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OUTBOUND OPEN INNOVATION IN ACADEMIA: A SYSTEMATIC REVIEW OF THE EXPLOITATION PRACTICES AND OUTCOMES IN UNIVERSITIES

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Abstract

In recent years, universities increasingly have been involved in the marketing and licensing of their intellectual property rights, mainly in the form of patent selling, technology licensing, and contract research. Although the reasons for this are clear, there are correlated research questions that deserve further attention. We examined how this happens and under which conditions universities carry out such activities to define outbound open innovation. This paper focuses on a specific part of the vast literature dealing with technology transfer from academia, and conducts a systematic review of the literature on the economic exploitation of the knowledge produced (in any form) and sold by universities. The results indicated that a greater part of such research analyzes commercialization modes, with licensing being the main channel of technology transfer, followed by analyses of the performance of the various research modes. In addition, some papers also mention the value network; fewer studies discuss strategies and the managerial perspectives. We analyzed the literature in 42 academic journals and 118 papers specifically dealing with this research topic. This review is the first to analyze literature systematically in terms of the financial benefit acquired by universities from technology transfer and to analyze the best means through which the income can be generated, e.g., licensing, commercializing, the creation of spin-offs, and transferring knowledge or technology to other institutions or establishments.

Keywords*: licensing, commercialization, intellectual property right, patent, university, spin-off*

1. INTRODUCTION

The pace of innovation processes is accelerating intensely in many sectors as new technologies—and especially enabling technologies such as cloud computing, artificial intelligence (AI) and the Internet of Things (IoT)—become more universal and embedded in a larger variety of products (Porter & Heppelman 2014; Macho-Stadler et al., 2007). In this context, innovating alone is less and less an option for firms because of the risks connected with rapid technological obsolescence and the continual discontinuities in technological development (Bianchi et al., 2011). Thus, a new approach to innovation, more open to collaboration with third parties, is needed by organizations aspiring to remain innovative (Chesbrough, 2007).

Such a scenario creates innumerable opportunities for universities because of their role as producers of base knowledge and new technologies (Phan and Siegel, 2006). However, great challenges come with these opportunities, such as exposure to competition, which might result in conflicting ideas among the various faculties (Baglieri et al., 2018), especially considering the inability of many universities and university researchers to transfer to the market the knowledge and the technology they produce (Mowery et al., 2002). This paper focuses on the business side of university technology transfer (UTT) which we call university outbound open innovation (UOOI).

The concept of "open innovation" first was mentioned by von Hippel in the 1990s and was emphasized in studies about open source software (von

Hippel 2003). It was highlighted by Chesbrough (2003), who subsequently defined it as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation" (Chesbrough 2006, 1). According to Chesbrough, open innovation has two sides: inbound and outbound. Inbound open innovation refers to the purposive involvement of third parties in the provision of new ideas and/or in the development of a new product or process, whereas outbound open innovation refers to the process of market valorization with third parties of knowledge, ideas, and other assets owned by an organization. The general aim of open innovation is to maximize the overall "return on innovation" of the organization or firm, which corresponds to the sum of efforts (financial and non-financial) put into innovation activities (Chesbrough 2003, 2006; Kutvonen, 2011).

Some authors, e.g., Lopes et al. (2018), have discovered in recent years that open innovation is a field of research that increasingly is being developed, as indicated by the increase in the number of publications in the field. This phenomenon has just begun, and therefore more attention is needed for better analysis. According to Bogers et al., (2017), it brings individual frameworks and a variety of levels of analysis to the research design, demanding more theory development. Furthermore, the term open innovation is a fundamentally dynamic process, which needs to be combined with some dynamic elements not only for better analysis, but also to achieve a good outcome (Appleyard and Chesbrough, 2017). UOOI refers to the strategies, the processes, and the organizational routines aimed at valorizing in the market, alone or in combination with other organizations, the knowledge, the resources, and the capabilities of universities and academics. Conventionally, the mechanisms through which universities have valorized their technologies include selling or licensing intellectual property rights (IPR) to already established companies (Penin, 2010).

Recent literature has discussed how universities have been changing, especially in the last decades, in relation to the valorization of their knowledge assets (Özel & Pénin, 2016; Ho et al., 2013). The literature has highlighted that many changes have occurred both internally—more-precise transfer strategies (Siegel et al., 2003); new modes of knowledge transfer (Mowery et al., 2001); and the creation of ad hoc structures, such as technology transfer (TT) offices (Thursby & Jensen, 2001; Chang et al., 2015; Baglieriet al., 2018)—and externally, for example, through the foundation of joint research laboratories with firms (Chatterjee & Sankaran, 2015) or the creation of university–industry incubators (Rothaermel et al., 2007). Empirical evidence of best practices is not missing from the literature, because the respective capabilities for technology transfer realization have a significant positive effect on technology transfer performance, whereas there is no significance in the capabilities of identifying technology transfer opportunities (Bauer et al., 2018).

What is missing, in our opinion, is more conceptual knowledge on the theme. We urge a comprehensive and updated framework aimed at systematizing the existing literature that can help researchers better position their research on this theme. The rest of this paper is organized as follows. First, we provide a brief background of the evolution of technology exploitation in general. A detail systematic analysis of the methodology used in this research is presented, and the literature is reviewed by categorizing it into research streams Then the main findings of the research are presented, followed by discussions and a conclusion.

2. THEORETICAL BACKGROUND

Technology transfer is the process of "transferring a technology-based innovation from the developer of the technology to an organization utilizing and applying the technology for marketable products" Kirchberger & Pohl, (2016: 5). The process originates with an invention, which subsequently is disclosed to the market through specific means and intermediaries, creating a certain impact on the society (Chang et al., 2015). It is presumed by some scholars that defining technology makes it less challenging to define technology transfer. Bozeman (2000: 629) defined technology transfer as "the movement of know-how, technical knowledge, or technology from one organizational setting to another."

Nevertheless, there are many uses of the term "technology transfer," mainly in describing and analyzing a wide range of organizational and institu-

tional interactions which involve some form of technology-related exchange. This includes sources such as private firms, government agencies, government laboratories, universities, non-profit research organizations, and even entire nations. Thus, technology transfer has been used to describe the processes though which ideas, proofs of concept, and prototypes move from research-related to production-related phases of product development.

Furthermore, based on the annual conference of the Technology Transfer Society in 2011, Technology Transfer in an International Economy was devoted to bringing together professionals from academia, research institutes, and business practitioners (Audretsch et al., 2014). Audretsch et al. further confirmed that the main objective is to promote movement of federally developed ideas, knowledge, and technologies created in public institutions to the marketplace for commercialization mindful of its numerous objectives, which depends on the resource, user, or mechanism. Abdul Razak and Murray (2017) similarly expressed the need for university research to be strengthened by relating it to industries to take full advantage of the commercial opportunities.

These definitions differ substantially depending on the discipline as well as the purpose of the research (Audretsch al., 2014). For instance, economists such as Dosi (1988) tend to define technology based on the properties of generic knowledge, focusing especially on variables that relate to production and design. Sociologists tend to link technology transfer to innovation and to view technology, including social technology, as "a design for instrumental action that reduces the uncertainty of cause - effect relationships involved in achieving a desired outcome" (Zhao and Reisman, 1992, 14). It further can be concluded that researchers from business disciplines concentrate mostly on the stages of technology transfer, particularly relating design and production stages and sales to transfer, whereas management researchers are more likely to focus on the intersectoral transfer and on the relation of technology transfer to strategy.

It was discovered that at the beginning, market exploitation opportunities of new discoveries are clear. This can be observed from the uncertainty of the activities of base research, which is conducted equally by universities, research centers, and private firms. However, inventions often fail to reach the market not because of technology-related reasons, but because of management-related reasons (Ismail et al., 2011). Some authors have argued that open innovation brings about the development of nations through innovation and constructive collaboration, through knowledge transfer. Developments in this area still are emerging, and some opportunities are presented (for instance, the open science, co-creation of knowledge, and open innovation triangle) as great opportunities to generate an original contribution from research to open educational theory and practices (Ramírez-Montoya & García-Peñalvo, 2018).

3. METHODOLOGY

We conducted a systematic review of the literature that focuses on the process of market exploitation of knowledge assets possessed by universities. Therefore, our interest, as mentioned in the Introduction, was limited to the process of market valorization (in any way possible) of the discoveries made by university researchers. In this case, a multi-step process was conducted, in which we began by combining some key terms which are related to the research topic, using Web of Science as the main search engine, as well as Google Scholar. The keywords Technology Transfer, Patent, Licensing, Exploitation, Open Innovation, Outbound Open Innovation, and Intellectual Property Right were combined with keywords such as Universities, Spin-Offs, Academia, and Science, which initially produced thousands of results.

Following this systematic review, some of the combined words generated a huge number of entries, which were difficult to import into Endnote before the elimination was done. For instance, Technology Transfer AND University generated 4,551 results, and Licensing AND University generated 4,651 entries. On the other hand, some of the combined words did not have many entries; for instance, Outbound Open Innovation AND University generated only three entries. Each combination was treated separately. To narrow down this search, it was refined by selecting only Journal Articles and Review and by restricting the category of search to only

Management Journals. At this point, only articles that contained at least one of the keywords were considered, resulting in 1,754 papers. Each entry was exported into Endnote by carefully considering only articles that centered on university invention, university technology transfer (UTT), commercialization, and patenting and licensing in university. This further reduced the number of articles to 340, which then were prepared for categorization.

In the next step, the papers were organized in a table in the order Authors, Title, Year, Journal Type, Volume, Issue, and Abstract. The column following Abstract categorized the papers using a Likert scale from 1 to 5 with respect to how close the paper was to the main keywords, in which 1 indicated that a paper related to the fewest keywords, and 5 indicated papers related to most of the keywords. My supervisor to categorized these papers using the same scale; we agreed and disagreed about some of the papers, and had to come to a consensus on the elimination criteria.

This categorization and elimination of papers was carried out not only by reading carefully the titles of the articles and their abstracts, but also by downloading (mostly through Google Scholar) and reading (not in detail) the full version of the papers. The first categories of papers that were eliminated were those that mentioned only patent diffusion and patent citation. These papers (78 articles) mostly discussed the cost that universities incur in carrying out research, and not the benefits, which was the focus of the present research.

