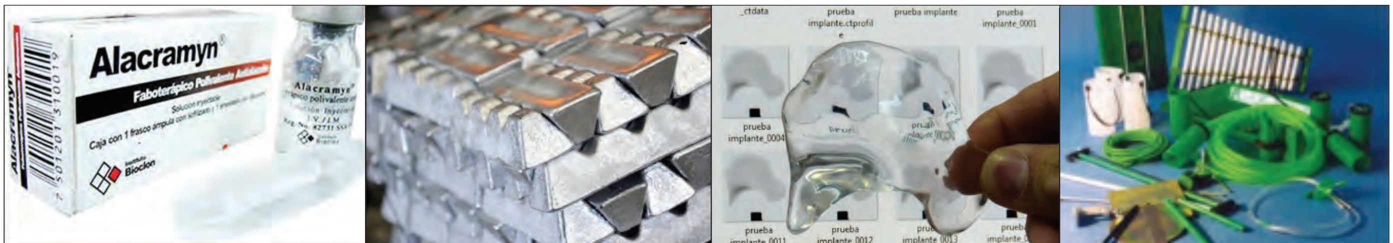
When the T^3 in addition to performing stages one and two, is capable of performing stage 3 Pilot Project, stage 4 Full scale implementation, and stage 5 Handover to beneficiaries, the project team has *Intermediate TT Capacity* because it is able to perform new product development and Full Scale production.

Finally, when T^3 in addition to performing stages 1 to 5, is capable of performing stages 6 & 7, we have a project team with *Complete & Successful TT Capacity*, which is remarkable and exceptional because it is capable of launching and putting new product on the market with economic and social impacts.

4. Analysis of cases proposed

In this section we briefly present four cases of technology transfer projects performed by project teams formed by different academic groups of a Mexican public university and their counterparts, other Mexican organizations. For each case, following the Overview Data Sheet we present the corresponding project flow graphic. Finally, the discussion section is presented for all the cases.

Figure 2 (a) Case 1. Scorpion Antivenom Technology; (b) Case 2. Zinc-Aluminum-Cooper (ZINALCO) alloy; (c) Case (3) Facial-Skull Implant Prostheses manufacturing process; (d) Case (4) Laboratories for Science teaching in elementary and high schools[1]



a) **b)** **c)** **d)**

4.1.1 ***Case 1 Technology Transfer Project: Scorpion antivenom technology***
Below is the data sheet of Case 1

Technology Transferor: Instituto de Biotecnología (IBt), Universidad Nacional Autónoma de México (UNAM)

Technology Receiver: Laboratorio Silanes S. A. de C. V. (private company in the Pharmaceutical field, with main offices located in Mexico City)

Heads of Technology Transfer Team (T3): from the IBt Lourival Possani PhD, and Alejandro Alagón Cano PhD; on the side of the firm: Lic. Antonio López de Silanes✞, legal representative and Araceli Olguín, Quality Affairs

Project time scope: (a) technology development took from 1970 to 2000 and continues. The UNAM R&D group dedicated more than 30 years to scorpion venom study obtaining national and international field experience. (Herrera 1997; Romero, 2007), (b) intellectual property has taken more than 25 years from 1990 to 2015 and still continues up to now.

Intellectual property: UNAM's scientist obtained the titles for the following patents as a result of their research: US2005065331 (A1)-2003-03-24 Recombinant immunogens for the generation of genus Centruroides antivenoms, MMX PA04008435A (A) Inmunógeno y antiveneno contra el veneno de la araña violinista. BR PI0514809 (A) inmúnogeno y antiveneno contra veneno o veneno de araña marrom. CL 22232006 (A) Proteína aislada y recombinante del veneno de araña Loxosteles bonetti, etc. US2011177078 (A) Immunogen and antivenom against violinist spider venom.

Technology Characteristics: The scorpion poison antivenom basic technology was first developed by the Biotechnology Institute (BIT: Instituto de Biotecnología) from The Autonomous National University of Mexico (UNAM, Universidad Nacional Autónoma de México); transferred to the pharmaceutical firm: Silanes* Labs (Laboratorios Silanes) for its commercialization, this Enterprise developed the poison antidote industrial fabrication process through Bioclon, its research and development Institute. Silanes first launched the antivenom product into the Mexican local market and through the years it developed new markets in some North African countries and in the USA. (Vega-González, 2012)

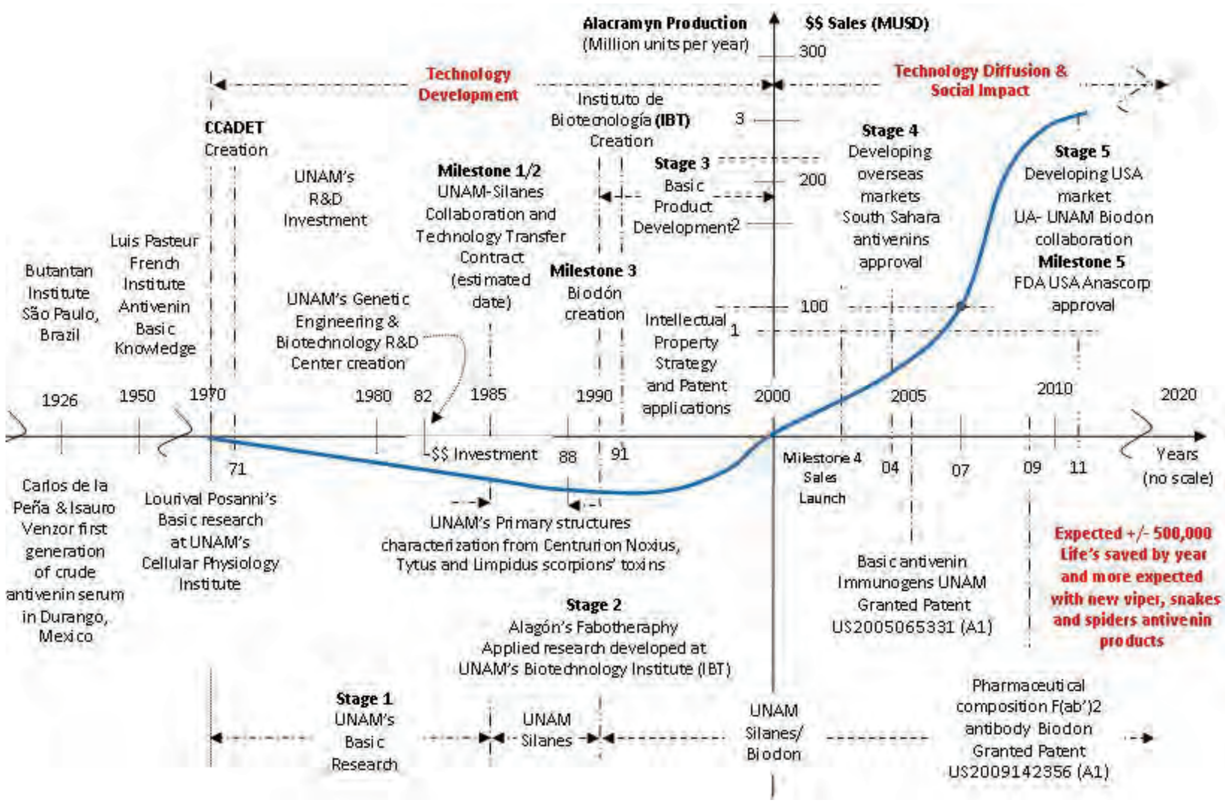
Project Milestones: UNAM-Silanes Collaboration and TT Agreement signed probably in the 1980-1990 decade (precise data N/A), creation of Bioclon R&D Institute by Silanes to develop new antivenom products, produce and commercialize them. Alacramyn (antivenom commercial name) launch to sale in 2000, Anascorp (USA antivenom commercial name) FDA Approval in 2011. Investment of 40MUSD in 2011 for two new production facilities in the State of Mexico. (Silanes Noticias, 2011)

Impacts: declared sales for $100 million USD in 2011, estimated $500 MUSD for 2017, estimated 500,000 life's saved every year, with the global use of the family of antivenom products.

(1) Photographs: Case 1 and 2 public domain (google images); Cases 3 and 4 CCADET-UNAM's property.

The TTP project flow graphic for case 1 is presented in Figure 3

Figure 3 Case 1 Antivenin Technology Project lifecycle graphic. (Vega-González, 2012)



4.1.2 **Case 2 Technology Transfer Project:** ***Zinc-Aluminum-Cooper (ZINALCO) alloy***

Below is the data sheet of Case 2

Technology Transferor: Instituto de Investigación en Materiales (IIM), Scientific Research Subsystem, Universidad Nacional Autónoma de México (UNAM)

Technology Receiver: Fundición FALMEX S. A. de C. V; private company in the Foundry field, with main offices located in Mexico City. Falmex received the Zinalco technology at Laboratory level and performed pilot industrial testing. Then, since they did not have the industrial installation to produce Zinalco, they signed a contract with ALCOMEX for the industrial production of the alloy during the 80s. Later, in 1992 a new company began participating in the project, the giant Industrias Unidas SA de CV (IUSA), a private company in many fields of industry, including the production of copper alloys for the electrical cable and the water tubes industries. In February 1993 the licensing rights of Zinalco Technology exploitation were transferred from Falmex to Zinalco Industrial with UNAM´s approval. Later, in july 1993 Zinalco Industrial S.A. de C.V. company was created with 45% stock participation of IUSA and 28% Falmex.

