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University-Firm Technology Transfer, a Literature Review

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Abstract

Since the Bayh-Dole Act was enacted by the United States in the 80's, several countries in Latin American have developed national policies on technology transfer for the university context. For instance, this is the case of Mexico with the latest science and technology law enacted in 2002 and Brazil with the innovation law enacted in 2004, among others. In these laws are stated that the universities must organize technology transfer offices to manage intellectual property and the corresponding relationship with the enterprises. More recently, in Peru was enacted the new university law in 2015. This law includes orientations for the universities about the internal organization of technology transfer and intellectual property.

In this context, the purpose of this study is the literature review about the identification and characterization of the different elements of the technology transfer processes between the university and enterprise. Also, the study aims to learn how the government of different countries is helping to foster the relationship between the university and enterprise through the technology transfer offices.

For this has conducted a systematic review of five databases (EBSCO, Emerald, ProQuest, IEEE and Science Direct) and a repository of conferences of the Latin American Association of Technology Management (ALTEC). Firstly, in this search it was selected the papers with the technology transfer words in the title. The period of the searching was from the year 1980 to 2015 and the result was a total of 320 scientific papers in journals and 30 conference papers. Then, it was made an initial filtering with the keywords *political*, *negotiation*, *barrier*, *international*, *strategy* and *model*. Also it was made a second filtering with the keywords *University*, *industry* and *government*.

The analysis of the gathered information in this study shows the evolution along the time of the several elements related with the technology transfer process in the university context. Thus, it is stated that there are a growing importance of the technology transfer offices and the university spin-offs. Finally, the literature review is important for outline a framework of policies for the context of Peruvian universities about the organization of the technology transfer.

Keywords: *technology transfer*, *mechanisms*, *university-industry*, *policy*, *model*.

Introduction

In the United States many institutions have established Offices of Transfer of Technology (OTT) after the incentive of the University and Small Business Patent Procedures Act, 1980, known as the Bayh-Dole Act (Siegel, Waldman & Link, 2003). In Europe the national legislation to promote the process of the transference of technology, also known as Transfer of Technology (TT henceforth) is more recent – for example, in Germany an equivalent of the Bayh-Dole Act only came to be twenty years later in 2002 (Grimper & Fier, 2010). Similarly, in Latin America, Brazil established the so-called Law of Innovation in 2004, to facilitate the innovation and the TT from the universities to the industrial sector (Brazil, 2004). Generally these legislations allow the public resources for the investigation, development and innovation to be used with more freedom by the industrial sector and the universities. Due to this, said legislations have promoted an urgency of OTT at a university level and have led to the increase of registration of patents, improving this complex process in terms of technology and organization (Anderson, Daim & Lavoie, 2007).

In 2015, the Peruvian government issued the university law (Congress of the Republic of Peru, 2014), in which for the first time rules related to the transference and commercialization of technology from university to the industrial sector is described. Hence, the research conducted in the university will be able to be transferred to the industrial sector with the support of a legal framework.

Attention should be given to the fact that the universities have experience in the TT, although many of their mechanisms are informal and their researchers do not have management skills. For this reason, the legal field allows them to improve their processes of the TT and to approach the industrial field for the development of projects which involve innovation in society.

In effect, the TT is a very complex issue due to the fact that many elements and social factors are intertwined throughout the process of migration of technology towards the industrial sector. Likewise, seen as a model it presents many ways of approach: alas some authors present their models on the base specific experiences whereas others do so from previous studies. The different perspectives from which a model of the TT can be defined, alongside its elements and factors, make it necessary to revise the pretext over TT between the universities and the industrial sector. The objective of this article is to describe the principal models, elements and factors of the TT, emphasizing the collaboration of the universities and the industrial sector, as well as looking for the similarities or differences between the described models.

1. Method of Systematic Revision

A method of systematic revision of literature will be used (Thomé, Savarda, Fernández & Scavarda, 2012), which consists of five stages that will help with the selection of suitable documents for the investigation. These are:

- i. Selection of the databases.
- ii. Identification of key works for the search.
- iii. Criteria of exclusion of the search.
- iv. Revision of the selected summaries.
- v. Revision of the complete texts of the selected articles.

EBSCO, Emerald, ProQuest, IEEE and Science direct were chosen as the selection of databases; alongside the digital library of the Latino-Iberoamerican association (ALTEC), due to its large publishing context in terms of the industrial sector and other issues related to TT. Regarding the identification of key words, it was decided that the following concern the terms

technological transference, and at least: *university, industrial sector, company or government*. Afterwards all of the articles were filtered so that at least *information technology, strategy, model, commercialization, policies, barriers or international* were included in the summary.

As a result of the search, 851 articles were obtained in magazines and 40 in conference proceedings which were entered into the memory tool of bibliographic references: Mendeley Desktop for proper administration. Regarding the criteria of exclusion, some duplicated articles were deleted. Moreover, some labels were defined which later helped to identify if the article should or should not have been excluded. There were two types: actors (industrial sector, university or government) and action (international, strategy, barrier, model or politics). The first label: actor, served to determine if the article was related to any of the actors which were selected to be revised; and the second label: action, determined if the article studied any of the actions relevant to the investigation. As such, the articles which didn't have any relation to either of the labels were taken away from the list. Another criteria of exclusion was the level of interest in terms not related to the management of the industrial sector, the government, the university or with the TT; however, issues related to agriculture, fishing, biomedicine amongst others were excluded.