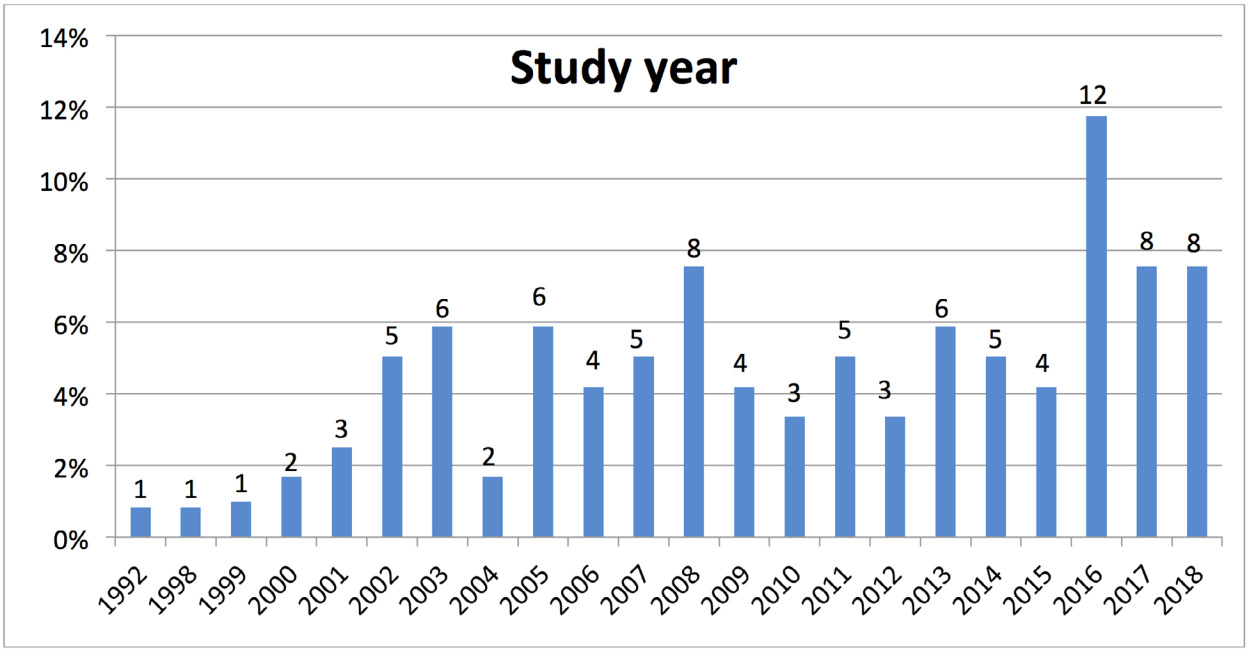
Following the second elimination criteria, 70 articles were identified which focused mostly on university–industry collaboration for purposes other than carrying out an income generating activity. In some of these papers, industries, enterprises, and firms were the beneficiaries, because most of these corporations used universities to achieve their respective goals. The next category of papers that were eliminated from the main review papers (74 articles) studied the theories that are involved in carrying out research in this area, and did not mention the financial obtained by the universities.

Only 100 articles satisfied the search results and were considered by the author to lay the foundation for this systematic review. In addition to these papers, 18 papers were selected carefully from Web of Science and Google Scholar, including some recent publications to update the research. As explained previously, no date range of research was included in the initial search criteria, because this field of study is not very old; 2003 is considered to be the year of breakthrough in this research area. Therefore the articles used in this research were published from 1998 onward (Fig. 1). Most of the articles used in this systematic review were published in 2016, which confirms the newness of this field.

After the 118 papers were obtained, the categorization was deepened by adding columns after the scale evaluation. These new columns were Paper Type, which included conceptual papers, empirical papers, and review papers; and Research Method, which included Quantitative, Qualitative, and Mixed Methods. Furthermore, we included the sources through which data were collected in these papers, such as Case Study, Survey, Investigation, Interview, Experiment Content Analysis, Ethnography, Data Mining, Statistical Analysis, and Annual Report. The next column categorized papers according to the methods of analysis, such as Disruptive Capacity, Regression, Comparative Cross-Case Analysis, Multidimensional Process, Multiple Methods, Descriptive Analysis, Data Envelopment Analysis (DEA), Cohort Analysis, Descriptive Statistics, Technology Transfer Model, Multiple Case Study, Content Analysis, Input-Output Model, Game-Theoretic Model, Practice-Based Analysis, Market Analysis, Multivariance Analysis, Multi-Stage Process, Revenue Maximization Model, Intermediate Input Model, Two-Stage Model, Multivariate Probit Model, Company Start-up Model, Conceptual Model, Cognitive Model, Licensing and Spin-off, Social Network Analysis, Systematic Literature Review, Semi-Structured Interview, Panel Analyses, Cross-Section Estimates, and Meta Data Analysis.

There was a slight increase in publications from 1992 to 2003, when many scholars started developing interest in this field of studies. Thereafter, publications fluctuated from 2004 to 2015, with 2008 having the highest percentage (8) of publications. The fewest publications in this field according to the data collected in this research were in 1992, 1998, and 1999, equivalent to 1% each. This fluctuation could be because researchers became interested in

Figure 1: Articles published from 1992 to 2018



this field of studies after the publications by Chesbrough in 2003 and 2006. From 2011, there was a continuous but slight increase of publications in this field of studies until 2016, when 12% of papers were published. Studies show that the number of researches carried out in this field will be greater in the future compared with previous years because this field of research has not been exploited fully by scholars. The years 2017 and 2018 show that there still is much research to be carried out in this field, because it now has been extended to companies and to society at large. The term OOI is not new; it has existed for many years, but with different meanings. This paper was updated by adding six papers which focus more on the relationship and benefits that universities obtain through their collaboration with some of the industries.

4. LITERATURE REVIEW

4.1 Introduction

This section reviews the literature on open innovation and discusses how some of these authors have approached the term technology transfer. We focused on the evolution of the literature on the transfer of knowledge in universities and the application of the open innovation perspective in university technology transfer. The literature subsequently was evaluated using details of the articles that were involved in carrying out this research. This classification helped to identify some streams of literature which then were classified further with respect to the author's main idea.

Friedman & Silberman (2003) highlighted that technology transfer has been cited by many university administrators as an indication of economic growth and as the main source through which universities derive their revenue, considering the reduction in university funding. According to these authors, the fact that the Patent and Trademark Law Amendments Act, P.L. 96-517 was established in the US and its content was later adopted elsewhere in Europe and Asia, rendered this concept uniform. This uniformity removed the restrictions on university licensing, allowing a rise in university patents resulting from federal research grants. Thus, the aim of this law was to permit universities to license their research to industry for commercial development in the public interest.

According to Roessner et al. (2013), there have been several efforts to improve technology transfer, including those of the National Science Foundation

and the Organisation for Economic Co-operation and Development. Thus, efforts by faculty and a firm's investment will determine the success of the technology transfer (Siegel et al., 2003). For example, there is a long history of technology transfer in the US university system, dating far back before the 1980s, and these activities have been rooted in the motivations created by the unusual scale and structure of the US higher education system compared with that of many Western European nations or Japan (Mowery & Sampat, 2005). However, this situation significantly changed in the early 2000s, beginning in the UK, France, and Spain and later spreading to most European countries, such that universities, rather than professors or scientists, retained the ownership of academic patents (Geuna & Rossi, 2011; Crespi, et al., 2011).

It is in academia that TT, in the form of university technology transfer, has been studied the most, because of the primary role played by universities as providers of base knowledge in many scientific and technological fields (Friedman & Silberman, 2003). However, concerns have been raised that this increased activity suggests that university scientists and engineers might be moving toward applied research and away from fundamental (basic) research in efforts to capture some of the gains from licensing (Thursby and& Thursby, 2007).

UTT has been studied abundantly in both the economic and managerial literature and from different angles (Friedman & Silberman, 2003). The definitions used by scholars reflect the differences in the perspectives used. For example, Vinig & Lips (2015) defined UTT as "the results of research from universities to the commercial sector," and Han and Kim (2016) considered this aspect as "the transfer of the research output from universities to the commercial sector." The similarity of these definitions arises from the fact that these authors mentioned that the product of research carries into the technology market, because results and output can be used interchangeably.

A different definition was provided by other scholars, such as Friedman & Silberman, (2003) who defined UTT as "the process whereby invention or intellectual property (IP) from academic research is licensed or conveyed through use rights to a for-profit entity and in the end commercialised." A similar viewpoint was shared by Mesny et al., (2016) and Kirchberger & Pohl, (2016) who referred to UTT mainly as a "process," specifically one through which technology is transferred or moved from the inventor to society and then is used to produce goods or services destined for the market. Similarly, Thursby and Thursby (2002) described technology transfer as a three-stage production process involving multiple inputs such as invention disclosures, intermediate inputs, and license and option agreements.

In contrast to the definition provided by previous authors, Siegel et al., (2003) referred to university industry technology transfer (UITT) as the movement or transfer of workers of a company from one division to another or from one country to another, either within the same company or between companies. This definition, however, does not actually precise the concept of technology as stipulated by other authors. For instance, Chen et al. (2016) referred to the case of China and some Western nations which have no standard definition of university technology transfer, so they compared it with patents, technology licenses, and university spin-offs.

4.2 Evolution of the literature on UTT

Over the centuries, the main responsibilities of academics have been to produce new discoveries for the benefit of the whole humanity and to instruct and tutor pupils to become future scholars (Litan et al., 2007). Only in the last few decades have academics been assisting with the market exploitation of the knowledge produced in universities (Breznitz et al., 2008; Schmitz et al., 2017). In recent years, this has provided modern universities with the opportunity to perform a wide range of activities in tandem, geared toward the development of economic and social aspects irrespective of their historical differences (Etzkowitz 2001, 2013).

Following the evolution of the transfer of university technology, Youtie and Shapira (2008) stated that universities have adopted the role of knowledge factories, which is manifested through the transformation of research inputs (mainly young researchers and funding) into output which comprises

Table 1: Summary of definitions of university technology transfer

Authors	Journal	Definition of TT
Chen, Patton & Kenney (2016: 892)	Journal of Technology Transfer, Vol. 41, N. 5.	It "equate(s) to patents, technology licenses, and university spin-offs."
Friedman & Silberman (2003: 18)	Journal of Technology Transfer, Vol. 28, N. 1.	"The process whereby invention or intellectual property from academic research is licensed or conveyed through use rights to a for-profit entity and in the end commercialised."
Vinig & Lips (2015: 1036)	Journal of Technology Transfer, Vol. 40, N. 6.	"The results of research from universities to the commercial sector."
Siegel, Waldman, Atwater & Link (2003: 3)	Journal of High Technology Management Research, Vol. 14, N. 1.	"The spreading of information through transfers of employees from one division or country to another referred to as intra-firm transfers of technology. University Industry Technology Transfer (UITT)."
Mesny, Pinget & Mailhot (2016: 2).	Canadian Journal of Administrative Sciences, Vol. 33, N. 4.	"The transformation of research results into technology whose intellectual property can be protected and transfer from university to existing company or a spin-off created purposely for commercializing this technology through granting IP rights in return for financial consideration."
Han & Kim (2016: 3)	International Journal of Innovation Management, Vol. 20, N. 8.	"The transfer of the research output from universities to the commercial sector."
Thursby & Thursby (2002: 1).	Management science, Vol. 48, N. 1.	"Technology transfer is a three-stage production process involving multiple inputs such as invention disclosures, patenting or intermediate inputs and licensing and option agreements".
Arvanitis, Kubli & Woerter (2008: 1866)	Research Policy Vol. 37, N. 10.	"Technology transfer is defined as any activity that aims at transferring knowledge or technology that may help whichever academic institution or company to further carry on with its activities."
Rasmussen & Rice (2012: 3)	International Journal of Technology Transfer and Commercialisation, Vol. 11 Ns. 1-2.	"Technology transfer is the process through which the outputs of academic research are conveyed to those who make use of the research results."
Kirchberger & Pohl (2016: 5)	The Journal of Technology Transfer, Vol. 41 N. 5.	"Technology commercialization/Transfer is defined as the process of transferring a technology-based innovation from the developer of the technology to an organization utilizing and applying the technology for marketable products."

is done outside the university as some academic researchers side-step their universities and pass technology directly to firms (Lee & Stuen, 2016).