Heads of Technology Transfer Team (T3): from the UNAM´s IIM: Gabriel Torres Villaseñor, PhD, Jesús Negrete Sánchez, PhD, Alfredo Valdez Hernández PhD; on the side of the firm: Lic. Ramón Galván Cavazos✞, legal representative FALMEX S.A. de C.V.; and Luis Miguel Galván Cavazos; Ing. Alejandro Peralta Soto, legal representative and General Director of the Controls Group of Industrias Unidas S.A. de C.V. (IUSA). Jaime Martuchelli PhD Center for Technology Innovation UNAM.

Project scope: the UNAM R&D group has dedicated more than 50 years to the study of aluminum alloys. Since 1973, with funds from the American States Organization (OEA), IIM has developped research lines on copper and zinc, additionally the IIM has a research line in metallic aluminum based materials.

Intellectual property: Intense intellectual property efforts were made particularly in the 80's and 90's. UNAM's scientist obtained the titles for the following patents as a result of their research: 164,705-1992 Improvement on the anodized process for Zn-Al-Cu alloys; 164,818-1992 Improvements to the method for passivation of Zn-Al-Cu alloys; 172354-1993 process for semi-continuous casting of Zn-AL-Cu alloys to obtain circular bars with fine dendritic structure; 294,849-1983 Zinalco Trademark. Following patents were obtained as co property between UNAM and Falmex: Mexican patent No. 161,143 "Process for obtaining profiles from zinc, aluminum and copper alloys"; Mexican patent application No. 200,935, Improvements to the method to passivize zinc-aluminum-copper alloys, Patent in Peru No. 4379; Mexican patent No. 70,912 "Improvements to the basic anodization process of zinc-aluminum-copper alloys"; Mexican patent application No. 17,400 "Process and equipment of semi-continuous casting of Zinalco to obtain circular dendritic bars"; Falmex Mexican Patent application No. 25,153 "Improvements to the process for obtaining profiles from zinc, aluminum and copper alloys", same patent request in Europe, USA, Japan, Peru (4380) ; Zn-Al-Cu alloy rolling process; Falmex Mexican patent application Nr. 91-00915 "Zinc alloys and their applications to industrial processes". UNAM registered in 1988 the Mexican ZINALCO trademark Nr. 294,849. Mexican trademark ZINALDIC Nr. 361807.

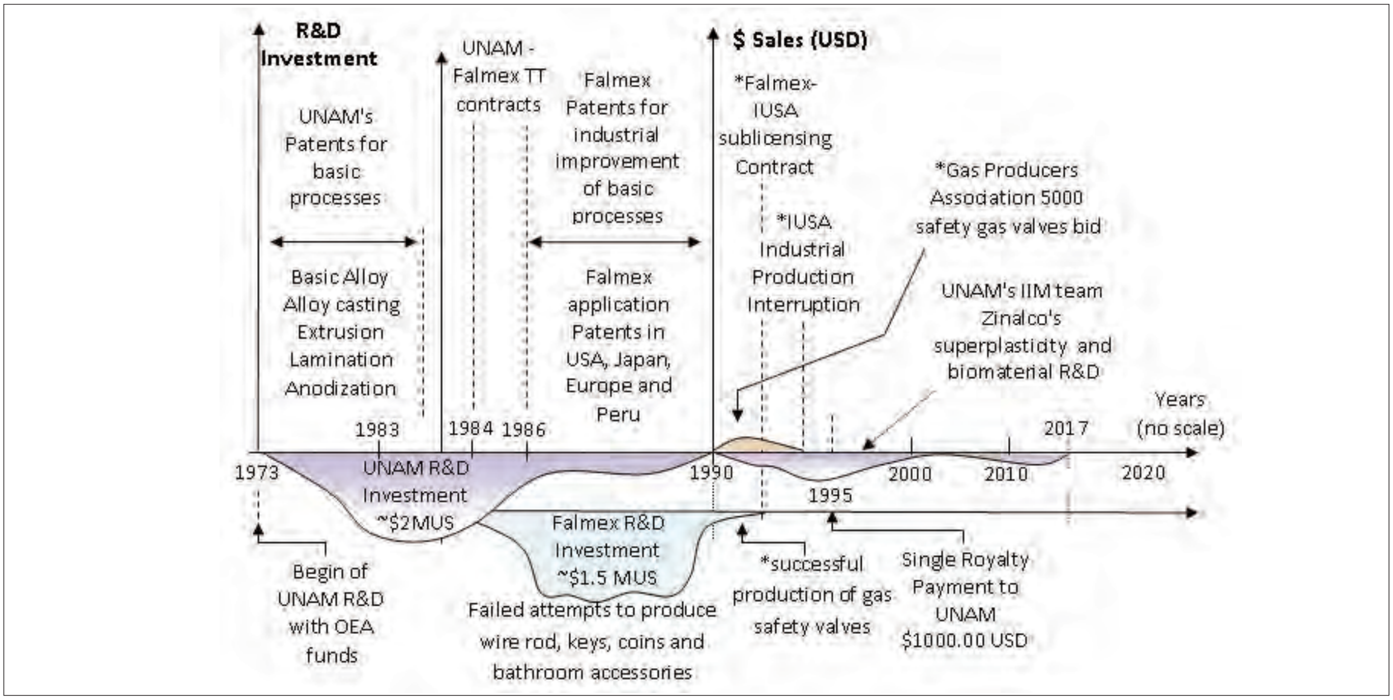
Technology Characteristics: Zinalco is an alloy from the combination of zinc, aluminum and copper; in 1983 It was possible to specify the precise alloy to obtain a material with weight/mechanical resistance relation similar to the aluminum series 6000. This achievement permitted that the alloy be processed in foundry, injection, lamination and extrusion. Zinalco can be used to manufacture: extruded profiles, gears, carburetors, pump housings, transmission parts, structures, roofs, valves, filters, regulators, electrical boxes, electrical conduits, and beaks parts, artistic and decorative objects. The goal was the use of Zinalco for the substitution of traditional materials such as brass, bronze, aluminum, zamak, gray iron and steel. Zinalco properties are: fusion temperature 421 to 481 DEGC, Density 5.4 g/cc, elastic module 110 to 130 Gpa, electric conductivity: 37%, thermal conductivity 37%, thermal expansion coefficient 25 micrometers/mmk, color grayish white. The alloy has a mechanical resistance similar to low carbon steel and high corrosion resistance like aluminum. Since the late 90's till now research has been oriented to the super-plasticity of the material and its biomaterial properties. Zinalco's superplastic deformation goes up to 500%. Zinalco can be used in the metal-mechanical industry and construction, among others. it was expected that the commercial potential of the alloy will grow when it replaced the import of low production metals in Mexico, such as zinc, lead, cadmium, mercury and bismuth. Zinalco alloy has the mechanical strength of structural steel, combined with the corrosion resistance of aluminum and an intermediate density. It does not weigh as little as aluminum, but it weighs 35% less than steel. It can be used in the manufacture of rods for machining or castings, previously made with brass and bronze; it can also be injected under pressure into a mold and make parts that were previously made of steel, like gears, but cheaper. An important property is that under certain rolling conditions it can behave like a plastic and return to being a steel. That versatility is unique in this material. Between 1979 and 1984 the majority of the alloy was characterized, and by 1991 there was already an acceptable industrial production.

Project Milestones: Two technology transfer contracts between UNAM and Falmex Industrial were signed in 1984 and june 1986 to implement different industrial processes to produce extrusion profiles to build window frames. Expected annual sales were 3126.4 tons, at a sale price of $5.00 USD/Kg, will produce sales of $78,175,000.00 USD in five years. The agreed royalty rate was 2.5% on sales of Zinalco based manufactured products. Falmex-Galvotec created the firm Zinalco Industrial SA de CV in 1993 to develop applications and final products using the alloy with shareholding divided between Falmex and IUSA. From 1993 to 1996 it was carried out the industrial scale up of Zinalco for manufacturing of safety gas valves, coins, and diverse car and bathroom accessories. In 1993 Falmex participated in an extraordinary bid for about 5000 gas safety valves. Their strategy was to produce the alloy material and the Zinalco molds to manufacture the valves body and parts, in order to offer them with immediate delivery. Regrettably, Falmex lost by price, competing with IUSA who was the bid winner offering the manufacturing of bronze valves and an extraordinary price discount since they controlled the production margins in the copper alloy industrial production in México. The valves produced by Falmex for the bid had to be discarded. The company went bankrupt and was forced to sublicense the technology to IUSA with UNAM's acceptance. Falmex went out of the market in 1997 and UNAM received a single royalty payment for less than $5,000 USD from IUSA. Finally IUSA advised UNAM that they will stop production of Zinalco because in the reverberation ovens they used to melt and produce copper alloys, they needed to reuse waste materials of pure composition. Since Zinalco alloy wasn´t pure itself, its composition makes it impossible to reuse the waste material in the process. This particularity increased production costs enormously, they said, motivating the end of Zinalco industrial production. UNAM´s technology, its patents and the Falmex patents were frozen and haven't been exploited since then.

Impacts: According to José Antonio Esteva Maraboto former director of the UNAM's Technology Innovation Center in 1995, the development of Zinalco cost about $2 MUSD including OEA's funding and different international grants obtained through the years. This quantity also included the payment of researchers and the equipment bought during the development years. UNAM only received royalties for about $1,000 USD. Nevertheless, through the years many other benefits occurred with this project, several PhD's, MSc and Engineers were formed and the UNAM's R&D and technology management teams learned a number of management of technology lessons.