Afterwards, summaries of the 302 articles in magazines and the 30 articles from the conference proceedings were selected; these were classified according to the different categories which were previously explained. Regarding the type: 'action', a reference is made to a set of activities or actions which can be described in the article, such as:

- i. International: it refers to whichever case of transference between countries- it could be between the industrial sector, universities with the industrial sector or governments.
- ii. Strategy: it has to be related to a study which determines how one or more actors have proceeded with the TT. It can be a specific case or a set of cases.
- iii. Model: it implicates a procedure which has already been established between the actors, and that has been executed.
- iv. Barrier: it is any study related to problems which could have existed between the actors of the TT.
- v. Politics: they are such studies which describe laws or rulings which allow the transfer.

In the last stage of systematic revision, 75 documents were selected; 60 scientific articles and 15 international conferences, which were used to carry out a description of the TT involving the last three decades. Afterwards, the state of collaboration of the universities with the industrial sector involved with the TT was presents, and due to this the main models, elements and factors of a transfer were shown.

2. Technological transfer throughout the years

With the aim to strengthen ties between universities and industrial sector throughout the years, mechanisms, politics and programs have been studied to transfer technology from universities to the industrial sector. It is known that in the United States during the 80s, the importance of the politics of the state to acquire new technologies was obvious. It is like this, that actors were positioned not only in the industrial sector, but also in the universities and to the very state. Regarding this, Diane Rahm (in Rahm, Bozeman & Crow, 1988) assigned herself to carry out a study about the politics of the domestic TT in which the politics of centers of investigation were highlighted (the universities were considered as such).

Then after, in the 1990's the investigation carried out in the university was considered as an important factor for the industrial sector to generate innovation. As such, the university

started to create programs (later known as the OTT), which were assigned to be in contact with the industrial sectors. Gold, Whitehouse and Hill (1996), alongside Carlsson and Fridh (2002) studied said university programs: the first authors were done by the Metropolitan University of Leeds, United Kingdom; and the second were done by twelve United States` universities. Furthermore, these authors presented a list of the importance of the programs which shall be summarized as following:

- i. Facilitate the TT and spread the technical and managerial skills.
- ii. Improve the profitability of the industrial sector.
- iii. Include mechanisms to obtain the results of the investigation.
- iv. Assist the investigators in the deals with the businessmen.
- v. Be a source of specialized awareness in the negotiation of industrial contracts.

Previously, in the 21st century, studies about the connections and motivations present in the universities appeared to generate transfers. As such, Agrawal & Cockburn (2003) analyzed the regional systems of innovation and concluded as such that important connections exist between the university-based investigations and the areas of investigation and development (I+D) of the industrial sectors. While many of the links are subtle and difficult to describe, they are fundamental in the process of regional innovation.

On the other hand, Lai (2011) analyzed the earnings which are gained by the university and the industrial sector in terms of collaboration. In the case of the university, the author highlights aspects such as the management of industrial instruments, the obtaining of real experience or private funding for an investigation. As such with the industrial sector, Lai highlights other aspects such as the access to laboratorial tools, the updating of the training of their workers or the improvement of their reputation.

3. Relation between University and Industrial Sector

To generate a regional innovation it is necessary to have on board a collaboration of: the university with the industrial sector and the government (Etzkowitz, 2000; Sábato & Botana, 1968). Each one of these agents should comply with its function and also interact with each other in order to generate a system of innovation, which develops ties (Sábato & Botana, 1968), and to consider related issues with culture and the environment of each of them (Etzkowitz, 2000). It ought to be noted that Etzkowitz (2000) points out that the university is in the second revolution of investigation and therefore has the objective of transferring its technology to society in order to help the system of regional innovation. For example, the United States, which has the objective to contribute to innovation in the industrial sector and take advantage of the investigations of the universities, created the previously mentioned law Bayh-Dole, which helps universities to transfer technology to the industrial sector through licenses. This law had positive results (Dai, Popp & Bretschneider, 2005) and helped the university to patent its investigations and transfer the technology in an effective way (Scott, 2004) – for example there was an increase of spin-off technology created in the university (Mowery, 2011). Although the aforementioned law brought many benefits alongside it, it is important to be careful in applying these politics due to the reason that the investigators can look to distinguish their investigations, but only to receive benefits without dealing with the fundamental objective of the university: the education (Scott, 2004).

Nowadays, there are many Latin-American countries which have executed said law (Stal & Fujino, 2005) with positive results. China is also another case of success in terms of TT between universities and the industrial sectors. A clear example are the programs which help students to become experts in a specific area of technology by using internships; later returning and becoming key suppliers for many local industries (Wu, 2010).

