A Study on the Performance of Technology Transfer Units

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Abstract: Universities are increasingly institutionalizing activities related to technology transfer and one of the main institutional mechanisms that has emerged is the "technology transfer unit" (TTU). Many of them are focusing their activities on the management of the university intellectual property. Studies have investigated factors that seem to affect their performance, but few have looked in detail at internal procedures and techniques that are used in their processes related to technology evaluation and licensing. The aim of this paper is to provide a comprehensive overview of some of the several steps that comprises the processes regarding technology evaluation and licensing, providing an analysis of the critical issues that affect each step of the process. A review of the literature was made, complemented with interviews to seven university TTUs, which was used as a check and a complement to the literature review and as way of perceiving from an insider perspective, the problems and issues that this paper wants to emphasize and to state clearly.

Keywords: Technology evaluation and licensing; technology transfer; technology transfer units; universities.

1. Introduction

Many universities are institutionalizing the activity of technology transfer that was formerly conducted on an informal basis (Abreu and Grinevich, 2013) and one of the main institutional mechanism that has emerged in the last thirty years is the so called "technology transfer unit" (Geuna and Muscio, 2009). Many technology transfer units (TTUs) are now focusing their activities on the management of the university intellectual property. We will explore the internal technical activities that are related to technology evaluation and licensing, as it seems that these specific activities, which we postulate are quite important for the performance of TTUs, seem to be under researched.

Several studies have tried to identify the variables that are more important in terms of explaining TTUs' performance. The variables can be tentatively grouped in three categories: variables related to the internal structure, resources and activities of the TTUs, variables related to the characteristics, structure and policies of the university to which they are attached, and variables related to the general environment that surrounds the TTUs.

In the category related to internal characteristics of the TTUs, age and size are generally positively related to increased performance, due to an accumulation of experience and learning curve effects, and to an adequacy, in terms of quantity of human resources that are necessary to deal effectively with the varied processes of technology transfer. The quality of human resources, in terms of the adequate skills that are necessary to deal with a process that has a fundamental business character, is an often mentioned issue (Jensen, Thursby and Thursby, 2003). The skills that are most often referred to are business skills and liaison skills, including information deficiencies, insufficient technology watch and the lack of administrative support in preparing financial applications and in project management (Arvanities*, et al.*, 2005). Apart from a general shortage of these skills attributable to understaffing of TTUs, this is also related to the fact that there was a tendency to rely on staff with a technological background, as it was believed that the high-tech characteristics of the technology involved in university license agreements would require this kind of expertise (Siegel, Waldman and Link, 2003). However, this practice did not acknowledge the fact that high-tech inventions are very difficult to commercialize, and indeed require expert skills of other natures (Swamidass and Vulasa, 2009). Liaison skills are important inasmuch as there are cultural barriers between university and industry that are always difficult to surmount. Law skills, which are necessary in the first steps of the technology transfer process (registration of the patent) and in subsequent steps (monitoring of license contracts and litigation), do not seem to be a dominant factor affecting performance, at least with the same degree of the business skills, and there may even be, within the TTUs, an excessive preoccupation with the legal dimension (Swamidass and Vulasa, 2009).

The main variables that have been identified regarding the characteristics of universities to which the TTUs are attached include the scientific characteristics of the inventors, namely their publication record, and the technological areas where the university is most prominent (Harmon*, et al.*, 1997). Studies seem to point to a relation between scientific output of researchers and their patent record and also to a relation between propensity to patent in technological areas that are more applied in nature, or have become so, such as engineering, biotechnology and other applied sciences

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(Bonaccorsi and Piccaluga, 1994). However, this relation is not linear, and it may depend on other factors such as the origin of funding, the researcher's links to industry or its career status.
The problem of incentives is also recurrent in the literature as well as the attitude of the university towards a more entrepreneurial stance (Bercovitz*, et al.*, 2001). Incentives structures that reward personnel staff, in terms of career development, or in terms of financial gains, seem to have an impact on the performance of TTUs, through the willingness of researchers to devote more time to applied research and eventually leading to an increase in inventions disclosure (Kalar and Antoncic, 2015). Studies also claim a positive relation between performance and specific policies aimed at technology transfer activities, and the building of infrastructures geared to those activities such as, besides the TTUs themselves, science parks or incubation centers (Caldera and Debande, 2010).
External factors affecting TTUs performance seem to be related to the stage of development of the technology and location factors. Technologies that do require extensive product concept definition or development work by the part of the firms, in order to make them commercially viable, affect the prospects of their commercialization, due to the perception of excessive financial or technological risk (Colyvas*, et al.*, 2002). TTUs attached to universities that are located in regions where the industrial sector is technologically developed are positively affected by the demand patterns of those industries (Friedman and Silberman, 2003).
Having made this short review of the main variables affecting TTUs performance addressed in the literature, we notice that the internal procedures of the TTUs are addressed in a rather fragmented way, in the sense that studies isolate a limited number of factors in order to treat them as independent variables (Wright, 2014). It is this gap that the present paper intends to address. We postulate that the internal procedures of the TTUs will affect its performance, independently of its attributes, such as age, size or skills. And in order to contribute to proposals that increase the efficiency and efficacy of internal procedures, there is the need, in the first place, to describe and identify the several steps that constitute those procedures, and to pinpoint their importance to the whole process.
The objective of this paper is to make an overview of the literature, highlighting the most important steps of the process of technology transfer from universities to industry, and their practical implications. The integration of the literature is made by assuming a sequence in the process of technology transfer. Observations will be made on each step, identifying the aspects that deserve more attention, or seem to be more fundamental, in view of their efficacy.