The TTP project flow graphic for case 2 is presented in Figure 4

Figure 4 Case 2 Zinalco's Alloy project lifecycle graphic (*estimated dates)



4.1.3 **Case 3 Technology Transfer Project: *Zinc-Aluminum-Cooper (ZINALCO) alloy***

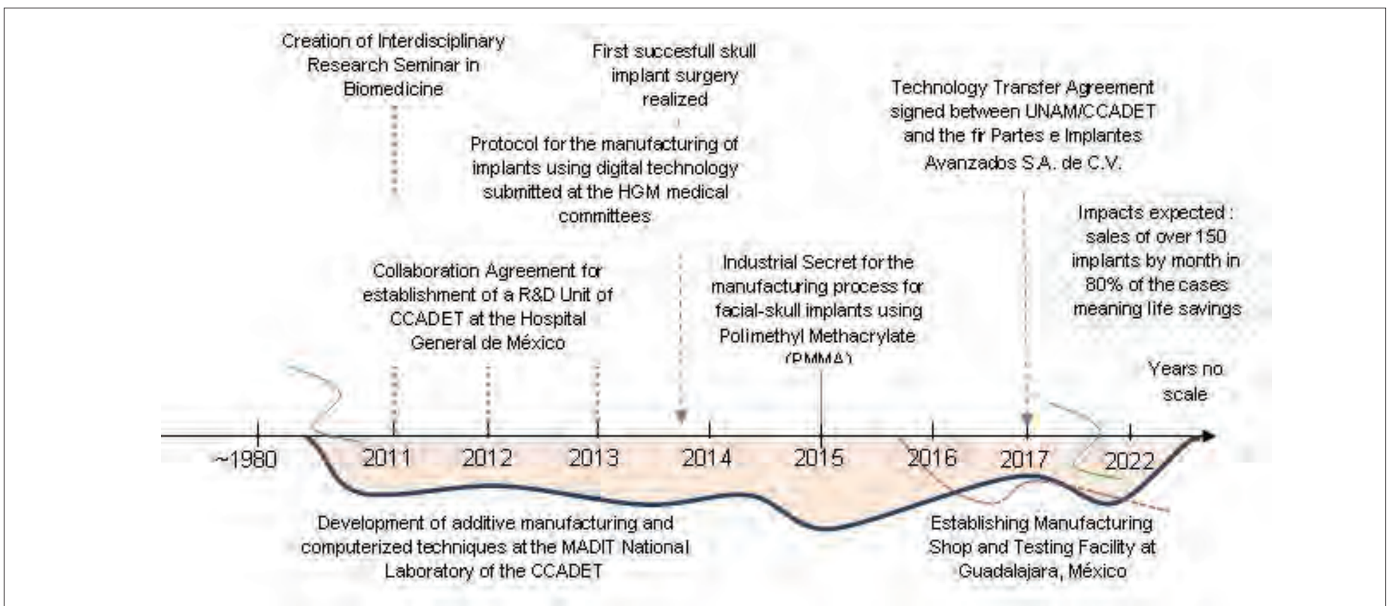
Below is the data sheet of Case 3

Technology Transferor: Centro de Ciencias Aplicadas y Desarrollo Tecnológico (CCADET), Universidad Nacional Autónoma de México (UNAM)
Technology Receiver: Partes e Implantes Avanzados S. A. de C. V. (private company in the biomedical supplies field, located in Guadalajara Jalisco, México)
Heads of Technology Transfer Team (T^3): from the UNAM's CCADET: Leopoldo Ruiz Huerta, PhD, and Alberto Caballero Ruiz PhD; on the side of the firm: Juan González Luna Marceille, legal representative and project head.
Project description: January, 2011, Dr. José Narro Robles, Rector of UNAM established the program called Interdisciplinary Research Seminar in Biomedicine. The main objectives were to provide a space for researchers from different academic areas to present and reflect on their research projects by stimulating the linking and generation of original ideas that can be applied to the health areas, as well as speeding up the innovation process, encouraging the development of talent and transferring research to society. Derived from this Seminar, the head of the research area of the Hospital General de México and academic members of Applied Sciences and Technology Development Center (CCADET, Spanish acronym) proposed and negotiated the signing of a Specific Collaboration Agreement for the establishment of a Research and Development Unit (UIDT) of the CCADET at the Hospital. This agreement was signed in February 2012. By the end of that year the UIDT was operating and used a space of about 85 m^2 at the HGM installations. On the other hand, in 2014 the National Council for Science and Technology (CONACYT, for its Spanish acronym), approved the UNAM's proposal to implement a "National Additive Manufacturing Laboratory, 3D digitalization and Computerized Tomography" (MADIT, for its Spanish acronym). This project was filed with the number 232719 and the original institutions network included the Hospital General de México (HGM), the Yucatan's Autonomous University and the Technological Superior Studies Monterrey Institute (ITESM). In a conference held in 2014 at the HGM, medical members of the maxillo-facial HGM's Department presented the problem they had to produce PMMA implants using molds. The academic coordinators of the MADIT's National Laboratory established collaboration with the HGM's doctors and by the end of that year the implants manufacturing solution using digital technologies emerged. The project protocol required the testing of molds manufactured with new technology in hospital patients. Protocol testing was approved by the medical committee and by the end of 2015 the firm Partes e Implantes Avanzados SA de CV expressed its interest in obtaining the licensing of the manufacturing technology. With HGM's research area authorization, a five years Technology Transfer and Licensing Agreement was signed in February 2017 between UNAM and the firm.

Intellectual property: UNAM obtained author rights register in 2015 for the technical report "Optimization of the manufacturing process for facial-skull implants using Polimethyl Methacrylate (PMMA) with additive manufacturing techniques", besides, the UNAM R&D team put together the information elements to produce an Industrial Secret special document for the manufacturing process to obtain high quality products (implants)
Technology Characteristics: the technology for skull-facial implants was developed by the Additive Manufacturing, 3D digitalization and Computerized Tomography (MADIT) CCADET's National Laboratory in collaboration with the team of Maxillary-Facial Surgery medical team of the Mexico's General Hospital where the CCADET by agreement has a Research and Technology Development Unit (UIDT, Spanish acronym). MADIT´s National Laboratory promotes research and development in the field of additive manufacturing (design, materials, properties, processes, among others), and 3D scanning and nondestructive testing in different fields of science The idea was to use this new technology to substitute the old molding process to prepare a facial-Skull prostheses. The old fashion facial-Skull PMM prostheses prepared using traditional methods and used by the General Hospital Surgeons required an average of 15 to 20 days to prepare because manufacturing was a completely manual craft process. The surgeon´s technical team usually took a sample of the implant needed by using a soft paste mold and adjusting it gently. They produced the male and female mold, in PMMA and cured it. Regrettably the craft implants sometimes required adjustment during the surgery, taking a longer time and making it more traumatic. The benefits of using the implants produced using additive manufacturing and computerized techniques are that it only takes from three to four days to be ready and tested to be used in surgery. Up today there have been no rejections in a number of surgeries and prostheses implanted since 2015. Implants fit and adjust 100% in the patients.
Project Milestones: (a) January 2011 UNAM's Rector José Narro established the Interdisciplinary Research Seminar in Biomedicine; (b) February 2012 signing of the collaboration agreement between UNAM and the Hospital General de México for the creation of a Research and Development Unit (UIDT) of the CCADET at the Hospital; (c) technology development in 2013; (d) first skull prostheses used in a surgery at the end of 2013, (e) intellectual property copyrights and trademark obtained in 2015 and industrial secret for the manufacturing process in 2017; (f) February 2017 a five year Technology Transfer and Licensing Agreement was signed between UNAM and the firm Partes e Implantes Avanzados S.A. de C.V.
Impacts: the private firm that received technology transference has made a market profile study finding that only in Mexico City's General Hospital there is an average of 15 to 20 patients per month that require some implant surgery, expanding this to the regional hospitals of Mexico City and the major cities of the Mexican Republic, it is expected that demand will increase up to one hundred and fifty (150) implants per month, or about 1800 implants per year. UNAM reserved its right to modulate the final public price of implants in order they be affordable for the average patient. They will also have a clause in the technology transfer agreement to assign two implants per year with no cost for the poorest people who require implants but do not have enough economic resources to afford them, according to a social worker study. With $500.00 USD implant average price, expected sales are $1,250,000.00 USD per year and royalties for about $40,000 USD. The expectation is that PMMA digital implants could save about 1000 lives a year from 2020.

The TTP project flow graphic for case 3 is presented in Figure 5

Figure 5 Case 3 Facial-Skull Implants project lifecycle graphic (*estimated dates)



4.1.4 **Case 4 Technology Transfer Project:** ***Laboratories for Science Teaching in elementary and Secondary Schools***

Below is the data sheet of Case 4

Technology Transferor: Centro de Ciencias Aplicadas y Desarrollo Tecnológico (CCADET), Universidad Nacional Autónoma de México (UNAM) which is a public university.

Technology Receiver: Fernandez Editores SA de CV (private firm in the editorial field)

Heads of Technology Transfer Team (T^3): from the UNAM's CCADET: Leticia Gallegos Cázares, PhD, and Fernando Flores Camacho, PhD; on the side of the firm: Jesús Garduño Lamadrid, legal Representative. Fernandez Editores S.A. de C.V. was founded by Luis Fernandez in 1943. It began industrial operations in 1986 with Tomas Garza Villarreal, operating with licenses from Walt Disney and Warner Bros for education. The company developed a distribution network in all regions of México, and has regional warehouses. It is leader in editions for elementary and secondary schools in the country. Till now, they dominate the market of texts and reference books for the Ministry of Education of Mexico. In 1999 UNAM signed a five year license agreement with Fernandez, covering the Labs of: Physics, natural sciences, sound, fluids, astronomy, heat, electricity and magnetism and light and optics. In 2005 Fernandez & the UNAM participated in several bids for the Secretaría de Educación Pública (Federal Ministry of Education in Mexico). Later, in September 2006 UNAM signed six different licensing agreements with Alberto Levet Contreras, Fernandez's General Director, and Tomas García Cerezo, Editorial Director, covering the Laboratories of Light and optics, Natural Sciences, Electricity and Magnetism, Mechanics, Sound and Modular Mechanics for elementary and high schools.