Other experiences exist in which the necessity to improve the politics is obvious, as is the case with Brazil and Sweden. The aforementioned South-American country has a law of innovation, but there are still no clear politics about intellectual property which produces a low increase in the spin-off (Botelho & Almeida, 2011). Sweden, on the other hand (Stal & Fujino, 2005), has a lot of politics for the investment of I+D but little incentive for the transfer, it does bring a lot of scientific production but little business innovation.

4. Model of Technological Transfer

It is necessary to see that the TT from the point of view of a model, due to being involved with key elements, processes, behaviors and social factors. Therefore, it isn't possible to think that a new technology created in a laboratory would be useful to commercialize (Heslop, McGregor & Griffith, 2001) in the market. Respecting that, Landau, Maddock, Shoemaker and Costello (1982) emphasize the need to see the TT as a model that has a structural logic in which the key elements are the user which acquires the technology, the contents of the load, the load to be transferred (in which the form of the transference of technology is considered) and the marketing or promotion.

It is easy to recognize that the TT is a complex process (Spencer, 1990) in which all of the activities should be related. Moreover, it is crucial to understand that social factors and behavior in the development of the successful process of TT are joined (Choi, 2009; Galbraith, Ehrlich & DeNoble, 2006; Heslop et al., 2001; Lulu, Seyoum & Swift, 1996; Pereira Fialho & Alberton de Lima, 2005; Purushotham, Sridhar & Sunder, 2013; Waroonkun & Stewart, 2008).

After studying the elements of a TT, Bozeman presents his 'Contingent Effectiveness Technology Transfer Model', in which two important components are highlighted: firstly, the determinants of the effectivity or those elements which help a transfer to be effective – and secondly: the criteria to initiate the effectivity of the TT or the environment of the process (Bozeman, Rimes & Youtie, 2015; Bozeman, 2000).

Despite many authors recognizing the difficulty which resides in the transferring of a technology, Malik (2004) described a model of TT as something simple, like a process of broadcasting. It is to say that a transmitter, a message and a receptor are all taken into count. This distribution of elements can be described in the models of Bozeman (2000), Rubiralta (2004) and Choi (2009), who presented a model of TT based on the triple helix (Etzkowit, 2000). Also, Mayer and Blaas (2002) presented different models of TT in countries of Europe, in which they placed the university as the transmitter, the industrial sector as the receptor and the transferred technology as the message.

Although the agents are repeated across all of the models, the process of broadcasting differs greatly from the process of TT. The receptor can often pass as the transmitter and vice versa in just one transfer; in the specific case between the university and the industrial sector there is a cyclical process of validation and learning (Burnside & Witkin, 2008; Gorschek, Garre, Larsson & Wohlin, 2006).

Taking in account the model of Malik (2004), the 'message' – or the technology, scientific knowledge or whichever other object to be transferred – can be sent in different ways to the object, which is known as means of transference – the transference can take place via different mechanisms – (Heinzl, Kor, Orange & Kaufmann, 2013).

It is worth noting that authors such as Bozeman, Rubiralta, Malik, Waroonkun and Khabiri do not define the difference between media and mechanism; but others do such as: Landau (who places the element media of packet and mechanism of marketing separately), Mayer (who separates that what the university sends and that what the industrial sector

receives) and Hoffmann (for whom, according to the level of the object, the university can use a different media and the transference is made in a different mechanism).

It also worthwhile taking into account the factors which influence the process of TT, or in other words, the environment in which it takes place. In this instance, the social factors or behavior are found. As such, authors such as Bozeman call them the criteria of effectivity and Malik describes them as influential factors – just to mention a few. The social factors or behavior influence each agent in a different way (Khabiri, Rast & Senin, 2013; Waroonkun & Stewart, 2008). This influence is manifested many times throughout the education or capacitation which the agents have obtained from the technology (Choi, 2009). Other important factors which are included in the models of TT are the level of the technology (Hoffmann, Amal & Mais, 2009; Landry, Amara, Cloutier & Halilem, 2013; Landry & Amara, 2012), the protection of the technology (Rahal & Rabelo, 2006), and the promotion, marketing and type of commercialization (Heslop et al., 2001; Landau et al., 1982).

Many other cases exist in which the transmitter, or donor, or the technology brings objectives, politics, and behaviors different from those of the receptor. The specific case of the collaboration of the university with the industrial sector (CUI) also exists, in which the presented models of Mayer (Mayer & Blaas, 2002), Rubiralta (2004) and Kalnins (Kalnins & Jarohnovich, 2015) highlight the presence of an intermediary. This agent's role is to translate the messages which are sent by both the university and the industrial sector (Lai, 2011; Landry & Amara, 2012; Mesquita & Popescu, 2014).

4.1. Involved Elements:

It wouldn't be justifiable to describe the elements of a TT based on just one model. As such, in Table 1 it can be seen that each author defines the elements depending on previous studies or according to the experience. Also the TT can vary if a transfer between the industrial sectors or between the university and the industrial sector is considered.

For this reason, this article will only focus on the TT between the university and the industrial sector, as many elements by many authors already exist.

4.1.1. Transmitter, Broadcaster or Donor Agent

This first element is one that develops the technology in laboratories; in this study it deals with the university. Bozeman describes it as being in charge of creating a technology (transferred object) to transfer to the agent receptor. This transference takes place with a mechanism: patents, licenses, exchange of personnel, etc.