2. The methodology of the study

An extensive review of the literature was made, and documental support concerning additional or complementary information was sought. The review was complemented with interviews to seven university TTUs. Information collection was achieved through personnel semi-structured interviews with TTUs' heads of staff, supported by a set of orientations and a questionnaire. The seven TTUs were attached to seven different Portuguese universities. This sample was purposefully chosen due to the high regional and national influence of the universities, and to the experience and ability of the TTUs to provide data that would expand the understanding of technology transfer processes. Six out of the seven universities appear regularly in world rankings of the top 1000 universities. The approach is exploratory and descriptive, but also analytical in the sense that it states the issues at stake in the process of technology transfer.

3. The level of selectivity in the protection of inventions

The communication of research results to a TTU triggers a process of evaluation and definition of the strategy of protection and commercialization of the invention, which allows the matching of the invention characteristics with the firms' development needs (Weckowska, 2015). The principles and proceedings of technology valuation that TTUs assume condition the selectivity level of each university at the moment of protection of an invention. The number of communication of research results, the money available for research, and the number of technology transfer professionals influence the number of licensing agreements (Chapple*, et al.*, 2005). The number of registered patents tends to be larger when there is an effective collaboration between the institutions specialized in invention protection and the researchers (Saragossi and Potterie, 2003). Some argue that technology licensing is found to be positively correlated with the number of registered patents (Shane, 2004), but others say that the number of registered patents does not reflect the impact that a university has on the economy, and the number of patents, on its own, does not describes the nature of the inventions nor their commercial impact (Agrawal and Henderson, 2002). The question of selectivity in the process of invention protection is, consequently, an important issue. One can roughly divide the TTUs into two main categories. The more selective ones devote more time and resources on a small number of high-potential inventions, and previously estimate the costs of managing the patent and the likelihood of finding adequate business partners. The less selective TTUs seek to increase the number of patents to foster a culture of intellectual property protection and believe that a greater number of patents will increase the likelihood of establishing technology license agreements.
Selectivity has a major impact on TTU performance. The critical issue here is that the decision to patent must be influenced by the market potential of the invention and not by its scientific merit, nor by the will of the inventor. The

bigger the technology portfolio of a TTU, the more are the resources necessary to manage them, and eventually there may be a need to concentrate commercialization efforts on a reduced number of technologies. Due to the high costs of maintaining a patent portfolio, strategic patenting is one of the most important tasks of the TTUs (Xu, Parry and Song, 2011). The decision to protect and commercialize an invention, must also involve a prejudgment on the definition of a strategy of technology diffusion in order to obtain license agreements. The next section addresses this issue.

4. Windows of opportunity and identification of firms interested and with capacity to license

With the aim of opening and to take full advantage of the window of opportunity to transfer technology, a strategy of identification of firms with the capacity and the interest in licensing the technology must be adopted by the TTUs. The strategy for the identification of firms must include, in addition to the market and technology description, the identification of competencies and resources which are necessary to its development and commercialization. It is necessary to understand how the technology fits within the firms' technology space, so that an alignment is achieved.

The decision to license is associated with the firms' perception of risk on an investment. Small firms and start-ups are the ones that are willing to assume larger risks and more experimentation to test what might work. Large firms have more pre-established compromises and are less flexible in the adoption of new technologies. Established enterprises have a preference for incremental technologies. Smaller firms are more willing to adopt technologies in initial development stages (Shane, 2004), or technologies that present disruptive characteristics.

