1st International Conference on Project Economic Evaluation
ICOPEV'2011, Guimarães, Portugal

TECHNOLOGY EVALUATION AND LICENSING: A LITERATURE REVIEW AND AN ASSESSMENT OF THE PORTUGUESE UNIVERSITIES TECHNOLOGY TRANSFER PRACTICES

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KEYWORDS
Technology evaluation and licensing, intellectual property rights, technology transfer

ABSTRACT

To improve the access to information about practices supporting the application of research results we looked at strategies and methods described on the literature review and in use by technology transfer units (TTUs) having in mind a set of questions underlying the processes of technology evaluation and licensing in universities. The research questions gave us the opportunity to understand the TTUs degree of selectivity in the protection of inventions, the factors at the origin of licensing agreements and its main obstacles, the main evaluation methods and payment modes and they also gave us the opportunity to know the universities at study structure of dividend distribution. Underneath the answer to this questions we affirmed that the development of complete and demonstrable turnkey solutions and products decreases the investment risk and makes the technology more attractive to potential licensees, and we concluded that only knowing the economic value of an invention can we fully exploit its full potential and can we carry out an appropriate technology valorization strategy.

INTRODUCTION

The protection and transfer of intellectual property rights allows the combination of the unique features of an invention with the needs and interests of companies' economic development, converting the scientific and technological production in new or improved products and processes. Foreseeing this end, universities have adopted knowledge valorization strategies to foster the practical application of research results. In this context, technology evaluation and licensing activities allow inventors and universities to obtain revenues through the establishment of technology transfer agreements. In order to understand this process and to improve the access to information on specific practices to support the commercialization of inventive activities this paper addresses the following research questions:

- What's the technology transfer units degree of selectivity in the protection of inventions?
- What factors are at the origin of licensing agreements?
- What are the main obstacles to technology transfer?
- What are the main evaluation methods used in technology transfer?
- What are the main payment modes used in licensing agreements?
- What is the structure of dividend distribution within universities?

The answer to this set of questions is provided through the development of an integrated and systemic approach to the process of valuation of intellectual property rights pursued by universities, under a well articulated set of concept, meant to generate a holistic body of knowledge where the comprehensive literature review is minted with information and data concerning the technology transfer activities realized by Portuguese universities. This structure gave us the opportunity to articulate and unify the main technology transfer concepts presented on the literature and it made possible to identify and present methods and strategies to improve and promote the practices of technology transfer professionals. Although the results must be read having in mind a specific national delimitation and context, we believe that the results reflect other realities and may constitute a basis on which further research work can be developed.

METHODOLOGY

This study involved seven Technology Transfer Units (TTUs) from seven Portuguese universities. This sample was purposefully chosen due to the regional influence of the university, the geographical proximity to obtain information and due to the experience and ability of the TTUs to provide data that would expand the understanding of technology transfer processes.

Information collection was achieved through a triangulation process where the knowledge and practical experience of the TTUs head of staff, obtained through personnel semi-structured interviews and a questionnaire, have been minted with a comprehensive literature review to gain a rich insight into the evaluation and licensing processes.
Through the collection and analysis of data which is mostly qualitative, and through the extensive literature review that was made, a well integrated set of concepts have been brought together to advance and generate a sequential body of knowledge which allow us to clearly articulate in each section the TTUs inputs with the literature state of the art to answer this study research questions under a systematic articulation and integration process.

Table 1: Research sample of higher education institutions and their respective technology transfer unit

University	Technology Transfer Unit
University of Aveiro (Universidade de Aveiro)	UATEC – Unidade de Transferência de Tecnologia da Universidade de Aveiro
University of Beira Interior (Universidade da Beira Interior)	GAAPI – Gabinete de Apoio A Projectos e Investigação
University of Coimbra (Universidade de Coimbra)	GATS – Gabinete de Apoio à Transferência de Saberes
University of Minho (Universidade do Minho)	TECMINHO – Associação de interface da Universidade do Minho
New University of Lisbon (Universidade Nova de Lisboa)	GAPI do Madan Parque – Parque de Ciência e Tecnologia
University of Porto (Universidade do Porto)	UPIN – Universidade do Porto Inovação
Technical University of Lisbon (Universidade Técnica de Lisboa)	OTIC-UTL – Oficina de Transferência de Tecnologia e de Conhecimento

THE UNIVERSITY TECHNOLOGY TRANSFER UNITS (TTUS)