Other authors such as Malik (2002), refer to the agent transmitter as the broadcaster and Waroonkun (Waroonkun & Stewart, 2008) describes it as the sedative or the donor of the technology.

It ought to be noted that the university is not only generating education, but that one of its main objectives is to support society in issues regarding the generation of technologies. The university realizes that it hosts laboratories which the industrial sector would not, and that if it doesn't assist it in this way, new technologies will not be able to be generated which could be turned into innovations in the long term (Sætre, Wiggins, Atkinson & Atkinson, 2009).

Table 1

Models of the transference of technology

Model	Range	Considered Elements	Points to be considered
Landau (Landau et al., 1982)	There is no difference between the transmitter or the donor and the receptor.	<ul style="list-style-type: none"> Use of the process of decision of innovation: conscience, knowledge, formation of attitudes, formation of judgement, decision, confirmation Parameters of output information: user, materials, packaging, marketing and delivery channels. 	<ul style="list-style-type: none"> The model is focused on the transfer of information but can be used for technology. Each transferable product has different characteristics at each stage of the decision process of innovation. Strengthens the characteristics of the receptor of the technology and the promoting and marketing to deliver the technology.
Bozeman (Bozeman, 2000; Bozeman, Rimes & Youtie, 2015)	The agent transmitter is a center which generates knowledge and the agent receptor is an exploiter of technology.	<ul style="list-style-type: none"> Determinants: agent transmitter, media of transfer, object of transfer, environment, agent receptor. Criteria of effectivity: 'Criteria of effectivity: 'out the door', impact in the marker, economic development, political development, cost opportunity, public value, human, scientific and technical capital. 	<ul style="list-style-type: none"> No difference is made between media and transference mechanism Difference between elements which generate the transference and the criteria which are evaluated for the effectivity. In 2015 the criteria: 'value of the public' was added, which corresponds to the value of entities which do not have a commercial objective but instead a social one. For example, universities or centers of research.
Malik (Malik, 2002)	Between areas of a company	<ul style="list-style-type: none"> Based on a model of broadcasting. The elements are: transmitter, receptor, message and retro-nutrition. 	<ul style="list-style-type: none"> The model is presented to be used between agents which have the same institutional objectives. It shows the positive and negative factors which influence the delivery of the message.
Khabiri (Khabiri et al., 2012)	Between areas of a company	<ul style="list-style-type: none"> Based on the model of TT of Malik. Adds the concept of 'bigger environment' which refers to the environment which includes the transmitter and the receptor. Can be seen as a sub-regional, regional or global environment. 	<ul style="list-style-type: none"> Adds to the model of Malik the concept of 'bigger environment'. This concept has a lot to do with the legislations and incentives influenced in the TT.
Hoffmann (Hoffmann et al., 2009)	University-company	<ul style="list-style-type: none"> The investigation offers different levels: level of science, level of technology and level of usage. The industrial sector can generate different benefits: knowledge, competence in the market and innovation. 	<ul style="list-style-type: none"> The TT can occur in any level The TT can occur within the same university- for example: a technology in basic research can pass to a level of usage.
Waroonkun (Waroonkun & Stewart, 2008a)	Between international industries	<ul style="list-style-type: none"> Describes the factors which influence the effectivity of the process of TT: environment of the transfer. Characteristics of Caesar or the purchaser. Characteristics of the grantor or the transmitter. Environment of learning. Added value. 	<ul style="list-style-type: none"> The model takes construction products as a base. As a model it is set in an international environment, it emphasizes on the environment in which the transfer is carried out, in other words the legislation of the countries. It also describes the factors which help with the learning of the TT.
Rubiralta (Rubiralta, 2004)	University-industry	<ul style="list-style-type: none"> The presented model is based on the triplex: the university as a generator of research; the industry as a receptor of technology and the appointed to commercialize it in order to generate innovation, and the state, which participates in a transversal way by means of the instruments (legislation for the university and fiscal incentives for the industry) Additionally, the OTT appears as the intermediary between the university and the industry. 	<ul style="list-style-type: none"> In this model agents already identified in previous articles appear. For example: technological centers, scientific parks, incubators, etc. The demand is presented by the industry and the university's offer. The state's input is considered as fundamental in order to generate the transfer.