Project time scope: (a) the CCADET's Cognition & Science Didactics academic group have developed technology for teaching science since 1975. This UNAM group has had an intense link with diverse organizations from the public and private sectors. They have dedicated more than 30 years to the development of didactic material, learning units, for teaching science even for indigenous schools (b) an intellectual property strategy has been advocated for the protection of books and laboratory manuals via author rights for more than 25 years since the late 1980's up to 2015 and still continues up to now.

Intellectual property: Copyrights: "Laboratorio de Ciencias Naturales, Manual de Prácticas para Educación Básica" (03-2004-052711355800-01); "Manual de Prácticas de Mecánica" (03-2004-052711433100-01); "Ciencias Naturales, EDUCIENCI" (03-2004-112312023900-01); Laboratorio de Electricidad y Magnetismo, Manual de Prácticas para Educación Básica" (03-2004-112210554000-01); "Educación en ciencias para Preescolar Luz y Óptica EDUCIENCI" (03-2006-092513260800-01); "Hojas de Registro 1er. Grado Luz y Óptica, observaciones de experimentos en Ciencias" (03-2006-092513245300-01); Carro de servicio para Laboratorios de Ciencias (03-2006-092513291900-01); "Hojas de Registro 3er. Grado Luz y Óptica, observaciones de experimentos en Ciencias" (03-2006-091413274700-01); Manual de Actividades de Óptica para estudiantes de secundaria y bachillerato" (03-2010-042213032200-01); "Electricidad y Magnetismo, Guía de uso de la Bobina de Inducción para demostraciones" (03-2010-051309562500-01); "Electrostática, Actividades con el generador electrostático Van de Gras y el graficador de líneas equipotenciales" (03-2010-051309550200-01); "Marco de Fuerzas, Manual de actividades experimentales" (03-2010-051309554700-01); "Placas de Magdeburgo y cámaras de vacío, Manual de actividades experimentales" (03-2010-051309542800-01); "1-6 Biología Ciencias Naturales Primaria Seres vivos y cuerpo humano. Laboratorio Integrado de Actividades para Primaria" (03-2010-062411352000-01); "1-3 Física Ciencias Naturales Primaria Materia, energía y cambio. Laboratorio Integrado de Actividades para Primaria" (03-2010-061712172800-01); 4-6 Física Ciencias Naturales Primaria Materia, energía y cambio. Laboratorio Integrado de Actividades para Primaria" (03-2010-061712160400-01); Hojas de registro combinación de colores luz y óptica, observaciones de experimentos en ciencias (03-2012-052312365300-14); Hojas de registro formación de sombras luz y óptica, observaciones de experimentos en ciencias (03-2012-052312423900-14); Hojas de registro imágenes en espejos y lentes luz y óptica, observaciones de experimentos en ciencias (03-2012-052312423900-14); Hojas de registro imágenes en espejos y lentes luz y óptica (03-2012-052312341300-14); Trademarks "EDUCIENCI" (379141- 1990); "EDUCIENCI" Y DISEÑO (507355-1995).

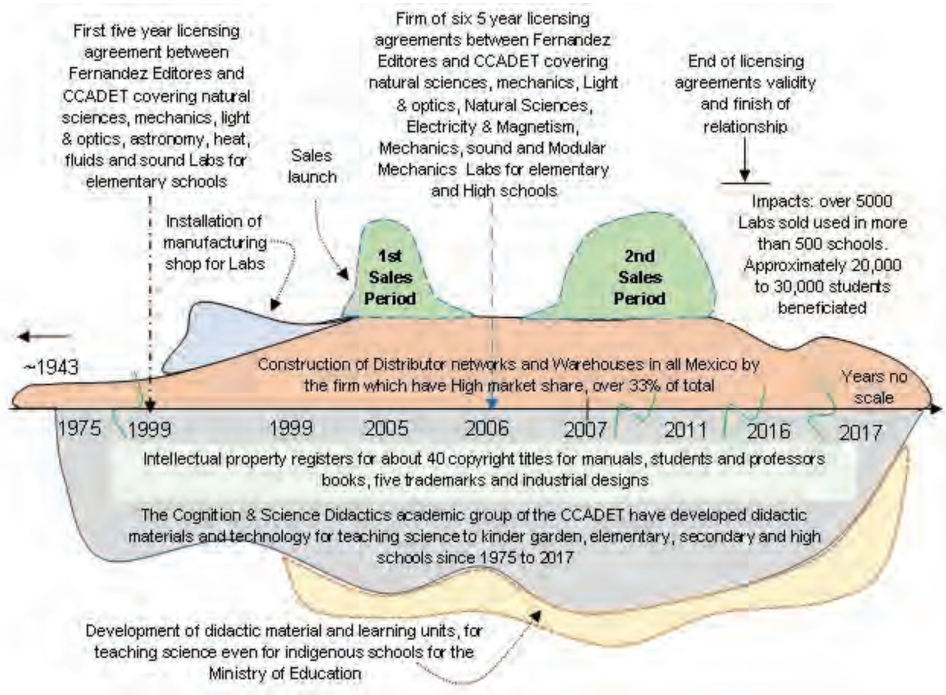
Project Characteristics: The CCADET Cognition and Science Didactics academic group for the last forty years, has contributed to the national education System with different pedagogic proposals sometimes financed by the Public Education Secretary (SEP, by its Spanish acronym), promoting science education in kinder garden, elementary, secondary and high schools

Project Milestones: UNAM and Fernandez Editores SA de CV signed a first Technology transfer and licensing agreement in 1999, including 8% Royalties, for the following Physics Laboratories: Sound, Fluids, Astronomy, Mechanics, Heat, Electricity and Magnetism, Light and Optics, and the Natural Science Lab. In 2006 five new technology transfer and licensing agreements were signed, for each of the following Labs: Light and optics, Modular Mechanics, Mechanics, Sound, Natural Sciences and Electricity and Magnetism.

Impacts: Fernandez Editores production and distribution efforts in conjunction with the support of the CCADET´s academic team permitted the UNAM Science Laboratories to be used by Public Education Secretary Schools for about 10 years from 2000 to 2011. More than 5000 Labs of each type were sold. UNAM received royalties for an estimated of $7 Million Pesos, about $400,000 USD. Furthermore, with this project the TT team contributed to improving the science education to thousands of students probably fostering their vocation toward sciences. Between 20,000 and 25,000 elementary, high school and Kindergarten students were benefited.

The TTP project flow graphic for case 4 is presented in Figure 6

Figure 6 Case 4 Laboratories for teaching science i elementary and high schools



5. Discussion and results

During its lifespan, each project followed the activities of the different stages of Beukman &Stein's (2012) model of Figure 1, including impacts, etc.

Case 1. *Scorpion antivenom technology*
From the Case Data Sheet we have the following relevant aspects

Organizations involved in the Technology Transfer had very good reputation; UNAM's Biotechnology Institute and Laboratorio Silanes, Pharmaceutical Company with recognition and presence in the market.

Intellectual Capital: Individuals of the Technology Transfer Team (T^3) had a high level in scientific and business management affairs.

Time scope: project took over 30 years and intellectual property for more than 25 years. Mature project with results well protected with more than five (5) specific patents.

Technology Level: mature, launched to the market in 1980 tested in real environmental conditions with specific target of scorpion venom, with FDA approval under the qualification of orphan product, practically level 7 of NASA Technology Readiness Level Scale (TRIZ). (Olechowski et al., 2015)

Project Milestones: Silanes created the R&D Center Bioclón with the specific objective of developing commercial antivenom products Alacramyn (antivenom commercial name) launch to sale in 2000, Anascorp (USA antivenin commercial name) FDA Approval in 2011. Impacts: sales of over \$100 million USD in 2011, estimated \$500 MUSD for 2017. Estimated over 100,000 lives saved by the global use of the antivenom products in its lifespan

Case 2. *Zinalco Alloy*
From the Case Data Sheet we note relevant aspects: High level Technology Transfer Team (T^3) with both scientific and business management capabilities. Strong technology knowledge: UNAM R&D group has dedicated more than 50 years to the study of aluminum alloys and since 1973, with funds from the American States Organization (OEA), IIM has develop research lines on copper and zinc, additionally the IIM has a research line in metallic aluminum based materials. Project Strength in Intellectual Property; more than ten process patents in Mexico, EUA and Peru.

Extraordinary Technology Characteristics: Zinalco is an alloy from the combination of zinc, aluminum and copper; in 1983 It was possible to specify the precise alloy to obtain a material with weight/mechanical resistance relation similar to the aluminum series 6000. It also has superplastic characteristics and is biocompatible.

In the late 1990's the company Zinalco Industrial was created to produce and sell Zinalco. Directives did not have a clear view of the competitors and the company was broken in two years.

Research and development cost over 2 million USD but technology could not reach the market.

Case 3. *Facial-Skull Implants Prostheses manufacturing process*
This is a young promising project, the Technology Transfer Team (T^3) has high R&D and firm qualifications.

Project derived from the Research and Development Unit (UIDT) of the CCADET at the Hospital General de México. Technology developed by members of the National Additive Manufacturing Laboratory, 3D digitalization and Computerized Tomography" (MADIT, for its Spanish acronym) to help fulfill the continuous requirement of skull prostheses at the Hospital.

Technology was licensed by the UNAM signing a Technology Transfer and Licensing Agreement with the firm Partes e Implantes Avanzados SA de CV with five years validity. The intellectual property used were author rights and the industrial secret for "Optimization of the manufacturing process for facial-skull implants using Polimethyl Methacrylate (PMMA) with additive manufacturing techniques". The characteristics of the technology transferred overpasses the handmade prostheses manufacturing process improving time, quality and with 0% rejections. The sales potential of the technology is very good but the main expectation is that PMMA digital implants could save about 1000 lives a year after 2020.