Some studies have shown that when a company develops an innovative idea, it does not directly bring it to market. Instead, the company partners with or sells the idea to another party, which then commercializes it. Chesbrough (2007) explained this phenomenon as an open business model which permits an organization to be more effective not only in the creation of value, but also in capturing it. Chesbrough further explained why this model should be implemented, giving reasons such as value creation by leveraging many more ideas because of their inclusion of a variety of external concepts; or permitting greater value capture using the key asset of a firm, resource, or position in both the organization's operations and other companies' businesses. This permits knowledge to pass through a variety of means for its enhancement.

Knowledge exploitation activity passes through many channels: technology transfer offices (TTO)—technical know-how, market insights, research evidence, consulting firms—or joint research ventures

that are opened by universities with the aim of facilitating the process of technology transfer from university to the market (Siegel et al., 2007; Thursby et al. 2002; Mesny et al. 2016; Slavtchev & Göktepe-Hultén, 2016). Hall et al. (2014) stated that the transfer of knowledge from the universities to the commercial market has been possible due to the availability of technology transfer offices. For instance, in 2005, US universities' economic activity totalled $40 billion, generating 628 start-ups and 4,932 licenses, whereas in 2012, the number increased to 705 start-up companies and 5,130 licenses as recorded by the Association of University Technology Managers (AUTM) Licensing Activity Survey (AUTM, 2006; Lee & Stuen, 2016).

Chang et al., (2015) stated that technology transfer offices of universities have drawn the most attention from researchers in the last two decades. Leitch & Harrison (2005) found that the efficacy and appropriateness of these TTOs can be involved in second-order spin-out activity and potentially determine the contribution to regional development mainly in the UK. Weckowska (2015) partially shared this view, but pointed out that TTOs can constitute a barrier to efficient and actual technology transfer due to bureaucracy (Siegel et al., 2003) or bottlenecks (Litan et al., 2008).

4.3 Applying an open innovation perspective to UTT

As mentioned previously, universities are less and less passive in managing their knowledge assets. According to Cardozo et al., (2011), it was only after the 1980s that most universities had the right to own and obtain revenues from inventions that were either entirely or partially developed with public funds. This evolution of the ownership of research by universities is termed open innovation because universities now can license their IP or valorize this knowledge through the transfer of technology to non-academic institutions such as firms and companies.

Chesbrough, (2003; 2006: 1) defined the concept of open innovation as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation." Consequently, according to Chesbrough, open innovation creates more-extensive collaboration and engagement in a wider scope of participants, including suppliers, customers, partners, third parties, and the community in general, with universities becoming friendlier through this trend.

The idea was shared by Lichtenthaler (2005), who describes external exploitation (in other words, external commercialization) as the deliberate commercialization of knowledge assets by one organization to another on a contractual basis, usually with an obligatory reward, whether in monetary terms or not. Nevertheless, this perspective of open innovation is quite different from the one proposed by von Hippel (2003), according to whom open innovation refers to a situation in which "all information related to the innovation is a public good non-rivalrous and non-excludable." Von Hippel first applied the concept of open and distributed innovation to open source software, explaining that open innovation includes the right to use the technology at no cost, and to study, modify and distribute it to others at zero cost.

However, this paper limits the definition of open innovation to that of Chesbrough, who also introduced the distinction between two forms of OI: inbound, also known as outside-in; and outbound, which refers to inside-out innovation (Chesbough, 2003). Whereas inbound refers to the part of OI involving the opening of the innovation processes of a company to a variety of external inputs and contributions, outbound refers to the transfer of unused and underutilized ideas outside the organization that can be useful to other organizations, adapted to their respective businesses or business models.

Unlike inbound, the concept of outbound is not popular, and still is underexplored in both industry and in academic research (Lichtenthaler, 2005). Chesbrough explained that the term OI describes the porous nature of organizational boundaries which makes it possible for firms to interact with their environment in the form of exploitation of external technology acquisition. Chesbrough further referred to it as a system that depends on the dynamic capability of the firm, whether internally (technology exploration) or externally (technology

exploitation), which carries out the main technology management tasks of the innovation process (Chesbrough, 2006).

Consequently, OI involves a range of both internal and external sources of technology as well as various technological channels of commercialization. Thus, a deeper consideration of the new managerial challenges in open innovation processes is applicable equally for researchers and practitioners (Chesbrough, 2006). In the same way, OOI is considered to be an independent commercialization of IP which is developed from within the portfolio of a firm, usually online using a market such as NineSigma (Katzy et al., 2013). According to Yuan et al. (2018), university technology transfer permits universities to extract benefits from their research. UTT is an important method that bring together universities and industries; it is a process to transfer, convert, and commercialize new basic university technology research. This process represents several activities that use resources from the universities to generate value-added products and services for commercialization, which then are reconfigured with respect to the change in the environment.

Inspired by the work of Chesbrough in relation to private firms, we define university outbound open innovation (UOOI) as the use of purposive influxes and leakages of knowledge, mainly from universities, to accelerate internal innovation and increase the markets for external use of innovation. We established the link between the knowledge created by the university and examine how this knowledge is transferred to other institutions or organizations using an established market, mainly for financial purposes. Thus, this study focuses only on technology exploitation, which in this case we refer to as university outbound open innovation technology transfer (UOOITT), mainly in the university context, and specifically focusing on the financial benefits. The following section discusses the outcomes of the various papers that have made up this review and summarizes the different streams of literature for better analysis.

5. FINDINGS

Table 2 presents the descriptive statistics of the 118 articles carefully selected from 42 different types of journal articles which were used in this review. However, some classifications which are not represented in this table, such as the theoretical perspective, the methods of analysis, and the journal articles, due to their magnitude, are listed in Appendices 1, 2, and 3, respectively.

Table 2: Descriptive statistics of the sample of papers reviewed

Classification variables	Values	Papers	%
Paper type	Empirical	93	78
	Review	16	13
	Conceptual	10	8
Research methods	Qualitative	71	76
	Quantitative	20	22
	Mixed	2	2
Data source	Survey	28	29
	Case study	24	26
	Interview	12	13
	Content analysis	9	9
	Investigation	9	9
	Statistical analysis	5	5
Study location	North America	46	39
	Europe	34	29
	Asia	16	14
	United Kingdom	12	10
	Mixed	5	4
	Others	5	4

With respect to the type of papers used in this review, empirical papers dominated (93 papers, accounting for 78% of the entire sample). Review papers occupied the second position in terms of type of papers used (16, accounting for 13%), whereas the last category of papers was conceptual (10, or 8%).

The second classification in Table 2 represents the methods of analysis used in this review. The qualitative method dominated, with 71 papers (76% of all classification methods). Quantitative occupied the second position (20), accounting for 22%, whereas mixed methods was the least common, accounting for only 2% of the entire sample.

A large part of the data (28, or 29%) came from surveys, mostly collected through questionnaires.

The second largest source from which data were collected for this review was case studies, with 24 studies (26% of all data sources). Twelve studies (13%) collected data through interviews, whereas 9 (9%) papers collected data via investigation. Nine studies, accounting for 9% of the research, used content analysis; statistical analysis represented 5% of the data sources; and data analysis occupied the last position, accounting for only 2% of all the research.

In terms of the locations where these studies were carried out, North America was first, with 46 studies (39% of the entire sample), with over 90% from the United States. Europe was the second most common study location, accounting for 34 studies (29%), mainly from Italy, Germany, and France, plus a few others.

Asia was the third most common study location (16 papers, 14% of the total), primarily China, Japan, and Taiwan, followed by the United Kingdom, which accounts for 10%. Finally, 5 articles (4%) came from a mixed location such as the UK and Europe, and 4% were from other countries, such as New Zealand.

Concerning the theoretical perspective (Appendix 1), each paper was classified with respect to the theory specified in the paper by the respective authors, although some of the papers did not mention any previous theory used, especially the conceptual papers. According to Appendix 1, the two most frequently used theories were resource-based and knowledge-based, each with seven studies (18%). The third most used theory was transaction cost theory, which was mentioned five times (13%).

Technological change and strategic management theories and game theory occupied the fourth and fifth positions, both occurring four times (11%), followed by stakeholder theory, with three articles

Figure 2: Classification according to the sources of data.