Model	Range	Considered Elements	Points to be considered
Gorschek (Gorschek et al., 2006)	Practical case between the university and the industry	<p>The process consists of seven stages:</p> <ol style="list-style-type: none"> 1. Identification of improvements (industry) 2. Study of art (university) 3. Candidates for the solution (university) 4. Validation of the academy (university) 5. Static validation in the experience (industry) 6. Dynamic validation and creation of pilots (industry) 7. Solution in the market (industry) 	<ul style="list-style-type: none"> • The model was presented surrounding a practical case. • Lectures learnt for each step are presented. • The OTT is not described as an intermediary.
Kalnins (Kalnins & Jarohnovich, 2015)	University-industry	<ul style="list-style-type: none"> • The model shows that the TT does not only happen in a formal way but also in an informal way. • The model is based on three missions which the university has: <ol style="list-style-type: none"> 1. First mission: the education. The university has contact with the industry by means of the graduates. As such an informal TT is generated. 2. Second mission: the investigation. The university has contact with the industry by means of its scientific knowledge. Both an informal and formal TT is formed. 3. Third mission: the TT. The university has contact with the industry by means of the cooperation to generate technology. As such a formal TT is made. 	<ul style="list-style-type: none"> • The university offers its technology in both a formal and informal way. • The university venture is considered as a type of transference.
Mayer (Mayer & Blaas, 2002)	University-industry	<ul style="list-style-type: none"> • It presents different models of those which carry out TT. <ol style="list-style-type: none"> 1. Model 1A: contract with the institute of research. Independent entity which commercializes investigations which are developed with universities. 2. Model 1B: center of competencies, in other words a group of industries cooperate with the university in order to form research. 3. Model 2A: TT from an extended center of the university. Alike model 1A, it commercializes technology. 4. Model 2B: TT tested between industries, in other words a provider of developed and possibly marketable technology offers its products to another industry. 	<ul style="list-style-type: none"> • It emphasizes the need to have an agent who can translate the objectives of the transmitter or the donor with the receptor. • The model is based on a study from the European research centers. • The study focuses on small industries such as receptors.

Note. Adapted from Bozeman (2000); Bozeman, Rimes and Youtie (2015); Gorschek et al.(2006); Hoffmann et al. (2009), Kalnins & Jarohnovich (2015); Khabiri et al. (2012); Landau et al. (1982); Malik (2002); Mayer & Blaas (2002); Rubiralta (2004), y Waroonkun y Stewart (2008a)

As such, the university looks to help the pymes, being their area of I+D, with the result that in the long term, these industries will be extensive and that they are sought after to invest in more investigations. Many benefits already exists in the ties between the university and the industrial sectors (UE), the universities should learn to work at the speed of the industrial sector, or in other words in terms of milestones (Rahmany et al., 2013), and that they should carry out punctual investigations but not necessarily fundamental investigations.

For example, in the 19th and 20th centuries, the government of the United States dedicated itself to solving issues regarding agriculture, public health and the industry (Mowery, 2011).

Nowadays, the universities are generating measurable investigations, which can be publicized in a magazine or a conference (Landry et al., 2013), many of which are patented and later transferred to the industry. Carrick (2014) comments that the university commercializes its patents via licenses or ventures (spin-off).

On the other hand, the university's contacts which the industrial sector are not only formal (patents or licenses) – but informal transfers also exist – which are a lot more common. As such, the informal transferences such as the recruitment of a recently graduated individual, or the reading of scientific publications are a lot more frequent than the licensing and the patents (Hughes & Kitson, 2012).

Besides this, the investigations which are transferred more often, relate to disciplines within engineering and science (Hughes & Kitson, 2012) and come from basic investigations or applied developments in the university. Dai, Popp and Bretschneider (2005) explain that the university develops basic and applied investigation and that the amount of the investigation is influenced according to the environment in which it is found (society). Nilsson, Rickne and Bengtsson (2010), support the study and present a classification of the motives for which an investigator would transfer their knowledge to the industry.

4.1.2. Receptor or receiver Agent

This is the element in which the technology and the elected are received and taken use of to generate innovation. Bozeman (2000) describes it as the receptor agent, Malik (2002) calls it the receptor and Waroonkun & Stewart (2008) as the Receptor.

Unlike the university, the industrial sector's objective is the profitability (Brennan & Turnbull, 2002) and for that reason, they look for the technologies which will bring them said benefit. For this reason, the industrial sector will always look for technologies which have a value, and the collaboration between the university and the industrial sector (CUI) is doing just that (Fialho & Alberton de Lima, 2001).

It should be taken note that the CUI does not only occur when the university offers a technology, but that also when the industrial sector seeks it out in order to contribute to the creation of new technologies or industries. In this context, the industrial sector is taking onboard the strategy of open innovation, and for that reason, within its strategies the collaboration with the university is found (2001). For example, we have the case which was studied by Sætre (2009), in which a Norwegian industry which was in contact with the university, sought it out in order to create an intelligent motor.

To conclude, the industrial sector should understand that the investigational centers, such as the university, can generate many benefits. Some of those are (Fialho & Alberton de Lima, 2001):

1. Create a contact with the university environment.
2. Have access to resources which are not inherent to them (laboratory, library, instruments, etc.).

3. Establish a risk division for projects of investigation.
4. Improve it's public image due to it's union with the university

It is important that the size of the industry is not of importance in relation to that of the university. Thus, the following should be taken into account: the experience of managing projects (Okamuro & Nishimura, 2013), due to university researchers lacking management skills (Fialho & Alberton de Lima, 2001) or that they don't have time to carry it out (Pérez, González González, Súchil, Hernández & Núñez Merchand, 2011). To continue, it is important to comprehend how the university transfers it's technology (Landry et al., 2013) and to have experience managing new technologies (Sætre et al., 2009).

4.1.3. The 'message' or objective to transfer:

According to the model presented by Malik (2002), the message, which is sent by the transmitter and received by the receptor, exists. Bozeman (2000) designates it as the transferred object; other authors know it as the technology which is being transferred.