Case 4. *Laboratories for Science Teaching in elementary and Secondary Schools*

High profile Technology Transfer Team, Fernandez Editores S.A. de C.V strength was market control through their book distribution network. UNAM's Intellectual property mainly based on about two dozen manual copyrights. More than 5000 Science laboratories were sold and more than 20,000 students of different levels were benefited. Very good technology transfer contracts, well negotiated. Table 1 shows the qualifications summary of the cases presented.

Table I. Summary of qualification highlights of presented cases

Case	Technology Transfer Team (T3)	Technology maturity/ Level	Impacts & market	Technology Transfer Capacity coarse scale
1 Scorpions Antivenin	Extraordinary	TRL 7-8/High Tech	Social over 100,000 Lives saved, Sales over 200 USD by year	Complete & Successful with great economic and social impact
2 Zinalco Alloy	High Level	TRL 3-4/	No market share	Basic-Intermediate. Not successful
3 Facial-Skull Implants digital Manufacturing Process	High Level	TRL 5-6	Expected high impact over 150 implants sold by year. Market with no national competitors	Intermediate Expectation of great success
4 Laboratories for teaching of Science	High Level	TRL 7	Over 5000 Labs sold. High market share	Complete & Successful with but with modest economic and social impacts within a narrow period of time

6. Conclusion

The basic information required to use the Beukmans (2011) model of technology transfer project activities, was obtained from the cases presented using the Overview Case Analysis methodology presented in this article. This methodology only can be applied case by case, therefore it doesn't allow us to obtain statistically proven conclusions, but it is a good tool that makes evident the relevant project characteristics of the phenomenon.

In the cases presented we found that one of the conditions for a technology transfer project to be successful is the technology maturity level. It can be seen that the TRL of the technology of successful Cases 1 and 4 were qualified from seven to eight. Naturally, good university technology attracts the interest of companies.

In second place, the success of a TTP depends on the relation of the transferor and the transferee. In that regard, from the results and the previous discussion, we found that in order for a technology transfer project to reach the grade of *Successful & Complete* the project must be handled by a well-integrated multidisciplinary team between the organizations involved, technology transferor and technology receiver, which must have mutual commitment. For a steady project advance, it is advisable that at least the heads of the Technology Transfer Team (*T^3*) must work together in the project through stages 1 to 7

Now, extending the concepts of Eliezer Geisler (2002), in the sense that we cannot evaluate technology unless and until we put it in the context of social and economic phenomena, or until and unless we put a human dimension upon it, then, we can think that a technology transfer project cannot be successful if there are no measurable economic and social impacts arising from them. In that regard Case 1 Scorpion antivenom technology obtains the first place followed by Case 4 Laboratories for teaching of science. In that vein, there is a great expectation that Case 3 Facial-Skull Implants will have future with increasing economic and social impacts.

We have to mention that we found that the intellectual property strategy of the part that owns the technology can be varied and does not always rely on patents. The investigation indicated the technology transfer on Cases 1 & and 2 were supported on well-structured patent families, nevertheless Case 2 failed. On the contrary, Case 3 was supported as an industrial secret and is very promising, while Case 4 was based only on copyrights and it qualified as a complete and successful project with medium social and economic impacts.

Another important conclusion is that the success of a technology transfer project does not depend on the amount of investments of capital and human resources, as can be seen in Case 2 Zinalco alloys; this project could not reach the market, and therefore there were no social nor economic impacts, even with the important amount of knowledge developed in it. This project also teaches us that the mere possession of the technology is not a guarantee that it will be utilized. Zinalco's technology was transferred to the firm Industrias Unidas (IUSA) which is one of the most important industrial conglomerates in Mexico, but they did not push the technology to reach the country market.

Finally analyzing the results of research surveys, Shrestha, (1995) found that organizational culture barriers, lack of time, capacities, attitudes of individuals, and lack of clear policy are the major barriers to technology transfer in joint venture construction companies. Accordingly, Kundu et al., (2015) expressed that doubtlessly, the success of technology transfer *depends on the right selection of technology and partner as well as on the right method of transfer*.

With the results of the cases presented in this article we have been able to prove that the success of the TTP goes beyond the selection of the partner and the method of transfer, it also depends on the establishment of an efficient technology transfer team (T^3), the technology maturity and the technology assimilation and diffusion that produces important economic and social impacts.

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El Papel de las Oficinas de Transferencia Tecnológica (OTT) en las Universidades: Una Perspectiva de la Última Década

*Felipe Alvarado-Moreno[1]**

Abstract: *The role of the Technology Transfer Offices (TTOs) in Universities: A Perspective of the Last Decade.*
In the framework of a global economy based on knowledge, entrepreneurial universities implement new guiding axes to become generators of knowledge that trigger technological development. In this context, the creation of the Technology Transfer Offices (TTOs) in universities is a vital strategy for the scientific-governmental-business-social ecosystem to subsist with balance and grow simultaneously. In this document, the configuration, performance, and problems of these offices are analyzed, based on a general literature review of the last decade.

Keywords: Technology Transfer Offices; University; Company; Innovation; Knowledge Commercialization.

Resumen: En el marco de una economía mundial basada en el conocimiento, las universidades emprendedoras implementan nuevos ejes rectores para convertirse en generadoras de conocimiento que detone desarrollo tecnológico. En este contexto, la creación de Oficinas de Transferencia Tecnológica (OTT) en las universidades es una estrategia vital para que el ecosistema científico-gubernamental-empresarial-social subsista con equilibrio y crezca simultáneamente. En este documento, se analiza la configuración, el desempeño y las problemáticas de estas oficinas, a partir de una revisión general de literatura de la última década.

Palabras Clave: oficinas de transferencia tecnológica; universidad; empresa; innovación; comercialización del conocimiento.

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Introducción

Desde que la universidad adquirió el compromiso social de fomentar el desarrollo económico mediante la transferencia de conocimientos y tecnologías hacia otras organizaciones, surgió la necesidad de crear espacios formalmente constituidos que se encargaran de movilizar los resultados de investigación mediante procesos de protección intelectual y comercialización sistemática. El nombre de estas instancias no es uniforme, aunque su función sea similar. Dependiendo del contexto, pueden adquirir el nombre de Oficinas de Transferencia Tecnológica (OTT), Oficinas de Transferencia de los Resultados de Investigación (OTRIS), Oficinas de Transferencia y Licenciamiento (OTL), Centros Universitarios de Vinculación y Transferencia Tecnológica (CUVyTT) e incluso, Agencias de Comercialización del Conocimiento (ACC). Cabe aclarar que estas oficinas no sólo han encontrado apertura en las universidades, sino también en instituciones de investigación públicas y privadas (Caballero, 2016). En este documento se les denomina Oficinas de Transferencia Tecnológica Universitarias (OTTUS) porque se hace énfasis en aquellas oficinas integradas en las Instituciones de Educación Superior.

Las OTTUS comenzaron a establecerse a partir de la promulgación de la Ley Bayh-Dole en 1980 en Estados Unidos de América; antes de este hecho no era posible configurar una oficina de este tipo puesto que a las universidades no se les había concedido derechos de propiedad para proteger sus procesos y productos de investigación financiados por fondos públicos (Prado, Cristina y Bubela, 2010). Actualmente, la mayoría de la universidades norteamericanas cuentan con una de estas oficinas (Apple, 2008). En el caso particular de Latinoamérica, también se ha venido considerando la pertinencia de establecer este tipo de oficinas en las instituciones de educación superior. Algunas investigaciones sobre las OTTUS en Latinoamérica son los casos de: México (Estrada, 2009; Pedraza y Velázquez, 2013, Rojas, 2017), Colombia (Rojas-Berrio, Ballesteros y Rodríguez, 2013; Manjarres, Volpe y Altamiranda, 2013), Argentina (Codner, Martin, Pellegrini, Becerra, y Baudry, 2014) y Chile (Rodríguez, Casanelles y Marí, 2017). Las OTTUS representan un medio para lograr una vinculación efectiva entre el sector académico y el sector industrial, — pese a que la transferencia de conocimiento por parte de las universidades latinoamericanas sea incipiente y además, carente de un marco jurídico legal que la propicie (Jiménez, 2016) —.

Metodología

La revisión de la literatura se realizó en tres etapas: la primera fue la búsqueda de la información en bases de datos especializadas; la segunda etapa, consistió en la organización de la información y en la tercera etapa, se realizó un ejercicio hermenéutico para inferir, describir y explicar los hallazgos.

La Configuración de las Oficinas de Transferencia Tecnológica Universitarias

La organización de una OTTU está compuesta por dos partes: La estructura de sus áreas y la estructura de su modelo de funcionamiento

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(Campbell, 2007). En cuanto a la primera, se sugiere que esté formada por un área de mercadeo, un área de economía y un área jurídica (Monsalve, 2014). Otra propuesta sugiere las siguientes áreas: área de publicidad, exposición y educación; área de habilitación de proyecto y consultoría y apoyo financiero; área de concesión de licencias y transferencia de tecnología; y el área de comercialización y emprendimiento (Sart, 2014). La estructura de una OTTU estaría incompleta sin la existencia de un área directiva, puesto que los directores son los principales estrategas (Fitzgerald y Cunningham, 2016). Es recomendable que los directores de estas oficinas sean gerentes profesionales (Muscio, 2010).