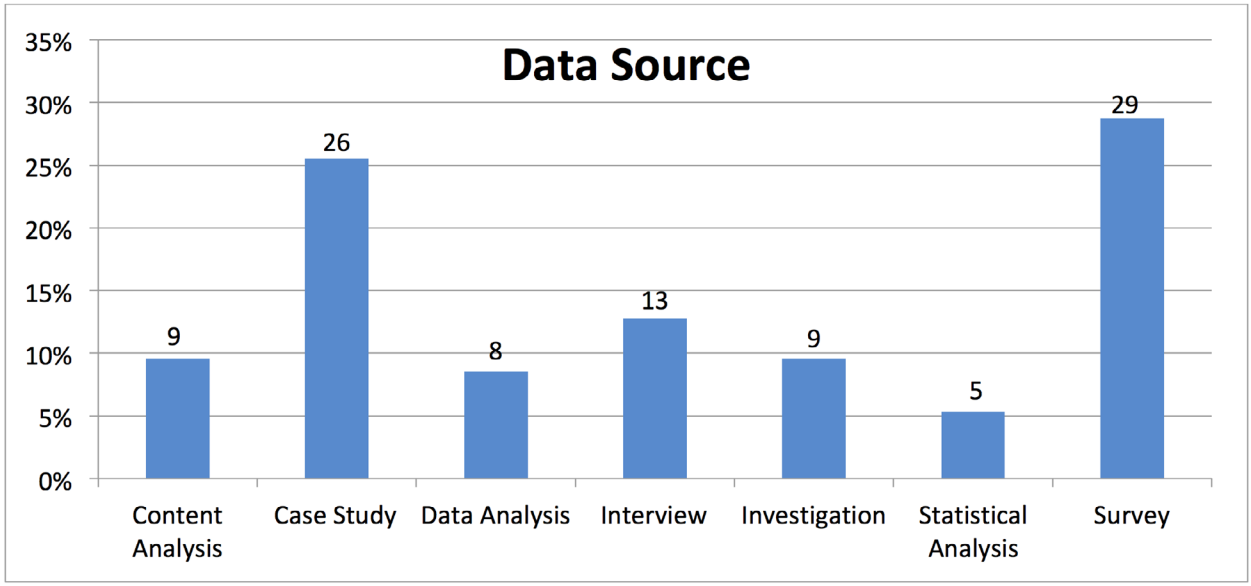
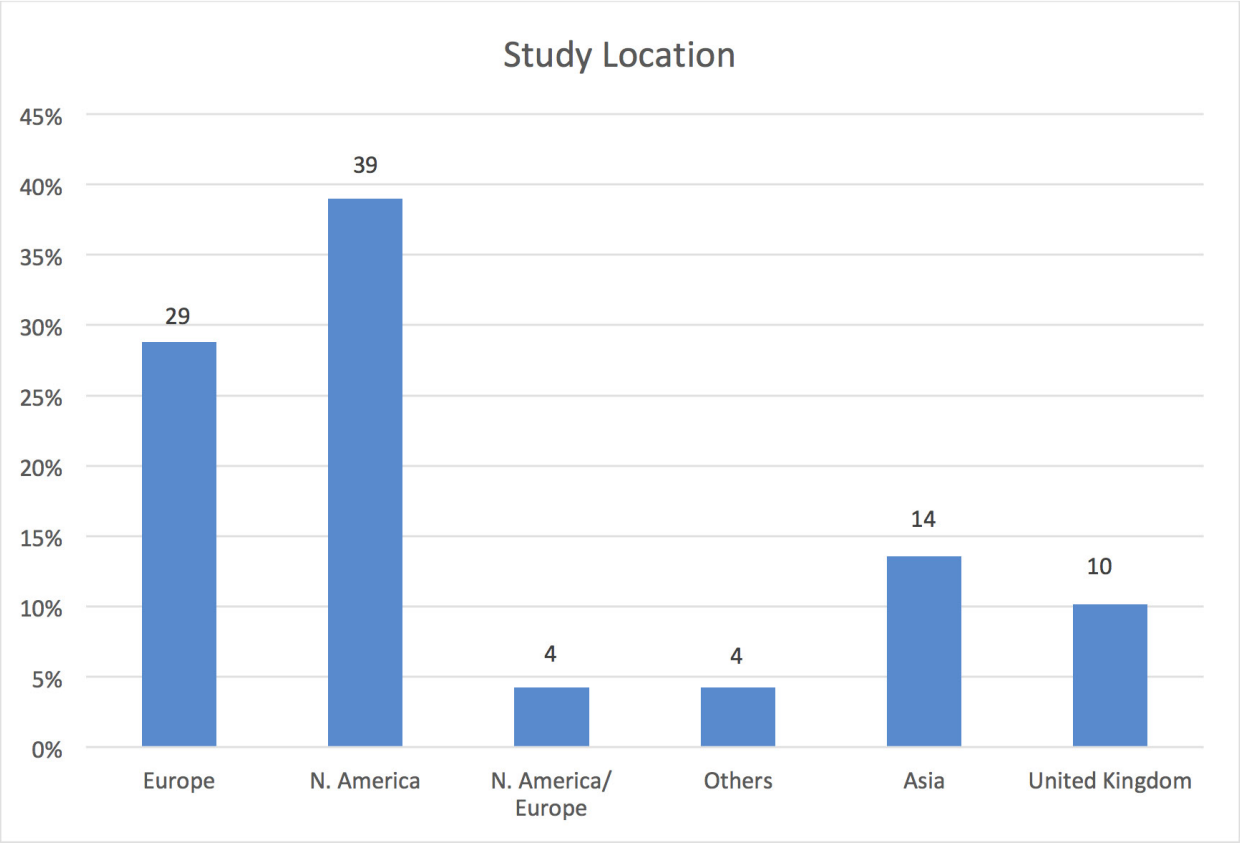


Figure 3: Classification with respect to location



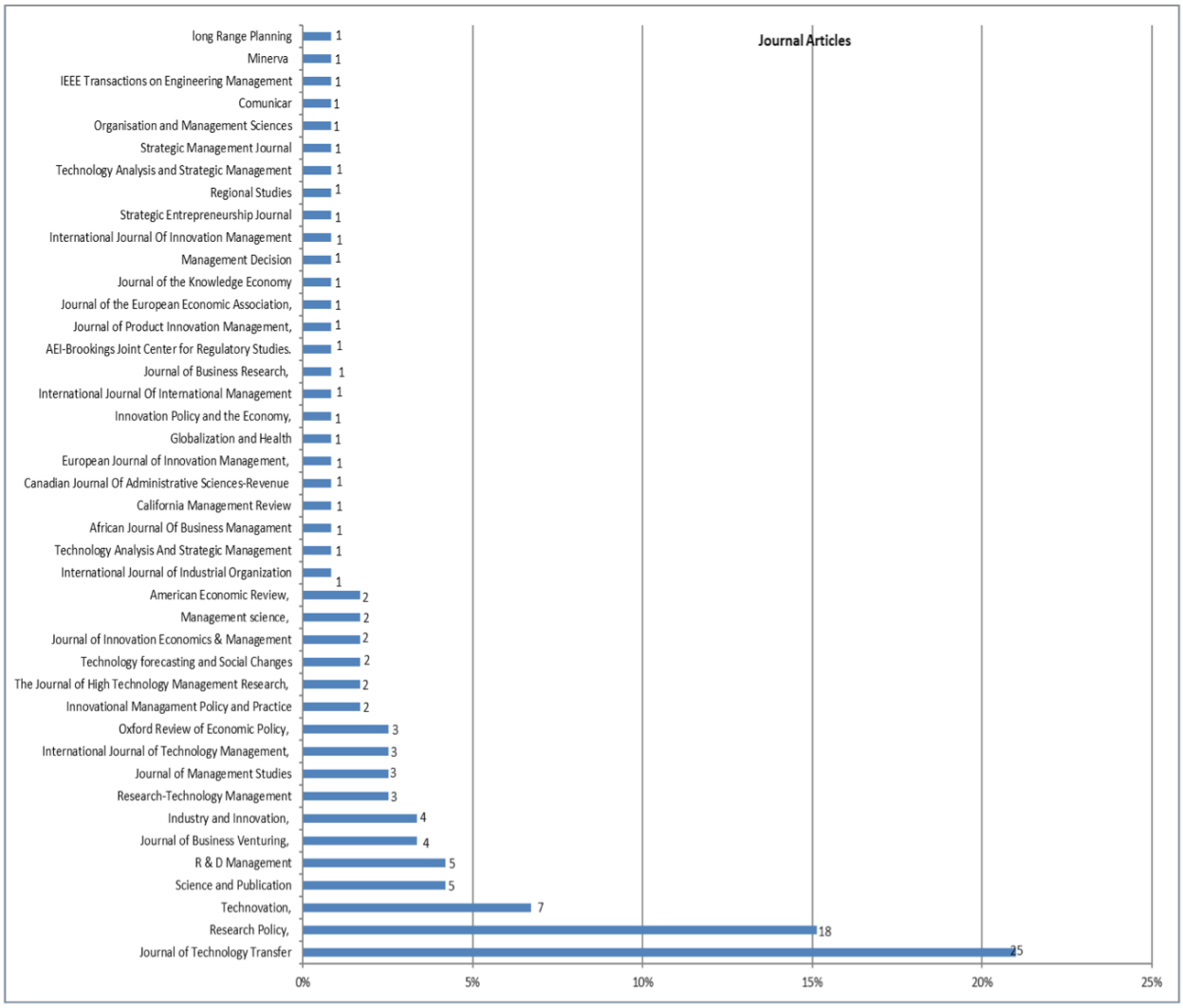
(8% of the entire research). The remaining 13 theories each were used in the journal articles only once, accounting for 3% each (Appendix 1).

Regression analysis (20 studies, 21%) was the most popular method of analysis among the papers studied (Appendix 2). Multiple analysis or methods (16 studies, 17%), which occupied the second position, constituted those articles which used more than a single method to analyze data. Descriptive statistics and multiple case studies each were used to analyze the statistical data in 11 of the articles (11%). Five papers (5%) implemented data envelopment analysis (DEA), whereas game-theoretic models constituted about 4% of all the studies. Revenue maximization models, semi-structured interviews, and content analyses accounted for 3% each, and meta data analyses, multivariate probit models, market analyses, and input-output models each accounted for 2% of the research. The remaining 12 methods of analysis were less frequent; each had a maximum of 1 occurrence (1%).

A significant number of the articles used in this review were taken from the *Journal of Technology Transfer*: 25 articles, constituting 21% of all the papers used in this study (Appendix 3). This journal was of great significance to this paper, because it constituted the basis of the research.

The second most used journal was *Research Policy*, which included 18 (15%) of the selected articles. *Technovation* was the third most used journal, accounting for 7% of the papers. *Science and Publication* and *R&D Management* each had five articles (4% each of all the research journals). The next 12 journals contributed between 2 and 4 articles each, accounting for 30% in total, whereas the last 25 journals had only 1 article each, together constituting 18% of all the journals (Fig. 3).

Figure 4: Number of articles per journal



6. RESEARCH STREAMS

The articles that were used in this research were categorized into four research streams, which were generated chronologically with respect to their significance in this research. The classification of the four streams was based not on any prior literature but on the results of personal interpretation. This was done after carefully reading the abstract, introduction, methodology, and conclusion of the papers involved. It was determined that the papers (although explaining similar views) had different focus. This classification was done to specify the main idea of these papers to determine the categories of papers. This classification also helped to show if any of the streams had evolved, which subsequently could be analyzed. The four streams involved in this research are as follows:

- Knowledge transfer modes and intermediaries: These papers focused on the variety of ways through which academic inventions can be transferred to users, whether through intermediaries such as the technology transfer offices, university incubators (UIs), and collaborative research centers (CRCs); or through main channels, including licensing, patenting, and creating spin-offs. These papers constituted the largest percentage (35%) of the research articles.

- Strategy, organization, and management: These were articles that mentioned how the institutions administer and achieve their inventions, and discuss some of the strategies put in place by these institutions to manage the intellectual property rights. Papers in this category accounted for 25% of all the research.
- Economic and social impact: These papers mainly centered on the price or monetary value generated by academic inventions due to expansions and partnerships with different scientists or institutions. This involves benefits not only to the university, but also to enterprises and society at large, which creates a network of values and growth. The papers in this section covered 18% of all the research.
- Internal impact: These articles explained the positive outcome of innovative research, including the performance and the successes of technology transfer or collaboration (usually with government for social benefits). These papers accounted for 22% of all the research articles.