As previously explained, the university develops basic and applied investigation and technological development, which could end up being offered to the industrial sectors by both formal and informal ways. Hughes & Kitson (2012) point out that the university doesn't just create technologies which can be transferred by formal means (licenses, patents), but also by informal means such as: publications, research joined with industry, consultancy services, catchment of recently graduated students, third-party services and spin-off (Agrawal & Cockburn, 2003; Khakbaz, 2012).

Due to the university not only developing profitable technologies, but also research, the objective to transfer can be sent by the university in different levels: science, technology and usage (Hoffmann et al., 2009). The industrial sector can also receive the objective and work with it in different levels of the technology: exploration, validation and exploitation (Landry et al., 2013).

As such, the technology which will be acquired by the industry needs to be evaluated to determine its profitability and to provide feedback to the university. Surrounding this issue, Van den Berghe and Guild (2008) arrived to the conclusion that if the objects which they are going to receive are correct, the industries need to respond, by means of their supervisors. In other words, if the new technology will increase the value of the client, if it is found on the market and if it will improve the current strategies of the industry. As it can be seen. The industrial sector doesn't make reference to the level in which the technology is found in the university, as the object can be transferred at any time.

4.1.4. Offices of the transfer of technology (OTT).

As it has already been pointed out, there are many ways to transfer technology; none of them are either correct or incorrect as everything depends on the context (Carrick, 2014). Additionally, it should not be thought that the contents of a paper is enough to transfer a technology, as many barriers already exist which obligate a good functioning of the CUI: communication, culture, motivation of the involved (Brennan & Turnbull, 2002) and political changes (Landry et al., 2013), alongside the lack of time for the industry, bad identification of the responsible parties amongst other factors (Hughes & Kitson, 2012). For this reason, it is necessary to have an agent who can exclusively take charge of the CUI (Costa Leja, Nicolás Gelonch, Badia Roig & Juárez Rubio, 2001).

Thus, the OTT arise from the need to enforce communication between the university and the industrial sectors, to benefit both areas. Presently, the universities are concerned in

creating a culture of commercialization of their investigations and are looking for the most efficient mechanisms of TT for each situation. By doing this, they do not only focus on the reputation given by the publications and the conferences (Khakbaz, 2012). It is due to this that the need to help the researcher to commercialize their work has come to be (Nilsson et al., 2010) and to give them an incentive to transfer their creations by a means which they deem as protected (Khakbaz, 2012).

One OTT is the axis which facilitates the commercialization of the academic investigation, the processing of patents, and the negotiation and management of active license (Rahmany et al., 2013). Within its functions, the support to connect the researchers with the users and graduates which are working throughout the industries is highlighted (Mowery, 2011). This involves being a bond between the university and the industrial sector Carrick, 2014). It is shown that nowadays the researchers do not necessarily use the OTT in order to generate a transference; in some cases they have direct contact with the industry (Nilsson et al., 2010).

Therefore, the role of the OTT is to look for investigations with high potential in the market, and to commercialize those (Pérez et al., 2011), not only patent investigations but also motivated and interested researchers in commercializing their research (Khakbaz, 2012). The OTT indeed have the objective to help with the transference of technology without impairing the researcher (Sætre et al., 2009), moreover supporting the entrepreneur with advice which collaborate with the strengthening of the industry (2009), without damaging the main purpose of the university – the teaching (Hughes & Kitson, 2012).

Thus, the OTT have the strategical focus that their most remarkable functions are as follows: boost the cooperation, support the agents with the recruitment which allows a correct process of TT, carry out vigilance and cultural activities, search to maintain the good of the society with technological development, amongst other things (Pereira Fialho & Alberton de Lima, 2005; Pérez et al., 2011).

An OTT can transfer the technology at any level, the casuistic of the transfer are varied and just one type of OTT cannot use all of the different types of mechanism (Landry et al., 2012). According to the study, different types of office can be defined. For this investigation three of them are described:

- i. University offices (OTTU): those which are focused in managing the university research, which are more closely linked with the legal aspect of the operation (licenses, patents, acts, etc.). As such, they focus on the new income (by means of grants from public bodies, income from services, license fee agreements, courses or projects) in order to form more research (Costa Leja et al., 2001). The graphic 6, with its basic process for the transfer of technology /Carlsson & Fridh, 2002).
- ii. Public offices (OTTP): they have specialized knowledge or they put themselves in charge of advanced issues; for example: China has an office which is subsidized by the state – which is in charge of the entrepreneurs (Wu, 2010).
- iii. Community offices (OTTC): these help the industries which don't have an area of I+D.

4.1.5. Spin-off: a new mechanism:

A spin-off in technological terms, is a new company which is being formed due to the commercial transfer of a science or developed technology from the university to the market. Valls Pasola and Condom Vilá explain it to be a modality of transfer which helps to optimize the market and to reduce the time between the discovery and the application of a technology (2001). Therefore, the spin-offs can be risen in a sporadic way when society needs them – or

a planned way through the supervision of the university. In this case, its objective can often change according to the experience of the entrepreneur (Khakbaz, 2012). In this case it is important to reiterate that the main part of the university researches are developed by the entrepreneurship (Carrick, 2014). It is for that reason that the university is complying an important role in regards to the creation of spin-off, as it does not only help with the development, but it also contributes social capital (seed-capital, incubator, counselling) (Valls Pasola & Condom Vilá, 2011).