Independently of the firms' maturity and size, the adoption of the technology is dependent on their strategic orientation. Potential licensees to look for are firms that are heavily dependent on new products and processes, and that continuously seek new technology and business opportunities. Firms who commercialize previous or similar products are typically good licensees. The level of complexity of the technology and the market that a firm commands are also important factors to bear in mind in the search for a licensee (Speser, 2006).

The task of identification of firms with capacity and interest in licensing requires a systematic work of technology and potential partner analysis, as well as identification of possible sources of financing. Ideally, a good partner for the introduction and development of the technology should have adequate technological capacity and competences, have the necessary networks and resources, have a significant client base and a strong brand, be able to address the markets that are relevant and have a risk taking attitude.

Having identified important aspects regarding the profile of the firms to be contacted, the next step is the communication and publicity of the technology, an issue to be addressed in the next section.

5. Publicizing and promoting technologies

The origin of licensing agreements is associated with the size and quality of the TTUs and researchers networks. Inventors are the most important source of contacts for licensing and they are the primary source in firms' identification (Thursby and Thursby, 2004). Inventors can be a "one stop source of market information" (di Sante, 2007), and the inventors direct contact with firms is the most important factor in the establishment of licensing agreements, and the second most important one is the marketing effort made by the TTUs. Agreements obtained by inventors are made predominantly with large enterprises, while the agreements obtained by the TTUs are made predominantly with smaller firms. The explanation seems to be related with the fact that smaller firms have fewer resources to invest in technology watch and are more receptive to the information provided by the TTUs communication channels. Thus, investment in direct marketing with small firms may prove more useful than marketing directed to large firms (Ramakrishnan, Chen and Balakrishnan, 2005). It is also important to consider the university prior relations with firms and their geographical proximity, strategic position and location in order to extend collaboration networks, having in mind that the majority of university-industry relations are informal in nature (Mowery and Nelson, 1999), and that multiple communication channels can be used to effectively communicate the technologies' value proposition. Informal networks may prove very useful in the evaluation of the technological and market potential of the patent, in obtaining funds, in identifying firms interested in the technology and in determining the geography of patent protection.

6. Evaluation methods

Technology evaluation and the assessment of its commercialization potential is a task that sweeps across the process of technology transfer. Several evaluation methods are used. The most common methods for qualitative and quantitative assessment of the market potential of the technology are pre-defined evaluation models and matrices and other scoring and checklist based models, and the discounted cash-flow method, which are the two most widely used methods. Evaluation based on development costs and the real options and Monte Carlo simulation methods are the least used methods. The methods which are used mainly for setting up a quantitative basis for negotiating a license agreement include the analysis of comparable license agreements and the observation of royalties practiced in industry, the 25% rule and patent auctions. In the following sections we address the main methods separately.

6.1 Pre-defined evaluation models and matrices

Methods based on checklists and in pre-defined evaluation models speed up the process and facilitate the consideration of multiple dimensions of the invention, from the intrinsic quality of the technology to the market potential and profitability, constituting the most widely used instruments in the evaluation of invention disclosures. The evaluation criteria that is used in these evaluation models and matrices include, in general, the technological dimension, the market dimension, the management dimension and the legal dimension, and, apparently, are similar to those used by private or for-profit organizations (Meseri and Maital, 2001).

These methods are used in the first evaluation of the technology disclosure. Later on, depending on the preliminary results coming out of that evaluation, on the commitment of the researchers, on the resources of the TTU, and on its policy on selectivity, the evaluation will be conducted in a more thorough way, although the methods that will be used will also rely heavily on existing scoring and checklists models and matrices. To the above mentioned criteria, operational and functional factors will be added, such as, for instance, production or distribution considerations. Quantitative methods will also be used.

It is important that every possible effort and care is taken in the evaluation stage. Attention should be paid to the criteria used by non-university for-profit units engaged in technology transfer, particularly when dealing with incremental innovations. Evaluation and licensing of technologies in an early stage of development should proceed with caution. Due to the high uncertainties associated with the possible applications and products that will ultimately come out of development efforts, licensing, in principle, should be made on a non-exclusive basis, in order to maintain open several avenues of research and product development and application areas (Colyvas*, et al.*, 2002).

6.2 Discounted cash-flow method

The discounted cash-flow method is widely used by organizations who deal with and license technology (Kemmerer and Lu, 2008). The calculus of the discounted cash-flows is important for assessing business profitability, on which the potential of the technology will be based. It will also provide a basis for setting up royalties and other payments value. Although these methods are widely applied, care should be taken on its use. These methods are not particularly adequate to the evaluation of new ideas and business concepts, especially on their early stages of development, where there is not a tangible commercial product (Damodaran, 2001). Traditional financial techniques do not include non-quantitative factors (intangibles, both in terms of benefits, or in terms of costs or risks) that may have great importance in terms of evaluation and adoption (Romero and Barbosa, 2012). Excessive reliance on these methods may provide wrong signals and may jeopardize the negotiation of eventual license agreements. These methods may prove important when the deal involves a lump sum payment for the utilization of a technology during a specified period of time, or when the creation of a firm is under consideration, providing a basis for the consideration for equity participation.