Classifying these articles into the preceding research streams showed that some papers mentioned issues concerning other research streams; however, this paper focused on the authors' main emphasis. The research streams might seem similar, but they focused on one of the streams. Citations were obtained using Google Scholar, which showed that many of the papers have been cited by other scholars, making these articles useful for this research. These streams are elaborated in the following paragraphs. About 80% of the 118 papers were used in the research streams, which demonstrated the clear difference of the articles.

6.1 Research Stream 1: Knowledge Transfer Modes and Intermediaries

The first stream is also chronologically first and is aimed at examining and analyzing the various methods and intermediaries necessary for transferring the knowledge generated by universities to different facets of society, specifically by licensing and commercializing the new inventions. Selected articles in this stream are represented in Table 2, which lists the authors and the year of publication, the citations of the articles obtained from Google Scholar in October 2017, the method used to collect data, and the main ideas and contributions.

It generally is argued that open innovation practices can be useful predominantly in moving technology off the shelves, mostly in cases in which the potential user community is small, disjointed, or not well linked to the sources of university research. Most authors thus have drawn inspiration from the pioneering work of Lichtenthaler (2005), who first mentioned the idea of technology commercialization. According to Hall et al. (2014), university research long has been considered to be the main source of possibly useful knowledge which has been commercialized in markets due to technology transfer offices. As an example, US universities created $40 billion in economic activity in 2005, which led to the creation of 628 start-ups and 4,932 licenses; in 2012, 705 start-up companies and 5,130 licenses were generated in the US according to the AUTM Licensing Activity Survey (AUTM, 2006). In addition, Weckowska (2014) and Chang et al. (2016) explained that technology transfer offices have for more than two decades drawn the attention of researchers, because most university revenue accrues from the disclosure and licensing of their inventions to these offices. Most businesses are well informed in recent years due to the growth of university technology transfer offices, coupled with the enactment of the Bayh–Dole Act (Thursby and Jensen, 2001).

Although Thursby et al. (2009) acknowledged that these offices experienced enormous growth in university licensing after the enactment of the Bayh–Dole Act in the 1980s, 26% of the patents generated in the US by universities were allocated to firms. According to Thursby et al., this proportion was even greater in Canada and in Europe. Furthermore, in recent years there has been an increase in the transfer of university technology and commercialization, usually because of licensing agreements (which have increased due to an increase in overall university resources), university start-ups, and joint research ventures (Thursby et al., 2002; Mesny et al., 2016). With an outstanding lead from the United States, most universities worldwide now have created technology transfer offices for the commercialization of public research from organizations. This has encouraged most researchers to contribute by commercializing the outcome of their research (Mesny et al., 2016).

Chatterjee and Sankaran (2015), on the other hand, highlighted the model of university technology transfer as a technology seller pooling inventions from numerous research laboratories found in a university. They further considered university transfer offices as a model of technology transfer from the university to industry, which is instrumental in creating and developing a lasting and reputable relationship across industries that could not be performed by a single lab. With the collaboration of industries, entrepreneurship among faculty members and other means of commercializing academic research have become more significant in recent years. Some universities in Asia (Malaysia, India, and Thailand) have not actually benefited from the scheme, because they still consider teaching to be fundamental, and have little or no interest in the commercialization of research, patenting, or relationships with industries (Chatterjee et al., 2015). Moreover, Rasmussen et al. (2006) stated that technology transfer can be more effective if the university focuses on entrepreneurial activities, licensing, and even the creation of spin-offs, rather than engaging in more general and diverse relationships or cooperation with industries. Rasmussen et al. focused on knowledge commercialization of the intellectual property rights of universities, which generates greater economic development and performance.

Raine and Beukman (2002) also confirmed that most universities transfer their technology to businesses and industries through the commercialization of intellectual property rights which result from the research carried out. This is due to the reduction of funds provided by governments, so that universities must seek other means of generating income and share the profits with these organizations. Carayannis (2015) stated that the commercialization of technology can be interpreted as any form of commercial use of intellectual property. This can be carried out through licensing, venture formation, or when the university internally uses the intellectual property (right to sell or license), which subsequently is commercialized by specialized companies (Giuri et al., 2013).

Furthermore, commercialization leads to new functions, such as business incubators, creating new companies (start-ups), executing innovative projects, and licensing (Kirchberger & Pohl, 2016). Thus, technology from the university easily can be taken to market due to the combination of these and other channels, whether formal or informal (Kirchberger and Pohl, 2016; Özel and Penin, 2016). Additionally, commercialization of technology resources is not limited only to the selling of a university's own products or services, but extends beyond the conversion of such approaches, including means such as patent selling, technology spin-offs, licensing, and technology-induced tactics (Kutvonen 2001; Lichtenthaler, 2005).

According to Wu (2010), licensing and patenting are the most effective ways through which technology can be transferred from universities to other entities. Wu referred to these research universities as technology transfer vehicles which convert scientific inventions into innovations, usually through licensing and patenting of the research production. In addition, Swamidass (2012) explained that a start-up may be the only or the best opportunity for the commercialization of over 70% of the total inventions which a university generates and which are never licensed to be commercialized by business units. Experience shows that many university inventions remains on the shelf if they are not licensed to start-ups, and therefore are of no benefit. This view is supported by data from the Association of University Technology Managers, which reports that from 1999 to 2007 about 30–35% of university licenses were allocated to large companies, 50–55% were allocated to small companies, and 10–15% were allocated to start-ups. Pries and Guild (2011), on the other hand, examine how commercial uncertainty, specialized harmonizing assets, technological dynamism, and other legal protection affect the choice of business models. Furthermore, the idea of academic engagement and commercialization is clarified in this review in that the former consists of traditional academic research activities which access useful resources to support the research agenda (Perkmann et al., 2013).

Considering this relationship, most pharmaceutical companies do not license their products in areas where the capacity to develop these products is low, for instance, in some parts of Asia and Africa. Furthermore, the fundamental strategy of a university after putting an invention in the commercial market is to look for established companies either in the same field of study or in related fields that

have the capacity to transform the newly developed invention or technology or knowledge into either research and development or a prevailing line of products, or using this new technology to develop a new product (Graff et al., 2002).

Table 3: Research Stream 1 - Citation counts from Google Scholar, October 2017

Authors	Cit.	Article method	Article focus and contribution
Hall et al. (2014)	14	Interview	Effectiveness of commercializing university research considering the diverse markets. Contributes to developing manager's awareness of the activities of the research community and monitor research developments.
Chang et al. (2016)	6	Conceptual	Faculty disclosure and selection of commercialization mode. Contribute to the existing literature on the impact of patent disclosure
Lichtenthaler (2005)	214	Review	Commercialization and exploitation of external knowledge and its consequences. Contribute to assisting managers to assess the utility of new approaches.
Thusby and Jensen (2001)	5	Survey	Reduction of federally funded research due to non-licensing of university patents. Contributes to the empirical literature on the industrial impact of university research.
Chatterjee and Sankaran (2015)	6	Interview	Variation of commercialization with respect to definitions and orientations. How learning occurs in TTOs, and how the learning processes involved shape learning outcomes.
Weckowska (2014)	39	Conceptual	Capacities needed by TTOs to facilitate commercial exploitation of research outputs. Contributes to novel conceptualization of the occurrence and processes of learning in TTOs, and shapes commercialization practice.
Rasmussen et al. (2006)	372	Case study	An expected increase in both University R&D and commercialization knowledge. Contributes to university responsiveness to the new role of commercialization
Özel and Penin (2016)	0	Review	Determinants and welfare implications of university intellectual property patenting and licensing strategies. Contribute more to economic development through TTOs.
Raine and Beukman (2002)	22	Content analysis	The role of university–industry liaison offices in the commercialization process. Contributes to the valorization of universities and industries.
Carayannis et al. (2015)	12	Content analysis	Practices, directions, and tasks of technology commercialization and licensing at the University of Maryland (USA). Contributes to demonstrating mechanisms to optimize and substantiate decisions concerning licensing contracts.
Mesny et al. (2016)	2	Case study	Commercialization of academic output in administrative science. Contributes to the harmonization of scholars, practitioners, and the knowledge used.
Kirchberger and Pohl (2016)	10	Review	Systematic review of current literature on technology commercialization. Contributes to providing a comprehensive and systematic overview of the current literature on technology commercialization channels to provide a better understanding of the factors that have been researched in this field.
Pries and Guild (2011)	64	Survey	Analysis of models used by universities for commercialization. When intellectual property protection is weak, a technology sale business model approach to commercialization is appropriate.
Wu (2010)	55	Survey	Analyzing the influence of successful licensing of university patents. Contribute to the complex reasoning and historical legacies underlying university decisions.

Swamidass (2012)	33	Case study	Developing appropriate polices to generate more university start-ups for technology commercialization. Contributes to advancing procedures and standardized agreements for easier licensing of university inventions to start-up enterprises
Graff et al. (2002)	117	Review	The business of technology transfer between universities and firms. Contributes to establishing unique research units that are unique in their capabilities and that have distinct relative advantages in terms of capacity and cost-effectiveness.
Giuri et al. (2013)	23	Survey	Commercializing academic patents, developed both in universities and in public research organizations (PROs). Contributes by investigating if ownership of a patent affects the eventual prospect of commercialization, comparing the commercialization outcomes of university-/PRO-owned and university-/PRO-invented patents by exploiting an extensive data set that spans multiple countries, and commercialization consequences for university/PRO patents in countries with different IPR legislative systems.
Perkmann et al. (2013)	661	Review	Academic engagement and commercialization of university–industry technology transfer. Contributes by providing the first review, synthesizing empirical results into theoretical frameworks and showing how academic engagement, which uses a methodological approach, differs from commercialization.
Thursby et al. (2009)	265	Survey	Assignment to inventor-related start-ups is less likely and higher than the share of revenue inventors receives from university-licensed patents. Contributes to policy viewpoint by sharing revenue from licensing that accrues to the inventor when inventions are assigned to and licensed by the university.

6.2 Research Stream 2: Strategic, Organization, and Management

Following the second research stream (which is considered according to previous research as the second stage of technology transfer), academic research generates institutions which organize and manage the various faculties involved in this sector. The management at this stage is not limited to the faculties, but includes the different actors involved, such as industries, government, and other third parties. This stream also mentions the various strategies through which technology transfer and exploitation is carried out. Some authors analyzed how the knowledge generated by universities is managed, and analyzed the strategies proposed to transfer this knowledge (Table 3). For example, Keupp et al. (2012) explained that strategic management of information is the use of strategic management techniques and measures to enhance the innovative activities of firms and ensure it growth and performance. Technological knowledge is becoming a foundation to maintain competitive advantage not only for high-technology industry firms, but also for some universities that conduct innovative research.