To conclude, the spin-off is one of the best mechanisms to beat the common barriers and as such transfer the technology, bringing with it benefits to the university as, the created industry generates job opportunities, and contracts specialized services and productive activities which the university more-than-likely offers (Valls Pasola & Condom Vilá, 2001). Specifically, the university spin-off is the best mechanism to beat the difficult stages in the creation of an industry. Of course, one of the most important roles that the spin-off complies with, it to fill the hole which exists in the ties between the universities and the industrial sectors (Khakbaz, 2012).

The process of the generation of a spin-off can be divided into four important steps (Botelho & Almeida, 2011):

- i. Generation of ideas due to the results of an investigation: it is recommendable to be in contact with a multi-disciplinary machine in order have different focuses on the value of the technology (Khakbaz, 2012).
- ii. Definition of the negotiation by means of the presented idea: it is important to have the support of a businessmen, due to their knowledge of the working of the market (Sætre et al., 2009).
- iii. Launching of the spin-off: the economic support for the release should be considered. For this, the entrepreneur should take out some time in order to find the ideal source. As such, the state grants are the more-used alternative (Sætre et al., 2009), but also there are others such as the risk capital (Carrick, 2014). Moreover it is necessary to dedicate an amount of time to the search for the space in the market; a bad decision could bring negative consequences (Botelho & Almeida, 2011).
- iv. Strengthening of the negotiation: at this stage it is necessary to establish a good connection of strategic alliances (the selection of whichever industry, as an ally, could bring negative consequences); in other words: it is better to ally oneself with legal consultants, banks, the industry of risk capital, chambers of commerce, business associations, incubators, public authorities responsible for politics, pymes amongst others (Khakbaz, 2012; Sætre et al., 2009).

Another important factor in a spin-off is the support which the university brings, not only regarding intellectual property, but also regarding the infrastructure which allows the entrepreneur to develop their technology (Botelho & Almeida, 2011). Strictly speaking, the university complies with the important role of the development of the spin-off university technologies. As it is often heard, the entrepreneur knows it's product well but little about the market, for that reason it would be important that the university would offer them advice about market ideas (Rahmany et al., 2013).

Furthermore, it should be highlighted that the university is placing incubators with the support of the government (Khakbaz, 2012), whose principle objective is to be in possession of university spin-offs of a high quality. If there is not a good choice of spin-offs, the quality of the industry is low; therefore, the university politics shouldn't only be focused on the control of the spin-off, but also on it's creation (Botelho & Almeida, 2011).

In some cases, the university can generate the entrepreneurship during the study. Khakbaz (2012) gives an example of this: the university gives the educational credit concession in return of business formation or the creation of new industrial ideas. At the same time, it creates obligatory courses for entrepreneurs. According to this template, it could be said that the success of a spin-off is given due to the mechanisms of support.

Finally, it is necessary to measure the performance of a spin-off, that being because a university can harm its reputation (Valls Pasola & Confom Vilá, 2001). Until now, the measurement of a spin-off is still not clear. For this reason, its performance could be considered long term and the time in which it takes to be commercialised, however it does not necessarily measure the success (Carrick, 2014).

4.1.6. Policies

Previously, different agents involved in the TT have been defined, but nothing to do with the environment has been explained. In light of this, authors such as Rubiralta (2004), Bozeman (2000) and Malik (2002), amongst others, highlight the legal environment, which is why it is necessary to revise what a variety of authors have explained about their politics.

The politics are part of the legal mark which the transfer is developed in; therefore not having good politics makes the process more difficult. Just like the OTT, they are not determinates in the relation UE but are very important (Mowery, 2011).

In this context, the state is the principal actor regarding passing politics of innovation. The industries, by their own means, are not investing in I+D, nor are they developing patents (Stal & Fujino, 2005), but they're currently developing politics which help the relation UE in order to generate innovation. Reflecting the state politics, the universities are also creating their own politics (Botelho & Almeida, 2011). As such, all of the politics should be clear enough that the university and the industries are aware of their functions (Scott, 2004).

Stay and Fujino (2005) carried out a study regarding the innovation law of Brazil, in which they presented some advice surrounding university politics:

- i. Work with government agencies, which participate in the discussions and the fight for the changes in the regulatory marks, with the aim to facilitate the collaboration with the industry.
- ii. Propose changes in the national scope of the universities, covering guidelines for the TT and the encouragement for the researchers and the involved personnel.
- iii. Change the administrative and operative structures and make them more agile and capable of operating in the mark of the collaboration with the industry.
- iv. Invest in the formation of human resources with specific abilities, emphasizing on the commerce and the commercialization of the technology, and, at the same time, in the investment of the sensitization and valuation of the TT activities within society.
- v. Promote a positive image of the university in order to win a space in the businessmen's agenda, and improve the academic research.
- vi. Promote the establishment/expansion of the technological and industrial incubators so that they're up-to-date.
- vii. Create specific laws for the promotion of the associations with small innovative industries.
- viii. Prepare guides for the negotiators, which implies considering different situations of financial criteria, technics, members – as they should be combined.