Technology transfer units are meant to evaluate, protect, and support the researchers on their efforts to obtain resources and to diffuse and transfer their inventive results (Young, 2007), and their instruments to enhance the university-industry relations (Siegel et al, 2003; Debackere and Veugeleres, 2005). They also negotiate licensing agreements and they support the creation of spin-off companies (firms created by university staff members, which aim to commercially exploit the university inventive results) (CEC, 2007). These technology valorization units also administer the licensing agreements and equity participations, they manage the licensing financial earnings and they proceed to its distribution according to the university intellectual property rules, and as a rule of thumb, the closer the proximity between the TTU and the researchers, the more efficient they will be on the establishment of mutual supportive relations (Dodds and Somersalo, 2007) which are essential to encourage the researchers to share, on a regular basis, information about their research activities and results (Di Sante, 2007) and to promote the knowledge and technology diffusion and the appropriation of economical benefits. The communication of research results is what triggers this valorization process, meant to match the invention characteristics with the firms' development needs and aspirations. Since the results disclosure until the association of an invention with a commercialization path, the TTUs assume valuation principles and proceedings influencing the methods and practices of technology evaluation and licensing, conditioning the universities selectivity level on the protection and territorial expansion of intellectual property rights. To understand these principles and proceedings the following sections will present an integrated literature review minted with the inputs brought by the information collected among technology transfer units.

THE LEVEL OF SELECTIVITY IN THE PROTECTION OF INVENTIONS

Technology licensing is positively correlated with the number of registered patents (Shane, 2004), and the number of invention disclosures, the money available for research, and the number of technology transfer professionals influence the number of licensing agreements (Chapple et al, 2005). Universities receiving funding from firms perform more applied research, cooperate more with external researchers, either from industry or from other universities, and register a larger number of scientific publications and entrepreneurial results (Gulbrandsen and Smedy, 2005). The number of registered patents tends to be higher when there's an effective collaboration between the researchers and the TTUs (Saragossi et al, 2003), and the protection rate enhances the impact of the patent portfolio (Owen-Smith, 2003) and there's a high correlation between the development of significant patent portfolios and the number of scientific publications (Stephen et al, 2002, cited by Godinho et al, 2008). The universities with a higher number of publications are also the ones registering higher rates of intellectual right (IPR) protection. On the other hand, the number of patents doesn't reflect the impact that a university has on the economy, and the number of patents, on its own, doesn't describe the nature of the inventions nor their commercial value (Agrawal and Henderson, 2002).
This last sentence raises the question of selectivity, and its significance on IPR protection. Selectivity on patent applications has a major impact on the TTUs performance (Powers and McDougall, 2005). A large patent portfolio requires greater resources and eventually there may be a need to concentrate the commercialization efforts on a reduced number of

technologies to bet on those who present a stronger market potential (Gardiner, 1997). It's essential to patent the invention on a strategic way, and the technology transfer professionals must be prepared to spend time, effort and money on this task, as it seems to be one of their most important ones (Dodds and Somersalo, 2007). The decision to patent must be influenced by the invention market potential and not by its scientific excellence, nor by the will of the inventor.

Among different TTUs it's usual to find distinctive selectivity levels and protection strategies. The more selective TTUs devote more time and resources on a smaller number of high-potential inventions and they prefer to patent by making a previous estimation of future patent and management costs to protect future dividends and to avoid copy and they also take into account the probability of finding suitable partners. The less selective TTUs seek to increase the number of patents to motivate the researchers' productivity and their culture and experience on writing patent applications. We can also find non selective units when applying to national protection, but they do perform evaluation work and they do identify potential partners to be selective when applying to international protection rights. This strategy has the disadvantage of potentially creating a large patent portfolio, which is costly to maintain, and difficult to manage (transfer), and usually the existence of a large patent portfolio isn't related with a larger number of licensing agreements, and as a rule of thumb, TTUs don't have all the resources necessary to expand internationally the protection of patents which are not expected to generate revenues, either via the European way or via the Patent Cooperation Treaty (PCT). Selectivity in the geographical rights expansion is important and some TTUs use the services of Brokers instead of internally managing the patent portfolio, since the costs of Brokers services may be compensated by the costs they didn't incurred with the management of a very large patent portfolio.

After having decided to patent arises the need to define the technology diffusion strategy. The next section addresses this issue.

THE LICENSING AGREEMENTS ORIGIN

To transfer a technology we must find a window of opportunity (Abell, 1980) to match, in the right moment, the characteristics and advantages of a technology with the firms' needs and interests. The window of opportunity is the moment on which the firms see a technology as being useful to correct, valuate or introduce a product or a process on their value chain, to gain a competitive advantage and to be able to maintain or conquer market share. The right timing for the technology introduction should be aligned with the firms' product replacement cycles, because if the replacement is made too soon, the firm may incur in high change over costs, but if a company replaces a product too late it may lose market share (Abell, 1980; Gatignon et al, 1997; Speser, 2007). The identification of firms willing to replace or to update existing products or processes, or willing to diversify its product range is the window of opportunity were looking for, and the lower the introduction costs, and the better the technology adequacy to the firm needs, the higher is the invention value and the probability of licensing it.