De acuerdo con Young (2007), antes de crear una OTTU es importante obtener una respuesta positiva a las siguientes preguntas:

> ¿La comercialización de la investigación se alinea con la misión de la institución? ¿Hacer la calidad y la cantidad de investigación dentro de la institución garantiza el establecimiento de una oficina de transferencia? ¿Está dispuesta la institución para hacer un compromiso a largo plazo con los requisitos institucionales y realizar los cambios e invertir adecuadamente en recursos y personas? (p.545)

Además, durante la primera fase de desarrollo de una OTTU es importante que esta establezca una sólida declaración de misión puesto que representa su centro de propósito y enfoque (Fitzgerald y Cunningham, 2016; Campbell, 2007) y además le permite diferenciarse de otras oficinas análogas (Fitzgerald y Cunningham, 2012).

En cuanto al modelo de transferencia tecnológica que adopte una OTTU, se sugiere que no sea un modelo lineal —dirige el proceso de transferencia bajo una secuencia unidireccional de etapas— puesto que este tiene muchas insuficiencias e inexactitudes (Bradley, Hayter y Link, 2013). Dependiendo de cómo las universidades desean organizar sus actividades de transferencia tecnológica pueden elegir alguno de los modelos organizacionales de OTTUS existentes: modelo interno, cuando la oficina está integrada a la infraestructura universitaria; modelo externo, cuando la oficina no es parte de la universidad sino que funciona como agente independiente; modelo mixto, cuando la oficina combina las dos formas anteriores (Brescia, Colombo y Landoni, 2016). De estos tres modelos, la primera opción es la más recomendada (Derrick, 2015). El modelo mixto recibe también el nombre de modelo híbrido (Huyghe, Knockaert, Wright, y Piva, 2014). Otra forma de clasificar los perfiles de las OTTUS, es de acuerdo a su estilo de gobernanza: integrales, perfiladas a realizar intercambios formales de comercialización; vinculatorias, enfocadas a la dimensión relacional; dispersas, movilizan los resultados de investigación mediante canales específicos; y embrionarias, aquellas que priorizan la dimensión formativa (Codner, Martin, Pellegrini, Becerra y Baudry, 2014). En general, la estructura de una OTTU puede estar centrada en las transacciones o en las relaciones (Weckowska, 2014).

Las OTTUS ya establecidas tienen la opción de crecer de dos maneras: La primera es internamente, mediante la expansión de su personal y la segunda, externamente, realizando redes con otras oficinas análogas. Las formas estructurales para un crecimiento externo son: la estructura *Network*, cuando varias OTTUS de diferentes universidades trabajan de forma interrelacionada; la estructura *Strong Hub*, cuando diferentes universidades crean una sola oficina central en común; y la estructura *Light Hub*, cuando varias universidades a pesar de contar con su propia OTTU deciden además crear una oficina central común. La elección de una de ellas dependerá del contexto (Battaglia, Landoni y Rizzitelli, 2017). Lo que sí es claro es que estas oficinas deben evolucionar continuamente (APLU, 2017).

El Desempeño de las Oficinas de Transferencia Tecnológica Universitarias

Al considerarse esencial medir el gasto en el rubro de la investigación (Heher, 2007), consecuentemente se cree que es importante determinar la eficiencia de las OTTUS mediante una evaluación constante (Gumbi, 2010). Incluso existe una sugerencia de elaborar un modelo global para medir con mayor precisión las actividades de transferencia tecnológica (Prado, Cristina y Bubela, 2010). Actualmente, la evaluación del desempeño no solo pretende enfocarse en una sola OTTU sino pretende extenderse hasta evaluar redes completas de este tipo de oficinas. Un caso específico es la Red Nacional Rumana de Innovación (Marin, Hadăr, Purcărea, y Boanță, 2017). Cualquiera que sea el alcance de la evaluación —local, regional o nacional—, en el fondo, el objetivo es tener una idea clara de los fracasos y éxitos de transferencia tecnológica por medio de un acercamiento a las OTTUS. En este sentido, el aprendizaje que estas oficinas adquieran, especialmente por las fallas y fracasos en alguna de las etapas de la transferencia, puede ser importante para implementar mejoras (Zheng, Miner y Georgey, 2013).

De acuerdo con Huyghe, Knockaert, Piva y Wright (2016), las OTTUS más exitosas son aquellas albergadas por escuelas politécnicas. Por otro lado, Estrada (2009:133), afirma que “las Oficinas de Transferencia Tecnológica son más eficientes al atender una disciplina concreta del conocimiento y un número pequeño de instituciones”. Mientras que Young (2007) sostiene que las OTTUS exitosas se caracterizan por tener una misión claramente establecida, aplicar políticas y procedimientos transparentes, poseer personal y entorno emprendedor y mantener buenas relaciones internas y externas. El bajo rendimiento de una OTTU puede deberse a la ausencia de un modelo de negocios eficiente para transferir el conocimiento (Marin, Hadăr, Purcărea, y Boanță, 2017).

Las funciones de las OTTUS varían dependiendo de su contexto (Sart, 2014). En el lado más entusiasta, existe mucha esperanza en el rol de estas oficinas como motores de la economía (Pedraza y Velázquez, 2013). En contraste, en el otro extremo, algunos autores se preguntan si las OTTUS son un instrumento de política eficiente para comercializar los resultados de la investigación de la universidad (Tang y Matt, 2009; Apple, 2008), o si existen otras estructuras organizativas además de una OTTU que se ajusten mejor a las necesidades de un investigador (Tseng y Raudensky 2014). La evidencia más contundente para sustentar estas aseveraciones radicales, es que existen universidades donde las OTTUS son ineficaces para acelerar la comercialización del conocimiento, asumiendo incluso que una universidad sin tener una oficina de este tipo, podría tener el mismo o mayor éxito en la transferencia de tecnología que aquellas universidades que sí cuentan con una (Tang y Matt, 2009). Por otra parte, el desacuerdo con la existencia de las OTTUS se debe a que existe la posibilidad de que otras áreas de la universidad realicen las actividades planeadas exclusivamente para estas oficinas con el mismo éxito (Sart, 2014). También existe la evidencia de que el desempeño de una OTTU no depende de su tamaño (Tseng y Raudensky, 2014), y tampoco depende de su antigüedad (Algieri, Alquino y Succurro, 2011), aunque se han dado casos como en Francia donde las OTTUS más antiguas son más eficientes (Curi, Daraio y Llerena, 2014).

En cambio, sí es determinante el apoyo estratégico de la administración universitaria (Olcay y Bulu, 2016), así como la receptividad de los departamentos universitarios (Muscio, 2010) y el capital relacional de las OTTUS (Feng, Chen, Wang y Chiang, 2012); mientras que el cambio en las reformas públicas sólo puede favorecer medianamente el rendimiento de estas oficinas, como ocurrió en Francia a finales del siglo XX (Curi, Daraio y Llerena, 2014).

El desempeño de las OTTUS está relacionado con dos aspectos: El primero, son las funciones que se les han delegado (Tabla 1) y el segundo, son los indicadores a través de los cuáles se ha venido midiendo su desempeño (Tabla 2).

Tabla 1. Funciones de las OTTUS.

FUNCIONES	AUTORES
1. Ser un agente intermediario entre la universidad, el sector productivo, el sector gubernamental y otras instituciones para asegurar el flujo de recursos tecnológicos, financieros, humanos y relacionales entre estos actores.	Lafuente y Berbegal, (2017); Gumbi (2010); Prado, Cristina y Bubela (2010), Heher (2007); Wai Fong, De-haan y Strom (2012); Marin, Hadăr, Purcărea, y Boanță (2017); Monsalve (2014); Estrada (2009); Sart (2014); Young (2007); Cruzado y Tostes (2015); Apple (2008); Caballero (2016); Codner, Baudry y Becerra (2013); Rojas (2017); Weckowska (2014); Rintoul y Lumb (2012); Pedraza y Velázquez, 2013); Vendrell y Ortín (2008); Tseng y Raudensky (2014); Gubitta, Tognazo y Destro (2016); Dos Santos y Torkomian (2013); World Bank Group y OECD (2011); Algieri, Alquino y Succurro (2011); Olcay y Bulu (2016); Lindenstein (2013); Cesaroni y Piccaluga (2016); Feng, Chen, Wang y Chiang (2012); O´kane, Mangematin, Goeghegan y Fitzgerald (2015); Muscio (2010).
2. Comercializar el conocimiento (resultados de la investigación) mediante diversos mecanismos para generar ingresos institucionales.	Lafuente y Berbegal (2017); Gumbi (2010); Huyghe, Knockaert, Piva y Wright (2016); Heher (2007); Wai Fong, De-haan y Strom (2012); Marin, Hadăr, Purcărea, y Boanță, (2017); Zheng, Miner y Georgey (2013); Sart (2014); Piccaluga y Balderi (2012); Derrick (2015); Caballero (2016); Rojas (2017); Vendrell y Ortín (2008); APLU (2017); Sharma, Kumar y Lalande (2006); World Bank Group y OECD (2011); Cesaroni y Piccaluga (2016); O´kane, Mangematin, Goeghegan y Fitzgerald (2015); Muscio (2010).
3. Gestionar la propiedad intelectual para proteger los resultados de la investigación.	Lafuente y Berbegal, (2017); Heher (2007); Olaya, Berbegal y Duarte (2014); Piccaluga y Balderi (2012); Caballero (2016); Pedraza y Velázquez (2013); World Bank Group y OECD (2011).
4. Prestar servicios para el beneficio de la sociedad.	Gumbi (2010); Prado, Cristina y Bubela, 2010); Sart (2014); Caballero (2016); Pedraza y Velázquez (2013); Olcay y Bulu (2016); Campbell (2007).
5. Elevar la competitividad de entidades públicas y privadas, potencializando el impacto de los resultados de la investigación.	Marin, Hadăr, Purcărea, y Boanță (2017); Sart (2014); Piccaluga y Balderi (2012); Rintoul y Lumb (2012); Pedraza y Velázquez (2013); Tseng y Raudensky (2014).
6. Fomentar la investigación por contrato o el desarrollo de proyectos en conjunto.	Gumbi (2010); Cruzado y Tostes (2015); Rojas (2017); World Bank Group y OECD (2011); Cesaroni y Piccaluga (2016).
7. Fomentar una cultura emprendedora.	APLU (2017); Young (2007); World Bank Group y OECD (2011); Jain y Georgey (2007).
8. Gestionar el capital humano académico (motivarlo, capacitarlo y movilizarlo).	Sart (2014); Piccaluga y Balderi (2012); Rojas (2017); World Bank Group y OECD (2011).
9. Brindar asesoría profesional a los investigadores respecto al destino de sus innovaciones (marketing, vigilancia, diagnóstico y valoración de la tecnología).	Monsalve (2014); Apple (2008).
10. Proporcionar nuevas experiencias educativas a investigadores y estudiantes.	Rintoul y Lumb (2012).