In its way, the state is creating politics which facilitate the creation of innovation funds, to help with the entrepreneurships and the technological research. Such politics also

prefer the investment by means of the industry (Dai et al., 2005; Scott, 2004) and the impulse of the infrastructure (Sætre et al., 2009) - such as specialised branches – and the connections of the external suppliers (Khakbaz, 2012). At the same time, this results in the improvement of the investigation of culture and entrepreneurship, due to the politics being closely tied with the culture (Botelho & Almeida, 2011).

In the scope of the universities, there is also an input of politics. It is known that the supervisory decisions have a great influence directly on the relationship UI (Okamuro & Nishimura, 2013) and, that a graduate that wishes to sell their technology, or to start an entrepreneurship, can not last for long without the help of the university or the industrial sector (Sætre et al., 2009). The university looks to create more flexible and more far politics, in which the industrial sector is its ally (Okamuro & Nishimura, 2013) without it meaning that one of the most fundamental objectives of the university is lost; the teaching (Carlsson & Fridh, 2002). On the other hand, the university should create politics which allow an efficient access into technology – for example: thinking towards the protection of the exclusive privileges for long periods turns out to be incompatible with the needs of the consuming public, and the speed of production (Tocach, 2011).

5. Conclusion and Final Notes

The systematic revisions helps us to see how a model of TT can be developed, by understand the profile of the involved, and by understanding that the transfer depends on an environment which determines its success; in table A1 (Appendix A), a summary of the different types of the TT and their relationships with each other can be appreciated.

In this study, the different models of TT have been analyzed, not only focusing on the CUI, but also looking at the industrial sector and international industries, in order to be able to explain that there are many investigations concerning the environment, but there are few involved with the routes of transfer.

Therefore, by revising the systematic revision, many relevant points, which can be used in further investigations, were found. This tool helped to understand that the form (model) of transferring a technology will depend on the environment in which it is carried out, and on the experience of the involved party. Likewise, the legal factors are very important in both making the process smoother but also for putting obstacles in the way.

The models of TT are a fundamental factor because they help to understand the process and formalize communications. In light of this, the authors are very much appreciated for their willing to explain that the TT is a process affected greatly by its environment (social factors, behaviors or legislative matters) but, the willing to describe the routes of transfer is not considered. For example, Bozeman describes each type of route as a mechanisms, but authors like Hoffmann make not of the difference between the university and the media; in other words, that the things produced by the university with the mechanism is the same way in which the transfer is carried out. There is not a clear definition which describes the routes, unlike the environment in where it is defined. It is also important to consider feedback, more than anything in the CUI, because it helps the transmitter to understand the necessities of the receptor in future projects of TT.

To conclude, it is necessary to highlight a mechanism of TT which is very successful: - the spin-off, which is fighting for the university to be in contact with the industrial world via its entrepreneurship and its students.

Appendix A: Elements of a Transference of Technology

Table A1: *Relation of elements of a transference of technology*

Object of transfer	Means of transfer	Mechanism TT	Modality	Output	Stage of use of the technology
<ul style="list-style-type: none"> · Scientific knowledge · Prototype · <i>Know-how</i> · Process · Design · Technological development 	Patent	License	Formal	Use of technology with legal restrictions for use by the market	Operation
		University <i>spin-off</i>		Industry with legal restrictions	Exploration, validation and operation
	Prototype	License		Use of technology with legal restrictions for use by the market	Operation
		Sales contract		Use of technology with legal restrictions for use by the market	Operation
	Research study	License		Use of technology with legal restrictions for use by the market	Exploration, validation and operation
		Sales contract		Use of technology with legal restrictions for use by the market	Operation
		Delivery of technology to the industry		Use of technology without legal restrictions for use by the market	Validation and operation
		University <i>spin-off</i>		Industry without legal restrictions	Validation and operation
	Conferential presentation	University <i>spin-off</i>	Informal	Industry without legal restrictions	Validation and operation
		Catchment of knowledge		Transferred knowledge	Exploration, validation and operation
	Publication of scientific article	University <i>spin-off</i>		Industry without legal restrictions	Validation and operation
		Catchment of knowledge		Transferred knowledge	Exploration, validation and operation
	Movement of personnel of the investigation	University <i>spin-off</i>		Industry without legal restrictions	Validation and operation
		Catchment of knowledge		Transferred knowledge	Exploration, validation and operation
		Contracting of personnel		Transferred knowledge	Exploration, validation and operation
	Informal discussions	University <i>spin-off</i>		Industry without legal restrictions	Validation and operation
		Catchment of knowledge		Transferred knowledge	Exploration, validation and operation

Note. Adapted from Costa Leja, Nicolás Gelonch, Badia Roig & Juárez Rubio (2001); (González, Díaz, & Guevara, 2013); Heinzl, Kor, Orange and Kaufmann (2013), and Nilsson, Rickne and Bengtsson (2010)

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