6.3 Evaluation based on development costs

Evaluation based on development costs is rarely a base on which firms negotiate license agreements (Razgaities, 2003). The point is worth making because some TTUs may be tempted to invoke these criteria. However, firms are interested in obtaining technology in an easy and cheaper way than it would if the technology was developed by themselves. The cost of developing technology has little to do with its value. The market value is a more appropriate metric for evaluating a technology (WIPO/ITC, 2005).

6.4 Comparable license agreements and the observation of royalties practiced in industry

Analysis of previous licensing agreements and the observation of royalties practiced in the industry may provide guidance to define and defend the structure of payments and their value during the negotiation of a technology transfer agreement (WIPO/ITC, 2005). It is important that TTUs build and maintain reference agreements portfolios which can be used if needed (Dodds and Somersalo, 2007). Databases and publication with royalty standards and licensing agreements are a good source of information.

6.5 The 25% rule

The 25% rule is usually applied to the EBIT (Kemmerer and Lu, 2008), suggesting that the licensee pays a fee equivalent to 25% of the invention contribution to the operational results obtained by the product that embodies the technology. The 25% rule divides the value of a technology in four parts: the creation of the invention, the preparation of the invention for industrial reproduction, industrial reproduction, and the sale of the invention, per se, or incorporated in a larger product. Each one of these parts represents one fourth of the invention value and, in this sense, the invention is one of four parts by which the commercialization gain is distributed. If the invention is already prepared for commercialization, it makes sense to define a lager value, say 33% or more, since the invention has already attained a threshold that includes production. In the case of software, these values can ascend to 50%, since the technology is

ready for commercialization. The rule may be a good starting point, and is adopted by licensors and firms, for royalties' negotiation, thanks to its simplicity, intuitive reasonability and acceptance by the stakeholders (Grandstrand, 2006).

6.6 The articulation between the methods

The methods presented above are used in different stages of the evaluation process. In a first stage, preparatory for the submission of a patent application, databases of patents are extensively used, to understand the invention and the state of the art related to it, and the scoring matrices and the rapid report models are used to understand the market potential of the invention. In a second stage, e.g., when there is a firm that has already demonstrated its interest in the invention, the technology transfer professionals tend to recur to comparable agreements and royalty standards, in order to prepare negotiations according to the risk involved. Discounted cash-flow projections are used in parallel, and sometimes, the 25% rule.

Simultaneously with these two stages, the TTUs network of contacts is activated, in order to obtain technical and market counseling, information on investment sources, and to facilitate access to equipment or materials external to the university that are necessary to develop the invention proof-of-concept. Contacts with final users of the technology may also be made. After the patent is registered, auction patents may also be utilized, and in this case the payment structure negotiation is relieved because the value is decided by the highest bid.

In general, the systematic work done previously, based on the various evaluation methods, will support the draft of an agreement that is seen positively by both parties, and a balanced distribution of the gains will be achieved.

7. Discussion and conclusion

The main research objective was the identification and thorough description and analysis of the processes used by TTUs, accompanied by an assessment of the most important issues to be considered on those processes which would potentially impinge on performance, whereby the number of license agreements obtained by the TTU is used as a proxy for performance. As a result, we identified a sequence of processes that starts with the communication of research results to the TTU, triggering a process of evaluation of the invention that will decide for its protection, followed by the search for a licensee. The steps that include the negotiation of a license agreement, the payment modes and the distribution of earnings amongst the actors within the university, were not covered due to space constrains. The aim of this paper was not to perform a comparative analysis between technology transfer offices located in different regional or geographical contexts, although the primary data that used to expand and substantiate the secondary data on which the arguments are largely bases, were collected on a specific national context. Due to space and scope limitations, the present paper focus on the thorough identification of internal procedures, which, we believe, are common to many if not all TTUs, and constitute (at least) partly) the essence of TTUs activity.