Bianchi et al. (2011) stated that the main issue in the strategic management of technology is the conversion of technical know-how into economic worth. According to Bianchi et al., this phenomenon can be conducted either internally through the combination of various technologies and know-how into a useful service which can be marketed, or by the direct selling of these innovations themselves, which is an external factor. In recent years, most universities have conducted more entrepreneurial roles, mainly as key players in the ecosystem of regional innovation with an outcome of technology transfer (Miller et al., 2016). This phenomenon usually is termed a triple helix ecosystem, which involves the interaction between universities, industries, and government, resulting in the growth. On the other hand, the diversity of stakeholders in knowledge transfer generates some cultural and institutional differences, possibly affecting the smooth acquiring, transforming, and exploiting external knowledge (Miller et al., 2016).

According to West (2008), most technical knowledge after the Second World War was managed through the condition and protection of intellectual property rights which were licensed by universities to firms either for equity payments or

for cash. Litan et al. (2008), on the other hand, explained that one of the ways through which universities manage their inventions is knowledge spill-over, also known as the process of university–industry technology transfer (Chang, 2016). This spill-over accrues either by distributing the knowledge in the process of peer review or by dispersing graduates into the labor force. Spill-over in this perspective implies that the resource changes from a private gain to a public good which then provides vital contributions to the inventions and licenses of other researchers, as well as the research and development of some industries (Chesbrough, 2003; Lach & Schankerman, 2004).

Furthermore, over the years universities have played a significant role in knowledge transfer across the pharmaceutical industries due to their collective nature of operation. According to Chaifetz et al. (2007), this has given them a stronger negotiation position with other players in the field, because university processes rights permits them to hold key components of different end products. As explained by Ismail et al. (2011), the recommendations for most universities from the National Research Council (NRC) are that these academic institutions should implement new strategies to boost the development of new university start-ups capable of commercializing the inventions which might not have been taken off the shelf. Thus, universities need new technology transfer policies which can permit them to regularly evaluate their inventions to meet the recommendations of the NRC.

Payumo et al. (2012) suggested that research and development should aim at educating the future workforce as well as conducting a balanced program of applied, basic, and experimental development research. This will create an opportunity for universities to search for new and better ways of financing their research activities. Payumo et al. emphasized that these tools are not familiar in less-developed countries, and therefore, along with detailed understanding of the management roles and the process of technology commercialization, it is a good target for institutions seeking to advance their capacity.

Conceic et al., (2013) also argued that the type of commercial market to target by universities is a strategic decision about the transformation of knowledge into monetary value. This is because some knowledge or technologies that are invented in some universities need to target selected markets. Likewise, a university can as well manage its strategy by maintaining a close relationship with scientific industries as well as externalizing its outstanding technology (Macho-Stadler et al., 2007; Kutvonen, 2001). Moreover, new academic institutions and organizations are being developed to realize scientific research and innovations in a faster way through better management of incubators, technology transfer offices, and science parks (Libaers, 2014).

6.3 Research Stream 3: Economic and Social Impact

With respect to this stream of research, some articles discussed on the value that these inventions create not only for the university, but to the society at large through internal and external network respectively (Table 4). In this section, a greater part of the authors emphasized that economic growth comes from the value network created by these academic institutions, mainly universities, through the interaction with scientists from other institutions or industries, organizations, and the government.

Financial value or knowledge also is generated either through licensing or creating spin-offs, incubators, or university technology transfer offices, both at home and abroad, and thereby creating a long-term network within universities and other corporations. As regions and nations around the world progressively are faced with key economic challenges, they seek ways to enhance their chances of economic growth. Consequently, it is important for legislators to better comprehend the part played by universities in the creation of value in the economy (Roessner et al., 2013).

In recent years, governments have made good use of knowledge generated in academic institutions through the valorization and fostering of innovation, as well as by encouraging competition in the knowledge-based economy (Chang et al., 2008). Furthermore, the bridge of the networking system by policymakers in the creation and utilization of academic knowledge by companies greatly influences the value created in this sector and could be

Table 4: Research Stream 2 - Citation counts obtained from Google Scholar, October 2017

Authors	Cit.	Article method	Article focus and contributions
Bianchi et al. (2011)	19	Case study	The challenges of technology sales and the management of the complexity of technology transition. Contributes to the development of managerial solutions to the challenges from technology sale.
Lach & Schankerman (2004)	160	Case study	Variations in royalty sharing arrangements across universities. Contributes by giving more attention to the university sectors and their designs.
Miller et al. (2016)	22	Interview	Knowledge transfer from universities to other stakeholders through licensing. Contributes to the emergence of the knowledge economy combined with the growing complexity and role of end users as a core stakeholder within the open innovation processes.
West (2008)	38	Content analysis	Analyzes different processes of knowledge spill-over from universities to industry. Contributes by significantly improving communication applications through the theory of information building up a stream of research in open science.
Chaifetz et al. (2007)	14	Descriptive	The influence of university research intellectual property to close the gap for health innovations in poor countries. Contributes to the adoption of Equitable Access Licence by universities and public sector to proactively avoid obstacles to the production of basic medicine.
Chang (2016)	6	Interview	Decisions in faculty invention disclosure towards commercialization mode in its invention. Contributes to the commercialization of university-invented patents in a more comprehensive process of UITT and to the impact of patent disclosure.
Ismail et al. (2011)	18	Survey	Business models permitting transfer of inventions from academia to commercial entities. Contributes to understanding the creation of a semiconductor diode laser for Xerox printer business.
Chesbrough (2003)	2309	Case study	The need to make important investment decisions to ensure the future. Contributes to the synthesis of open innovation into new paradigm for managing corporate research and carrying new technologies to market.
Kutvonen (2001)	56	Review	Measuring outbound open innovation by identifying strategic objectives for external knowledge exploitation. Contributes by considering outbound open innovation as an enabler of additional strategic mobility and flexibility.
Macho-Stadler et al. (2007)	185	Theory	The role of technology transfer in universities. Contributes to characterizing empirically the correlation between technology transfer offices and revenue from licensing.
Payumo et al. (2012)	10	Case study	Presents different IP and technology commercialization policies and lessons learned to offer options to public research institutions. Contributes to understanding how government funding works in different institutions when commercializing IP technology.
Conceic et al. (2013)	44	Interview	Analyzes decisions regarding commercialization strategies of research based businesses. Contributes to recent work by determining the commercialization strategy of technology-based SMEs.
Libaers (2014)	8	Survey	Managing the interactions of foreign-born academic scientists with private firms. Contributes to the literature stream on foreign-born academic scientists in the framework of university–industry interactions.

detrimental to the economic growth of the country involved. Prior research has studied the implications of academic spin-offs, patenting, licensing in the regional economy, and the implementation of the Bayh–Dole Act on market orientation in addition to the value generated from these actions (Thursby and Thursby 2002).

Chang et al. (2008) highlighted that much value has been created in academic institutions by intellectual property rights, spin-offs, incubators, and the licensing of technology transfer. In addition, the Bayh–Dole Act in the US in the 1980s has been a source of inspiration to some Asian countries, mainly Taiwan, Japan, and Korea, which also endorsed the Science and Technology Basic Law permitting the ownership and management of IPRs in academia, which allows universities now to be in full control of their intellectual property. This accelerated the commercialization of new technologies while promoting economic development and entrepreneurial activity. This also has formed new links with other organizations to create and operate on the same platform.

However, Mowery et al. (2001) pointed out that some universities, such as the University of California and Stanford, had recorded successes in technology licensing before the passage of the laws, which have had little influence on the content of academic research. This is because these universities were large-scale patentors who have established strong relationships with already well-established institutions and organizations due to the government expansion efforts in gaining robust international protection for intellectual property. In addition, the constant increase in productivity of research and development is due to research-related activities, namely the development of new university technical know-how, and the provision of valued human capital for both faculty and students, which greatly has enhanced the growth of the national economy (Roessner et al., 2013).

The growth of academic research commercial output has drawn considerable attention from both the managers of technology and university administrators, who valorized this phenomenon by consistently engaging in commercial activities. This has led to some changes in business behavior toward universities, increasing the contribution of economy growth (Thursby et al., 2002). In addition, the social, political, and economic aspects have significantly influenced the ability of universities to economically develop and organize knowledge useful to society, contributing to both the success and economic growth (Bercovitz and Feldman, 2006).

Furthermore, there has been a shift from a traditional to a more advanced, protected, and wider approach by considering patents as sellable assets which can obtain licenses and generate enough money for academic institutions through commercialization. Studies have shown that over 40% of US patent holders account for about 99% of the entire revenue generated by US licensing, whereas the remaining 1% of revenue from licenses comes from 60% of patent holders, leading to the paradox that licensing still is relatively low in this area (Ziegler et al., 2013).

Furthermore, education, as explained by some authors, is one of the oldest academic activities that contributes to economic growth because these institutions also take into consideration the commercialization time of their technology (Carree et al., 2014; Markman et al., 2005). University administrators constantly have cited UTT as a catalyst to regional economic growth or development due to the revenue generated in the contemporary economic environment. As a result, some universities have experienced a decrease in funding from both government and other organizations (Friedman and Silberman, 2006). Moreover, higher education institutes (HEIs) for some time have played an outstanding role in the continuous generation of economic value through regional development as well as the creation of employment in the economy. Much attention also has been given to knowledge generated from the university, because it is geared toward economic growth and technology innovation, consequently, increasing competitiveness and national successes (Chang and Yang, 2008).

Because universities for some time have contributed significantly to the value creation of regional economic growth (through the conversion of scientific inventions to innovation through specific instruments, mostly licensing and patenting, and research output), it thus is necessary to examine further the influence of the growth in the licensing of

these university patents (Wu et al. 2015; Litan et al., 2007). In addition to training young minds, transmitting culture, and generating knowledge, universities act as a mediator of economic growth (Cardozo et al., 2011). Additionally, there has been an enormous encouragement by some universities in the search of alternative means through which their technology can be commercialized, which has led to the development of spin-off companies with the aim of generating more money. This is because, these universities can obtain equity in the creation of start-ups to commercialize their technology more easily than by selling the license to an already established company (Bray and Lee, 2000).

6.4 Research Stream 4: Internal Impact

According to Han and Kim (2016), most previous studies of technology transfer have shown great performance relating to the characteristics of numerous universities, including the existence of university TTOs and the type of university involved. In addition, a few former researchers have studied the relationship existing between technology transfer performance and the Bayh–Dole Act, which was created to enhance university innovation. However, there are many stakeholders in academic research institutions (namely managers of technology licensing offices, faculty, and administrators) with diverse perceptions about commercializing research, which, according to Kim and Daim (2014), makes it difficult to measure the performance. However, further research suggests that institutions should compare their practices with others by measuring the productive efficiency of the licensing practice and benchmarking studies (Anderson et al., 2007; Thursby and Kemp, 2002).

The performance of universities in the transfer of technology seems greater when the scientists of the university work alongside those of the biotechnological firms, which increases the tacit knowledge of the academic institution (Zuker et al., 2002). The case of China is a good example, in which academic research performance in technology transfer over the years has had an equivalent increase to that in the West, resulting from a synergy of the two research communities (Chen et al., 2016).