With the aim of opening and to take full advantage of the window of opportunity, a firms identification strategy must be adopted, coupled with a marketing and diffusion strategy to present the invention value proposition. The next sections address these issues.

The firms' identification strategy

The firms' identification strategy must include, in addition to the market and technology description, the identification of the competencies and resources which are necessary for its development and commercialization. A good licensee or technological partner is the one who's able to complement our present resources and competencies to make our invention viable. The referred actions and the appraisal of required resources presupposes an assessment of the development, production and distribution stages of the products or processes which will include the technology. During this analysis, we should have in mind, the firms' skills and their production capabilities, as well as their competitive strengths in terms of products, distribution channels, marketing and sales force, to find licensees able and willing to support the technology market penetration. This analysis can be enhanced if a SWOT procedure or a 4Ps marketing analysis (product, price, promotion, point of distribution) is followed (Di Sante, 2007), this may be helpful to determine what's necessary to commercialize the invention and to assess and select suitable firms to access markets and to raise its value for both parties and final-consumers.

We also need to determine what intellectual property rights are required for the technology to function as a product or integrated in a product or in a larger platform (Di Sante, 2007), what knowledge must be transferred to the licensees, and we need to assess if the firms are able to absorb it. It's also desirable to understand how the technology fits within the firms' technological space, with whom we intend to negotiate, so that an alignment between the technology characteristics and the firms' capabilities and resources is achieved.

While determining the invention potential and attractiveness and while we identify potential partners, we must determine the technologies that have to be integrated with our invention to obtain a complete commercial product, and we need to analyze the possibility of combining the technology with existing products or systems, we should also measure the

possibility of producing the technology on a large scale and with what resources and skills. The technology friendly use, its easy and intuitive reproduction and packaging, its robustness, its adaptability to different environments, and the user possibility to perform tests to decide on its usefulness are also relevant factors on technology licensing decisions (Thornatzky and Fleischer, 1990), they also influence the licensees perception of risk. As a rule of thumb, smaller firms and start-ups are the ones willing to assume greater risks and more experimentation to test what might work, larger firms have more pre-established compromises and are less flexible in the adoption of new technologies (Speser, 2006). Established enterprises have a preference for incremental technologies, which bring something new to an existing invention or who alters its design (Shane, 2004). Smaller firms are more willing to adopt technologies in initial development stages, or technologies that present disruptive characteristics allowing the development of new generation products based on different scientific domains (Thursby et al, 2001; Shane, 2001).

Independently of the firms' maturity and size, the technology adoption is under the dependence of the firms' strategic orientation (Miles et al, 1978). Firms whose growth is more dependent on new products and processes continuously seek new technologies and business opportunities, and their usually potential licensees to be looked for. But our technology may not be the only one to solve a particular problem, and it may be useful to existing firms willing to remain competitive or to insurgent firms willing to compete with established players. Therefore, we must pay attention to existing patents leading to the same results and to their owners, so that the search for licensees is oriented to those firms requiring new technologies to maintain or acquire a competitive position. The patenting and articles publication rhythm in certain areas, their respective owners and their applications should also be accompanied, as well as the importance and value of different patent subclasses. We should also bear in mind that firms who commercialize previous or similar products are typically good licensees.

The technology complexity level and the market that a firm commands are also important factors to bear in mind when searching for a licensee (Speser, 2006). In short, a good development and commercialization partner should:

- Have adequate technological capacities and competences;
- Have the necessary networks and resources;
- Have a significant client base and a strong brand;
- Be able to address the relevant market segments targeted by our technology;
- Have a risk taking attitude.

The main purpose is to create and develop new solutions and to gain uncontested market space (Kim and Mauborgne, 2005).

The development of complete, demonstrable, turnkey solutions and products decreases the investment risk and makes the technology more attractive to potential licensees. We should notice that many solutions are licensed not because they embed an innovative technology, but because there's a complete product, which includes a patent, whose functionalities have been demonstrated on the ground. However, it's not always possible to license the technology to the firms we consider to be the most suitable to develop and commercialize it, because firms may have no interest on the technology, or may not be interested on it at that particular time for strategic reasons. When isn't possible to license to the most adequate partner, and because it's usually better to obtain an agreement than to not obtaining it, then the TTUs normally prefer to license to the firm that's quicker in manifesting its interest. When other firms, a posteriori, offer more value for the invention, the TTUs don't step back and uphold the partnership with the firm their working with, to enhance the collaboration previously established, being the TTUs general perception of a good partner, associated with their capacity to initiate a large scale production, to access the required networks to address the relevant markets and, above all, the TTUs look for a credible partner, that respects deadlines and meets the defined targets and that negotiates fairly so that each part feels that a balanced agreement is achieved.