We identified several important areas within those processes and identified essential issues that must be considered. The first is related to the question of selectivity in patent protection, which derives from the realization that the size of the patent portfolio is not necessarily related in a proportional way to the number of license agreements. TTUs differ in their degree of selectivity. The more selective TTUs prefer to patent by estimating future patent management costs and the probability of finding suitable partners. Others are selective only when considering expanding the geographical scope of the patent protection, i.e., they are not selective when considering national protection, but they are selective when applying to international protection. This strategy may be advantageous in terms of securing protection, but it has risks associated with the maturity of the technologies and the dispersion of resources regarding the management of the portfolio. The use of brokers may be considered in this case, with cost advantages relative to internal management of the portfolio. Less selective TTUs want to increase the number of patents, as an end in itself, assuming that the number of patents is proportional to the number of license agreements, and as a way to acquire experience in patent application and to motivate researchers to protect their research results. The main caveat in this approach is the costs of managing the portfolio, and the human resources needed to do so. As a general principle, we suggest that patent protection should be driven by market potential of the invention and not by other reasons, such as scientific excellence or the will of the inventor. Processes of evaluation are thus fundamental for defining the portfolio of the TTU and, consequently, its performance in terms of transfer capacity. As a way of summarizing, table 1 lists the most important aspects in the decision to protect.

Having made the decision to protect a disclosed research result, the TTU must find a firm that wants to license the technology. In many cases the research team already has some firms in mind or has ideas concerning the markets that the invention will serve better. The articulation and communication of the TTU with the research team is fundamental in this step, because of the previous contacts that the researchers possess. The role of the TTU, in this case, will be oriented towards the pricing of the technology and the negotiation of a favorable agreement.

In the case where there is no identified firm interested in the technology, the role of the TTU involves the search for a potential licensee. The most important issues in this step are: the need to match the technology and the needs of the

firm, which is related to timing issues, the stage of development of the technology and the characteristics of the potential licensee; the need to promote and publicize the technology, which may involve several communication and diffusion strategies, the most important of which may be the clear communication of the value proposition of the invention; the need to make use of the network resources that the TTU has at its disposal, including contacts with firms, with other TTUs, with financial partners, with other institutions, and other actors of several natures. In principle, SMEs are more receptive than large firms to the technologies proposed by TTUs. The latter tend to establish direct contacts with the researchers. Large firms tend to be interested in more incremental innovations while incumbent or smaller firms are willing to take more risks and adopt more disruptive innovations.

Table 1. Issues in identifying potential licensees.

Matching the technology and the firm's needs	Timing of technology release Development status of the technology Characteristics of the licensee Large firms tend to adopt more incremental innovations Incumbent or smaller firms are willing to take more risks and test more disruptive technologies
Publicizing and promoting the technology	Inventors' contacts Public presentations and diffusion strategies Defining the value proposition Demonstrable products reduce the perception of risk Prior relations of the TTU with firms
Use of informal networks	In assessing the invention technological and market potential In identifying companies interested in the invention In raising funds In the creation of spin-off companies

Evaluation is a transversal task that sweeps all steps. Checklists, scoring models and predefined models are the most utilized methods for technology evaluation by the TTUs, because, due to major constrains in human resources, methods that allow a quick assessment of the commercial potential of research results, based on technological and market parameters, are preferred. However, in spite of the fact that, eventually, there is not a very thorough evaluation of the research result, the criteria used by TTU should be similar to those used by private for-profit similar institutions. Business and marketing skills, a much noticed factor in the literature, are important, if not crucial, qualifications that the TTU must possess. The main issue at stake in this step are: the need to adequate the technique to the stage of the process (for instance, utilizing financial based evaluation methods only in incremental innovations or in later stages of the process of evaluation, and not on ill-defined concepts or incipient technologies, or utilizing appropriate techniques that help to price the technology and negotiate an acceptable license agreement), and the need to maintain an open process of evaluation until a final agreement is reached. The correct utilization and interpretation of the evaluation techniques and results are crucial elements for the TTUs' performance. In this paper we have made explicit consideration of the sequence of the process of technology transfer conducted by the TTUs in the form of license agreements, which is seldom considered in its entirety in the literature. A thorough description of the characteristics of the steps of the sequence of the process of technology transfer, as well as a detailed analytical examination of the factors that may have potential impacts on the performance of the TTU, was also a major concern in this article, which hopefully will provide a contribution to the knowledge of this recent phenomena of institutionalized technology transfer and their activities, and may contribute to structure future research on the subject. However, there are still many unanswered questions, and better research is needed to fully understand the determinants of performance of TTU, particularly as it refers to their evaluation and licensing techniques and practices. This study opens several possibilities for continuing research, and for empirical substantiation of some of the advanced arguments (Bozeman, Rimes and Youtie, 2015). The relation between adequate use of evaluation techniques, the qualifications resource base of the TTU and its performance, is a much pertinent research question.

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