Despite the economic benefits of the valorization of university technology transfer, some countries, such as the Netherlands, do not seem to benefit from this scheme. This is because, due to the limited data provided by Dutch universities, research from these institutions cannot provide clear results regarding their performance (Vinig & Lips, 2015). In addition, Vinig & Lips considered technology transfer to be a broad and unmeasurable term. For instance, although the presence of variety of stockholders makes performance to be measured by the monetary income generated from universities, it does not measure the real performance. This is because it does not offer the potential for technology transfer that relies on university research. Therefore, technology transfer with a high dollar income could have low performance because the dollar income is less than the available potential.

According to Caldera and Debande (2016), enhancing the performance of university technology transfer draws much attention from most policymakers, and permits them to better administer their research activities in the respective institutions. These policymakers, whether in state or national government, also regard the growing research in universities as a catalyst for economic growth, which triggers the performance of these institutions (Chapple et al., 2005). To effectively measure the performance of the research carried out in an academic institution, if possible, universities should sustain completely this process, which encompasses inventing, innovating, commercializing, and transferring of the new technology (Litan et al., 2008). Despite this, there has been little analysis of efficiency in the system of university technology transfer. An analysis of US university performance determined that this varies greatly from one university to another due to the number of licenses, the formation of spin-offs, and the income generated from these licenses (McAdam et al., 2009; Siegel et al., 2007).

As explained by Calcagnini and Favaretto (2010), time is the most important factor when considering the internal impact of the university knowledge invention. Calcagnini and Favaretto applied the innovation speed theory and developed two assumptions. First, the performance of an academic institution is greater if the commercialized knowl-

Table 5: Research Stream 3 - Citation counts obtained from Google Scholar, October 2017

Authors	Cit.	Article method	Article focus
Ziegler et al. (2013)	17	Case study	Value capture through the commercialization of IP. Contributes to the implementation and deliberations on the structure of IP commercialization by universities and firms.
Carree et al. (2014)	39	Case study	The transformation of academic knowledge into regional economic growth. Contributes to transforming the outputs of new ventures into enhanced performance.
Chang et al. (2008)	10	Survey	The influence of university IPR management and external research partnerships on creating income through patenting and licensing. Contributes to the enhancement of policy implementation in the national interactions of the triple helix.
Mowery et al. (2001)	1518	Content analysis	The growth of university patenting and licensing resulting from the introduction of the Bayh–Dole Act. Contributes be presenting the comparative analysis of academic research enterprise and the innovation system of the US.
Chang and Yang (2008)	32	Case study	Knowledge generated from university drives economic growth and technology innovation. Research exploitation. Contributes to managerial and attitudinal changes between academics regarding the collaborative projects of university–industry
Roessner et al. (2013)	44	Case study	Contributions made by university licensing to the US national economy. Contributes to increasing productivity in industry, resulting in university technology growth and new knowledge generation.
Thursby and Thursby (2002)	954	Survey	Analyzes the dramatic increase in university technology transfer through licensing. Universities contribute to the economy through substantial attention on academic research from both university administrators and technology managers.
Thursby et al. (2002)	580	Survey	The increase in licensing for reasons other than increases in overall university resources. Contributes by proposing reasons for and analyzing factors associated with the shift of universities to a more productive commercialization level.
Bercovitz and Feldman (2006)	638	Conceptual	Determines the role of universities in systems of innovation. Contributes to social governance and development of relations at work and economic efficiency of absorbed knowledge.
Bray and Lee (2000)	33	Interview	The success of incubators or university parks depends on how much technology is transferred from their labs to start-ups. US universities contribute data to both equity sales and holdings.
Chang et al. (2008)	10	Survey	The adaptation of the new international IRP regulations (passed 1962–2002) by Italian universities. Contributes to understanding the rapid development of novel high-technology firms in the US economy during the 90s.
Markman et al. (2005)	386	Case study	The slow rate of technology transfer and its impact on economic growth. Contributes to the debate of policymakers for a shift from applied to basic research.
Cardozo et al. (2011)	30	Survey	Using commercialization time of patent-protected technology as a means of speeding innovation. Contributes to the understanding of the present and future evolution of the technology commercialization.

Litan et al. (2007)	49	Review	The introduction of the Bayh–Dole Act in the19 80s and growth of university innovation commercialization. Contributes to maximizing the potential for university-based inventions, resulting in the commercialization of new innovations and products.
Friedman and Silberman (2006)	657	Empirical	The increasing importance of university technology transfer activities increasingly are important as a source of regional economic development and revenue for the university.
Wu et al. (2015)	44	Survey	Determining the likelihood of individuals and institutions licensing university patents. Contributes by providing new insights into licensing for the process of commercializing university inventions.

edge can generate further revenue through licensing or creating new ventures. Second, the performance of an academic institution is greater if the university can identify what determines the speed of its innovation. Apparently, universities can become more flexible in negotiating their license agreements, which can be absorbed by other firms. As highlighted by Siegel et al. (2003), the capacities of university TTOs partially determine the performance of university commercialization, because not all results from university research are released to these transfer offices.

However, this simplifies the academic invention exploitation in the application of commercialization, because not all researchers have the interest and the ability to advance potential commercial applications of their research (Chapple et al., 2005). In addition, the increase of performance of university technology transfer can be evaluated either by profits, portraying a more diverse goal, or through the identification of some new potential partners, by creating incubators or new ventures to commercialize the exploitation of academic inventions, securing the intellectual property rights, and evaluating technological inventions (Chen, 2009 and Thursby et al., 2001).

7. DISCUSSION AND CONCLUSION

Although nearly all universities carry out technology transfer activities, the distribution of successful commercialization activities is highly skewed among universities whose TTOs sometimes do not benefit financially as anticipated (Litan et al., 2007). The question of why some universities perform better than others has been studied by many authors for over the years, and reasonable answers have been found, some of which involve the general commercialization activities (Rasmussen et al., 2006) or other methods of commercialization put in place by some universities, for example, licensing or spin-offs and patenting (Siegel et al., 2007). Some universities own specific structures or carry out a variety of activities that others do not, such as operating UTTOs, research incubators, and spin-offs, among others.

Analysis of the research streams indicated that many authors (35%) mainly based their research on the commercialization modes, and studied the deficiencies in developing this sector of research. This stream of research identifies what modes of commercialization can be administered better by universities worldwide to better benefit financially from their inventions. Some of the modes identified in this stream are licensing (which forms the basis of the present research) by universities, and the creation of start-ups and technology transfer offices, which in recent years have increase because most corporations also use these offices to market their new technologies. In addition, the creation of research incubators has facilitated invention and commercialization of university knowledge, thereby enhancing the transfer of this knowledge to other institutions or organizations. Thus, given these research modes, universities around the world can select the commercialization mode that best fits their objectives. The benefits accrued to such universities will permit them to cover the cost of research and encourage the institutions to further their research in new fields of studies.

Table 6: Research Stream 4 - Citation counts obtained from Google Scholar, October 2017

Authors	Cit.	Article method	Article focus and contribution
Han and Kim (2016)	0	Multiple source	Examining the determinants of technology transfer in universities in Korea. Contributes to the creation of new firms resulting from the ineffectiveness of patents.
Caldera and Debande (2010)	178	Investigation	Investigating the role of policies on performance. Contributes by examining university technology transfer through the investigation of policies' effect on performance.
Chapple et al. (2005)	428	Case study	Investigating the relative efficacy of UK university TTOs. Contributes by presenting the first empirical evidence on the relative efficacy of UK universities and comparing parametric and non-parametric approaches to productivity dimension.
McAdam et al. (2009)	23	Case study	Means for improving the commercialization of university technology transfer using an absorptive capacity perspective. Contributes to the modern evidence affecting university technology commercialization and using absorptive capacity as an interpretive outline in this context.
Calcagnini and Favaretto (2016)	5	Survey	Innovation leaders perform better than economies with low levels of innovation investment and institutions that do not favor knowledge and technology transfer activities.
Siegel et al. (2003)	729	Interview	Analyzes the outcome of UITT processes. Contributes to improving the consideration of UITT so that managers of the process in universities and industry can enhance its effectiveness.
Siegel et al. (2007)	374	Review	The increase in commercialization rate of intellectual property at US and European universities has important performance and policy implications. Contributes to assisting policy makers and practitioners in organizing TTOs for better performance.
Thursby et al. (2001)	750	Survey	Relationship between licensing outcomes and both the objectives of the TTOs and the characteristics of the technologies. Contributes to the literature by providing evidence of universities on their purposes, in addition to a new indication on the type of inventions licensed.
Kim and Daim (2014)	5	Survey	Ways to identify time lags in the licensing process. Contributes to measuring the performance of licensing of US research institutions by suggesting a method for recognizing time lags in the process of licensing.
Chen et al. (2016)	4	Review	Outlining and evaluating the state of research about university technology transfer in China. Contributes to a deeper understanding of the advanced discussion in China compared with other nations.
Chen (2009)	172	Case study	The effects of technology commercialization incubator and venture capital. Contributes to intermediating the effects of technology commercialization capacity and the moderating effects of incubators and venture capital support on performance.
Vinig and Lips (2015)	13	Annual report	Measuring empirically the performance of Dutch university technology transfer. Contributes to the literature on university technology transfer by adding a new approach to measure its performance.
Anderson et al. (2007)	284	Conceptual	Evaluating public versus private universities in terms of procession of medical schools. Contributes to technological changes in definite subfields of nanotech.
Thursby and Thursby (2007)	164	Survey	Analyzes the success of growth in university technology transfer through licensing. Contributes in motivating inventors to disburse resources in risky innovative activity.

Litan et al. (2008)	91	Review	Progress made in innovation practices since the 1980s and its prospects. Contributes to improving the human condition, thus aiding the transfer and commercialization of findings attends the inventor and society interest.
Thursby and Kemp (2002)	581	Survey	Examining the overall productivity of university licensing activity and the productivity of individual universities. Contributes to measuring the success of a university's technology transfer.
Zuker et al. (2002)	1132	Content analysis	Analysing university tacit knowledge transfer to firms. Contributes by recommending affordable bibliometric measures which are better than, but not perfect substitutes for, costly to construct star measures.

Furthermore, about 25% of all the research papers discussed strategies as well as how inventions are managed during licensing. In this stream, some researchers concluded that for a university to succeed in taking its research off the shelf, the university needs to implement better and new strategies, such as enhancing the existing faculties for better production or creating new institutions. These strategies can be implemented or administered better by managing the various outlets (TTOs, spin-offs, and incubators) so that the university can successfully commercialize the invented technologies. This also is a chance for university administrators to bring in skilled managers or researchers who have the potential to get the research off the shelf and into the market.