Fuente: Elaboración propia.

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No todas las OTTUS cumplen o deben cumplir con las funciones mencionadas anteriormente. Todo depende del modelo, la visión y la misión que adopte cada oficina. Algo similar ocurre con los indicadores para medir su desempeño: no siempre se aplican todos.

TABLA 2. Indicadores para la evaluación de las OTTUS.

INDICADORES	AUTORES
1. Cantidad de patentes solicitadas y registradas (otorgadas)	Prado, Cristina y Bubela (2010); Huyghe, Knockaert, Piva y Wright (2016); Heher (2007); Estrada (2009); Zheng, Miner y Georgey (2013); Cruzado y Tostes (2015); Rojas (2017); Tseng y Raudensky (2014); APLU (2017); World Bank Group y OECD (2011); Sellenthin (2009); Cesaroni y Piccaluga (2016).
2. Cantidad de licenciamientos	Prado, Cristina y Bubela (2010); Huyghe, Knockaert, Piva y Wright (2016); Heher (2007); Zheng, Miner y Georgey (2013); Cruzado y Tostes (2015); Apple (2008); Rojas (2017); APLU (2017); Sharma, Kumar y Lalande (2006); Dos Santos y Torkomian (2013); World Bank Group y OECD (2011); Cesaroni y Piccaluga (2016).
3. Cantidad de empresas fundadas	Prado, Cristina y Bubela (2010); Huyghe, Knockaert, Piva y Wright, 2016); Heher (2007); Wai Fong, Dehaan y Strom (2012); Caballero (2016); Rojas (2017); APLU (2017); Gubitta, Tognazo y Destro (2016); Dos Santos y Torkomian (2013); World Bank Group y OECD (2011); Algieri, Alquino y Succurro (2011); Huyghe, Knockaert, Wright, y Piva (2014); Olcay y Bulu (2016); Cesaroni y Piccaluga (2016).
4. Total de ingresos generados	Marin, Hadăr, Purcărea, y Boanţă (2017); Tseng y Raudensky 2014).

Fuente: Elaboración propia.

La elección de los indicadores para medir el desempeño de las OTTUS depende de las instituciones o de los investigadores que evalúan estas instancias.

Problemáticas de las Oficinas de Transferencia Tecnológica Universitarias

Los obstáculos que las OTTUS enfrentan para poder realizar exitosamente su papel, regularmente son:

a) **Desacuerdo en cuanto a su papel comercializador.** Actualmente se critica y advierte del peligro de que la principal y única meta de una OTTU sea generar ingresos institucionales mediante la comercialización del conocimiento universitario, se argumenta que los beneficios sociales que puede generar la transferencia de tecnología pueden superar a los beneficios económicos (Heher, 2007). Se ha planteado también, que los beneficios a corto plazo son meramente financieros, mientras que los beneficios a largo plazo son estructurales, pues pretenden fortalecer el desarrollo de ecosistemas científicos (APLU, 2017). En el fondo de estos desacuerdos existe un debate: por un lado, se defiende una política universitaria de ciencia abierta —como una reacción del acumulamiento de las preocupaciones y temores de investigadores en relación a la privatización del conocimiento (Derrick, 2015)—; y por otro lado, existe una tendencia empresarial de la ciencia (UNESCO, 2015). La existencia de las OTTUS se ve cuestionada principalmente por esta polémica permanente, pero a pesar de todo, el establecimiento de estas oficinas sigue expandiéndose como un fenómeno irreversible causado por el capitalismo académico (Piccaluga y Balderi, 2012; Cesaroni y Piccaluga, 2016).

b) **Escasa visibilidad de las OTTUS.** Estas oficinas fueron creadas para atender a diversos usuarios pero el problema radica en que frecuentemente estos destinatarios desconocen la existencia de estas oficinas. Un caso específico son los investigadores que comercializan sus inventos de forma personal y pasan por alto las OTTUS (Goel y Göktepe-Húlten, 2018) —excepto aquellos investigadores que se han involucrado previamente en actividades de emprendedurismo— (Huyghe, Knockaert, Piva y Wright, 2016). Los investigadores que están bien informados sobre la existencia de las OTTUS y sus funciones aplican más patentes y licencias (Sart, 2014). Algo similar ocurre con los estudiantes, pues al estar informados sobre las OTTUS se interesan más por involucrarse en la creación de nuevas empresas (Sart, 2014).

c) **La falta de identidad de las OTTUS.** Puesto que estas oficinas son agentes que manejan asuntos tanto con la universidad que las alberga, como con el sector productivo, su identidad no queda clara. Estas se ven conflictuadas al tener que asumir una doble identidad: por un lado, una identidad académica; y por otro lado, una identidad empresarial (O´kane, Mangematin, Goeghegan y Fitzgerald, 2015). En otras palabras, las OTTUS se deben alinear a las políticas de la universidad (Prado, Cristina y Bubela, 2010; Olaya, Berbegal y Duarte, 2014), pero también deben ajustarse a los intereses del sector productivo (Marin, Hadăr, Purcărea, y Boanţă, 2017). En general, es recomendable que una OTTU legitime claramente su identidad para poder acceder a más recursos y para aminorar la resistencia que enfrenta al promover actividades de comercialización (O´kane, Mangematin, Goeghegan y Fitzgerald, 2015).

d) El peligro de generar expectativas falsas. Otro problema latente al que se pueden enfrentar estas oficinas, es que sean promotoras de expectativas poco realistas. Puesto que muchas de las OTTUS de reciente creación adoptan los modelos de los Estados Unidos de América (Prado, Cristina y Bubela, 2010) o los modelos de Canadá (Sharma, Kumar y Lalande, 2006), dan por hecho que tendrán el mismo éxito que las OTTUS estadounidenses o canadienses, pero dejan de lado que las condiciones sociales y económicas no son las mismas (Heher, 2007).

e) El problema de la autosustentabilidad. Algunos autores se muestran entusiastas en cuanto a la capacidad autosostenible de las OTTUS (Tseng y Raudensky, 2014; Marin, Hadăr, Purcărea, y Boanţă, 2017), pero otros muestran lo contrario, argumentado por ejemplo que estas oficinas sólo son autosostenibles cuando los ingresos por licenciamiento son altos —como el caso de las OTTUS de Canadá— (Prado, Cristina y Bubela, 2010). En general, los ingresos recaudados por medio de actividades de transferencia tecnológica son inciertos y variables (Heher, 2007). Al parecer la transferencia de tecnología no garantiza la recaudación de fondos (Cesaroni y Piccaluga, 2016).

f) La falta de personal idóneo. No todas estas oficinas cuentan con personal altamente capacitado (González, 2016) y esto representa un obstáculo para el éxito de sus funciones (Huyghe, Knockaert, Piva y Wright, 2016). Como consecuencia de no contar con capital humano capacitado, suelen redactarse inadecuadamente las patentes (Rosa y Frega, 2017). Por lo anterior, se recomienda a las OTTUS establecidas en países en desarrollo, que mantengan como prioridad la formación continua de su personal para elevar su competitividad (Heher, 2007; González, 2016).

g) La poca participación de los investigadores en actividades de transferencia tecnológica. De las tres misiones que recientemente se les han asignado a los investigadores: investigación, enseñanza y transferencia; la tercera es la menos cumplida (Sellenthin, 2009), excepto en algunos contextos concretos, como Alemania, donde las bonificaciones a los investigadores que transfieren tecnología son considerables y diversas (Sellenthin, 2009). Sin la colaboración de los investigadores en la producción de innovación, las OTTUS no pueden lograr mucho. Este problema obedece a diferentes factores, entre estos destaca la deficiencia de un sistema universitario de incentivos (Heher, 2007; Estrada, 2009). Para aumentar la participación de los académicos y estudiantes es determinante el apoyo de la universidad hacia las OTTUS. Una forma de hacerlo es involucrando a los estudiantes de posgrado en actividades de transferencia tecnológica, otorgándoles incluso educación empresarial (Wai Fong, De-haan y Strom, 2012). En este punto, se busca que las OTTUS catalicen en los investigadores un comportamiento empresarial (Sart, 2014). Se sabe que existen fricciones entre los investigadores y las OTTUS. Al parecer los investigadores no están de acuerdo con las reglas y los sistemas de recompensa de la investigación. Esto representa un problema para estas oficinas puesto que deben adecuar sus políticas a las necesidades de los investigadores (Derrick, 2015) para lograr, entre otras cosas, que los investigadores adquieran experiencia en procesos de patentamiento —sin perder de vista el otorgamiento correspondiente de incentivos— (Sellenthin, 2009).