In addition, almost 18% of the articles focused on the economic and social impact, which is considered to be one of the goals of each university engaged in the commercialization of research. As explained by most authors, the aim of carrying out research in universities is to take it into the commercial market. Thus, this stream of research shapes out the fact that any research ready for the market must possess a certain value of importance not only to the university but also to society at large, because the knowledge created in such institutions must be transferred to other facets of the economy. Therefore, universities have tried over the years to analyze the value created by these inventions to measure the level of social and economic growth in the economy. Here, studies focus mostly on the valorization of technology transfer by universities due to the involvement of organizations and the government, known as the triple helix era.

The last stream (composed of 22% of the articles) discusses the internal impact of the university and how it can be analyzed or measured. Universities in recent years have engaged in the production and marketing of technology with the aim of acquiring some financial benefits to carry on with further research. However, most of the articles in this stream discussed how universities have put in place procedures to measure their performance, which will permit them to decide either to continue in that research field or to engage in new research fields with enormous benefits. Furthermore, not all technology that is generated in the university is licenced; these unlicensed technologies either are for internal use or already exist in the market because of time lag (from the creation to the commercialization). Nevertheless, performance in the academic field can be a measure which permits academia or administrators to successfully transfer long-term technology or knowledge with outstanding performance. Thus, all research when put to market is expected to have a positive impact on both the university (in monetary form) and society (economic growth).

Unlike in the past, when universities aimed at carrying out basic research, there has been an evolutionary change in the global activities of universities over the years which has led universities gradually to change from carrying out only basic research to adding a much more commercialized level. Many universities now compete among each other, especially in the domain of advancement of innovation and technology transfer. This has strengthened the relationship between universities and industry at the level of technology transfer from universities to industry (Jensen and Thursby, 2001). The creation and transfer of knowledge from universities to other

organizations not only capitalizes on the advantages of these institutions, but to a greater extent is geared toward societal benefits which can foster regional development. Spin-out companies and licensing arrangements are highly funded because of the successes recorded in the commercialization of useful technology generated from basic research (McAdam et al., 2009). However, such developments usually are accompanied by risk of uncertainty, with a greater demand for resource funding. Thus, there is a need to minimize related developmental risk while increasingly allocating resources.

This paper focused on a specific part of an enormous literature dealing with technology transfer from academia, by systematically reviewing the literature involving the economic exploitation of the knowledge produced and marketed by universities, irrespective of its form. This was done through the systematic analysis of the literature in 34 academic journals and 100 papers specifically dealing with the topic. This review is the first to analyze systematically the literature on the financial benefits generated by universities from the vast knowledge produced in these institutions and the best means through which income can be generated, whether through licensing, the creation of spin-offs, or commercializing and transferring these inventions to other institutes or corporations.

The paper provided a brief introduction to and background on outbound open innovation, which was first emphasized by Chesbrough (2003). Universities are more diverse in their organizations because they have many faculties which are specialized in the production and marketing of intellectual property. Technology and biotechnological industries are some examples, which produce and market medical technology and other materials (Macho-Stadler et al. 2007). With the creation of university technology transfer offices, there has been a significant turning point in the commercialization of university inventions, because these offices facilitate the flow and transfer of this knowledge (Siegel et al., 2007, 2004; Graffet al., 2002; Carree et al., 2014). Through the key role played by universities in the creation of knowledge, licensing accords, spin-offs, academic start-ups, and the process of technology transfer, they are highly considered by this research which has enriched the study in many dimensions (Swamidass, 2012; Giuri et al., 2013).

This research is not without its limitations. We considered only journal articles and reviews, without necessarily taking into consideration other sources such as conference papers, books, and others. In addition, we did not provide any time limit, but narrowed the search to the required papers by considering only articles that had most of the keywords of interest. The number of papers used in this research might not reflect the exact expectation of the results to be obtained because the field of study still is growing, with much to be published in the future. Furthermore, most universities during this process face challenges such as limited research funding, lack of follow-up of young researchers, competition with other institutions, knowledge spill-over, and many others, which highly differentiate some universities from others. Some authors (e.g., Goldfarb & Henrekson, 2003) considered that the incorrect allocation of incentives to universities could lead to unsuccessful commercialization of university technology. An example is Swedish universities, which have unsuccessful technology transfer compared with that of universities in the US.

There is no doubt that there are alternative ways through which research from universities can be transferred or commercialized to other institutions or organizations. This study addressed the issue by grouping the research articles into four streams, knowledge transfer modes and intermediaries, strategic organization and management, economic and social impacts, and the internal impact or performance recorded by these institutions. From this classification, it is evident that although not much is written on the intermediaries and various modes of commercialization, there still is a wide range of opportunity to better enhance this stream of research.

This research thus could be a starting point for most academic institutions, especially universities which are more engaged in carrying out research as a basic activity. This is because this study addressed issues that are relevant to the invention and commercialization of university research, such as the modes of commercialization of licensing, organization and management of strategies for licensing, economic growth and social networks in the creation of value, and the internal impact or performance of these universities. The literature on

university technology exploitation is carefully categorized in a technology commercialization context, characterized from different viewpoints through the analysis of the various modes.

Furthermore, this research could be developed further by first differentiating state universities from private universities to analyze the aforementioned issues separately. The results could demonstrate whether state-owned universities benefit as much from licensing their research as do private institutions, and the means of commercialization through which these benefits come. In addition, future studies can focus on a single continent, country, or region and can integrate other aspects determining the financial benefits of university licensing, such as environmental, social, cultural, political, or religious factors. Likewise, it could be necessary to analyze whether the licensing of IP can be influenced by existing markets during the licensing period. Finally, one of the aforementioned channels or modes could be concentrated on and exploited to determine exactly the financial benefit that this channel accrues to the university. Thus, there is a need to further analyze the measurement of success of technology commercialization or licensing and to compare these successes with those of other modes.

EXTENDED SUMMARY/IZVLEČEK

V zadnjih letih se univerze vse bolj ukvarjajo s trženjem in licenciranjem intelektualne lastnine, predvsem v obliki prodaje patentov, licenciranja tehnologij in pogodbenih raziskav. Kljub temu, da so razlogi za slednje znani, se v povezavi s tem pojavljanjo določena vprašanja na katere je potrebno najti odgovore. V prispevku so avtorji preučevali, kako točno poteka omenjeno trženje in licenciranje ter pod katerimi pogoji lahko univerze izvajajo takšne dejavnosti. Prispevek temelji na pregledu obsežnega dela literature o prenosu tehnologije iz akademskih krogov in sistematičnem pregledu raziskav o tem, kako gospodarstvo izkorišča znanje, ki je pridobljeno in (v kakršni koli obliki) prodano s strani univerz. Bolj natančno, omenjene raziskave predstavljajo analizo različnih načinov komercializacije intelektualne lastnine. Preučevanje slednjih je pokazalo, da je licenciranje glavni način prenosa tehnologije, medtem ko so analize uspešnosti različnih načinov raziskovanja drugi najpogostejši način. Nadalje, prispevek vključuje pregled raziskav, ki preučujejo vrednost sodelovanja in povezav, ter raziskav, ki preučujejo tematiko iz perspektive managementa. Avtorji so v prispevku analizirali literaturo, objavljeno v 42 različnih akademskih revijah in skupno 118 posameznih znanstvenih študijah. Ta prispevek je prvi, ki ponuja sistematično analizo literature glede finančnih koristi, ki so jih univerze deležne ob prenosu tehnologije, in analizira najboljše načine za ustvarjanje dohodka, npr. licenciranje, komercializacija in prenos znanja ali tehnologije na druge institucijam oziroma ustanove.

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APPENDICES

Appendix 1

Theoretical perspective	Frequency (percentage)
Resource and capability based	7 (16%)
Knowledge-based theory	7 (16%)
Transaction cost theory	5 (12%)
Technological change and strategic management theories	4 (9%)
Game theory	4 (9%)
Stakeholder theory	3 (7%)
Open innovation theory	1 (2%)
Investment risk perspective	1 (2%)
Organizational Theory	1 (2%)
Information theory	1 (2%)
Innovation speed theory	1 (2%)
Both deductive and inductive approaches	1 (2%)
Agency theory	1 (2%)
Endogenous growth theory	1 (2%)
Grounded theory	1 (2%)
Hannan and Carroll's theory	1 (2%)
New growth theory	1 (2%)
Shannon's communication theory	1 (2%)
Status characteristics theory	1 (2%)
Total	**43 (100%)**

Appendix 2

Methods of Analysis	Frequency (percentage)
Regression (probit, Tobit, time lag, linear, etc.)	20 (21%)
Multiple methods	16 (17%)
Descriptive statistics	11 (11%)
Multiple case study	11 (11%)
Data envelopment analysis (DEA)	5 (5%)
Game-theoretic model	4 (4%)
Revenue maximization model	3 (3%)
Semi-structured interview	3 (3%)
Content analysis	3 (3%)
Meta data analysis	2 (2%)
Multivariate probit model	2 (2%)
Market analysis	2 (2%)
Input-output model	2 (2%)
Cohort analysis	1 (1%)
Cognitive model	1 (1%)
Company Start-up Model	1 (1%)
Comparative cross case analysis	1 (1%)
Business model	1 (1%)
Deductive and Inductive Approach	1 (1%)
Desorptive capacity model	1 (1%)
Absorptive capacity model	1 (1%)
Conceptual model	1 (1%)
Panel analyses and cross-section estimates	1 (1%)
Social network analysis	1 (1%)
Theoretical analysis	1 (1%)
Total	**96 (100%)**

Appendix 3

Journals	Frequency	Percentage
Journal of Technology Transfer	25	21%
Research Policy	18	15%
Technovation	8	7%
Science and Public Policy	5	4%
R & D Management	5	4%
Journal of Business Venturing	4	3%
Research-Technology Management	3	3%
Industry and Innovation	4	3%
Oxford Review of Economic Policy	3	3%
International Journal of Technology Management	3	3%
Aei-Brookings Joint Centre for Regulatory Studies	2	2%
Innovation-Management Policy & Practice	2	2%
The Journal of High Technology Management Research	2	2%
Journal of Innovation Economics & Management	2	2%
Management Science	2	2%
Journal of Product Innovation Management	2	2%
International Journal of Industrial Organization	2	2%
American Economic Review	2	1%
African Journal of Business Management	1	1%
California Management Review	1	1%
Canadian Journal Of Administrative Sciences-Revue Canadienne Des Sciences De L'Administration	1	1%
Technology Analysis And Strategic Management	1	1%
European Journal of Innovation Management	1	1%
Globalization and Health	1	1%
Regional Studies	1	1%
Innovation Policy and The Economy	1	1%
International Journal of Innovation Management	1	1%
Journal of Business Research	1	1%
Technology Forecasting and Social Changes	1	1%
Journal of Management Studies	1	1%
Journal of The European Economic Association	1	1%
Journal of The Knowledge Economy	1	1%
Management Decision	1	1%
IEEE Transactions on Engineering Management	1	1%
Organisational Science	1	1%
Strategic Management Journal	1	1%
Long Range Planning	1	1%
Minerva	1	1%
COMUNICAR	1	1%
Total	**118**	**100%**