Una razón por la cual los investigadores no participan con las OTTUS es por estar laboralmente sobrecargados (Rosa y Frega, 2017). Otra justificación es que los investigadores prefieren dedicarse a la investigación básica y en cambio, guardan una relación distante con la cultura de la comercialización (Vendrell y Ortín, 2008). Además existe evidencia de que los investigadores prefieren dejar la comercialización de sus descubrimientos a otra persona. Las razones son diversas: en primer lugar, la mayoría de investigadores no fueron contratados para involucrarse en actividades de transferencia; en segundo lugar, regularmente los investigadores hacen ciencia por el bien de la ciencia; y en tercer lugar, los investigadores no desean poner en riesgo su puesto docente y su alto salario solo por aventurarse en comenzar una empresa. Por estos motivos, resulta muy difícil convencer a un investigador para que deje de enfocarse solamente en cuestiones académicas y comience a involucrarse en actividades empresariales (Lindenstein, 2013). También se ha planteado la posibilidad de que las OTTUS no sean las estructuras más idóneas para atender las necesidades de los investigadores y quizás esto explique su apatía (Tseng y Raudensky, 2014). Sea cual sea la razón por la cual los investigadores no colaboran, las OTTUS como estructuras de interfaz tienen la responsabilidad de establecer buenas relaciones no sólo con el sector académico sino también con el gubernamental y productivo (Codner, Baudry y Becerra, 2013; Dos Santos y Torkomian, 2013), pues el capital relacional es un factor clave en el éxito del proceso de transferencia tecnológica (Feng, Chen, Wang y Chiang, 2012).

h) Resolver retos en el rubro de políticas públicas. Puesto que las OTTUS son los agentes intermediarios principales entre la producción y la comercialización de los resultados de investigación, tienen el reto de colaborar en la resolución de temas fuertemente polémicos, como lo resalta la UNESCO (2015):

> Cada vez más países se enfrentan a una serie de dilemas comunes, tales como la dificultad de encontrar un equilibrio entre la participación local e internacional en investigación, o entre la ciencia básica y la aplicada, la generación de nuevos conocimientos y de conocimientos comercializables, o la oposición entre ciencia para el bien común y ciencia para impulsar el comercio. (p. 2)

Si no se logran políticas públicas que fomenten la producción y comercialización de los resultados de la investigación de manera armónica y justa, existe: por un lado, el riesgo de obstaculizar los procesos de desarrollo científico, tecnológico y económico; y por otro lado, existe la posibilidad de causar inconformidad pública entre los actores implicados, al no haberse discutido previamente —un caso particular a considerar, es el proyecto de ley del

Ministerio de Ciencia de la República de Chile, que ha causado gran polémica entre los investigadores universitarios por los nuevos lineamientos que establece en relación a la comercialización de la propiedad intelectual y el reingreso de los fondos otorgados para la investigación (Ministerio de Ciencia y Tecnología, 2018). —. Lo anterior sugiere que las políticas públicas en el rubro de la innovación, deben establecerse de acuerdo a las características y condiciones de la región, garantizando un comercio libre y justo de las invenciones científicas, sin violar los derechos de los inventores, las universidades y los empresarios.

Conclusiones

A partir de la revisión de la literatura se hallaron brechas de investigación que representan oportunidades para realizar nuevos estudios:

a) Independientemente de los indicadores aquí mencionados (Tabla 2) para evaluar el desempeño de las OTTUS, es necesario indagar sobre la dinámica que cada universidad utiliza para valorar el trabajo de su propia OTTU, de esta manera sería posible conocer aquellos indicadores regionalizados y por lo tanto, el acto evaluativo sería más justo y diversificado. Aquí la interrogante es: ¿cuáles son los mecanismos de rendición de cuentas de las OTTUS ante las autoridades universitarias inmediatas?

b) Las OTTUS son claves como intermediarias entre los diferentes agentes implicados en las actividades de transferencia, pero falta claridad en cuanto a las estrategias que pueden fortalecer y mejorar los vínculos de estas oficinas con los sectores: gubernamental, productivo y académico. La cuestión que permanece es: ¿cómo pueden las OTTUS adquirir mayor y mejor capital relacional?

c) Para que las estas oficinas puedan ejecutar exitosamente sus planes de trabajo, primero deben cambiar la cultura universitaria. En necesario conducir a la comunidad académica de manera paulatina a una nueva forma de concebir la producción del conocimiento y sus destinos alternos. La pregunta central es: ¿cómo pueden generar las OTTUS óptimos entornos empresariales dentro de la comunidad universitaria?

d) Sin la participación de los investigadores universitarios, las OTTUS no tienen casi nada que ofrecer o gestionar. La literatura demuestra que existe un choque de intereses entre estas oficinas y los investigadores. Por lo tanto, sería factible realizar estudios al respecto para dar un panorama amplio sobre el proceso de adaptación y negociación entre ambos intereses. La cuestión es: ¿cómo pueden conciliarse los intereses de las OTTUS con los intereses de los investigadores?

e) El trabajo colaborativo en el proceso de producción de conocimiento entre investigadores y estudiantes es un cuadro perfecto para aprender a través de la experiencia. Las OTTUS podrían aprovecharse de esta dinámica de aprendizaje para lograr mejores resultados en sus metas comerciales y sociales, extendiendo su influencia al ámbito educativo. En otras palabras, la pregunta es: ¿cómo pueden generar las OTTUS experiencias educativas a partir de las actividades empresariales universitarias?

f) Más de la mitad de las investigaciones realizadas en este rubro no se sustentan en una teoría sólida para explicar el tejido dinámico entre actores, prácticas e intereses presentes dentro y fuera de las OTTUS. Regularmente los estudios sólo describen el problema apoyándose en datos duros. Hasta el momento, la tendencia ha sido realizar estudios de naturaleza cuantitativa y los pocos estudios cualitativos realizados carecen de una teoría explicativa. En consecuencia, permanece la cuestión: ¿de qué forma se puede explicar el fenómeno de la transferencia tecnológica, incluida en la comercialización del conocimiento, a partir de un acercamiento a las OTTUS?

g) La emergencia de realizar estudios que brinden respuestas para el desarrollo de políticas públicas pertinentes que fomenten la innovación científica y tecnológica de manera efectiva. Las OTTUS, los investigadores, los empresarios y el gobierno son los actores principales en la gestión es estas políticas. Determinar de qué manera pueden las OTTUS involucrarse en el desarrollo de buenas políticas públicas, que favorezcan la comercialización de tecnología, es un asunto que permanece abierto a la intervención de la investigación científica.

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Journal of Technology Management and Innovation
Call for Papers: Special Issue

Innovation Challenges in Latin America

Deadline 30 March 2018

Innovation emerges as an option for companies to achieve growth and sustainability in a dynamic, complex and increasingly competitive environment. Thus, the innovation process has been analyzed from different perspectives, finding different definitions and classifications (Porter, 1998; Cooke, 2008; McCann and Ortega-Argiles, 2015; Geldes *et al*, 2017a).

However, most innovation studies have focused on developed economies. In fact, in the case of Latin America, studies started late and are relatively scarce (Ketelhöhn and Ogliastri, 2013; Olavarrieta and Villena, 2014). In addition, it has been established that business innovation is determined by internal and external factors that are specific to each industrial sector and country, so those general recommendations can only be made to promote innovation in developing or emerging countries (Brenes *et al*, 2016; Geldes *et al*, 2017a; Heredia *et al*, 2018a). Moreover, there are specific variables in Latin American and emerging economies that affect innovation processes such as high levels of informal competition, low levels of inter-organizational cooperation, differences between companies in regions and capitals, among others (Pino *et al*, 2016; Brache and Felzensztein, 2017; Geldes *et al*, 2017b; Heredia *et al*, 2018b).

Given the above, we propose this "special issue" of the Journal of Technology Management and Innovation (www.jotmi.org), with the purpose of contributing to the discussion of the challenges to promote innovation in Latin America. With the purpose of orienting the research proposals, we propose the Global Index of Innovation[1] as a framework, considering the disaggregation of its dimensions and components. It will allow shedding light on topics that can be addressed for this special issue oriented to the firm´s innovation, such as:

<u>Institutions</u>
Ease of starting a business
Ease of resolving insolvency

<u>Human Capital and Research</u>
Researchers
Global R&D companies

<u>Infrastructure</u>
Uses and access of Information and Communication Technologies
ISO 14001 environmental certificates

<u>Market sophistication</u>
Ease of getting credit
Intensity of local competition
Domestic market scale

<u>Business sophistication</u>
The percentage of females employed with advanced degrees out of total employed
University/industry research collaboration
Intellectual property payments
Research talent in business enterprise

(1) https://www.globalinnovationindex.org/Home

ISSN: 0718-2724. (http://jotmi.org)

Knowledge and technology outputs
Patent applications by origin
New business density
Total computer software spending
High-tech exports

Creative outputs.
Cultural and creative services exports
Mobile app creation

Submission Instructions

Paper submissions will follow the Editorial Policies and Peer review Process of Journal of Technology Management and Innovation. Please consult the Journal`s Author page[2]. Submissions can take the form of research articles, cases study and review.

Timeline

Submissions to the Special Issue due by **30 March 2019**
Publication of the Special Issue in November 2019

Editorial information

The guest editors of this special issue are three scholars who are part of the International Research Network *"Entrepreneurship, Innovation, and Cooperation in Regional SMEs[3]"* financed by CONICYT[4], Chile.

Cristian Geldes, Faculty of Economic and Business, Alberto Hurtado University, Chile.
Alejandro Flores, Departament of Administration, University of Pacific, Peru.
Christian Felzensztein, Dean's Chair in Strategy, Massey University, New Zealand.

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(2) http://www.jotmi.org/index.php/GT/about/submissions#authorGuidelines
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