Having clarified the profile of the firms to be contacted, the next step is the technology marketing and diffusion, an issue to be addressed in the next section.

Technology diffusion

The licensing agreements origin is associated with the size and quality of the TTUs and researchers networks - "one's worth can be approximated by the size (and quality) of one's network" (Kolchinsky, 2004:95). TTUs acknowledge that the inventors are the most important source of licensing contacts (Hsu and Bernstein, 1997), and they're the primary source for firms identification (Thursby and Thursby, 2004; Young, 2007). Inventors can be a "one stop source of market information" (Di Sante, 2007), and the inventor direct contact with firms is the most important factor on the establishment of licensing agreements, the second most important one is the TTUs marketing efforts. Agreements obtained by inventors are made predominantly with larger enterprises, while the agreements obtained by TTUs are made predominantly with smaller firms. The explanation seems to be related with the fact that smaller firms have fewer resources to invest on technology watch and are more receptive to the information provided by the TTUs communication channels. The TTUs investment on direct marketing

intended for smaller firms may prove more useful than the marketing directed to larger enterprises (Ramakrishnan et al, 2005). On technology diffusion it's also important to consider the university prior relations with firms and their geographical proximity (Mansfield and Lee, 1996) and strategic position and location, to extend our present collaboration networks having in mind that the majority of the university-industry relations are informal (Mowery and Nelson, 1999), and multiple communication channels should be used to effectively communicate the technologies value proposition. The TTUs recur to these informal networks of contact to assess the invention technical and market potential, to identify companies potentially interested on the invention, to raise money for further developments, to support spin-off companies' creation and to determine the patent territorial expansion opportunities. These informal networks are composed by different economical, technological, governmental and entrepreneurial stakeholders. Another important factor on the origin of licensing agreements is the development of technology tailored to the firms' needs and requests. To respond adequately to those needs and requests, many TTUs make regular and comprehensive updates of the university scientific and technological supply, arising projects, initiated either by the firms, the TTUs or the researchers, and their aim isn't only to patent and license, but also to solve specific problems and to take advantage of governmental (or other) programs supporting R&D activities.

The previous licensing agreements, the contact with former collaborators and students working in the targeted industry, and the contact with firms beyond the region are also relevant factors on the universities technology transfer processes - the Portuguese speaking countries, including Macau, but specially Angola, are considered by the Portuguese TTUs as very important markets for the development of new projects, but as a key trend, the TTUs interests and actions are oriented to the expansion of their international connections beyond their traditional lusophone markets.

In short, the TTUs recur to multiple communication channels to diffuse the technologies value proposition which must be a concise and quantitative presentation of the problem (and the reason why the consumer will adopt the solution), the identification of the market, its size, the economic and social benefits for the adopters and its comparison with competing technologies and solutions (Gomes, 2007).

Beyond the technology value proposition diffusion and the establishment of industry relations, it's important to make an integrated management of the units that support entrepreneurial activities and technology transfer processes, to enhance the relationship between the researchers and knowledge valorization professionals and to improve the definition of integrated commercialization strategies. It's also important to foster a more structured relation between the university departments and research centers, and the technology transfer professionals to monitor the development of projects from their inception until their diffusion.

The technology diffusion enhances the application of research results and ensures further resources, clients and new projects, and there are essentially four options for an effective technology transfer process:

- The inventor creates a new enterprise to commercialize the invention;
- The invention is integrated in a larger product or system and solves a firm specific problem. In this case we already have at least one potential licensee for our invention.
- The researcher makes an invention to solve a firms' problem with whom he's already working. In this case, the licensee will be the firm.
- The inventor delegates the technology commercialization responsibility on an external entity. This last option is the one that's less likely to succeed. The inventor must be actively involved on the technology transfer process, he also has to try to sell or license the invention by himself or with the TTUs collaboration.

The inventors' engagement on technology licensing processes is essential, and this is well acknowledged by the TTUs, who recognize that behind their success and growth are the relations of trust with the researchers and their informal networks. Together, they provide a powerful framework for an effective internal and external communication strategy. Being the TTUs a "value shop" that manages a network of actors and technologies, providing support to researchers during the knowledge valorization processes (Stabell and Fjeldstat, 1998).

OBSTACLES TO TECHNOLOGY TRANSFER

All communication and licensing strategies encounter obstacles, knowing them is a good principle to avoid or to work to surpass many of them. Some of the obstacles are the TTUs lack of experience on the evaluation and licensing processes (Collins and Wakoh, 2000; Chukumba and Jensen, 2005), the location of the university in a pour technological developed region, the universities lack of a clearly defined mission towards the support of technology transfer (Friedman and Silberman, 2003), the availability of financial resources (Dodds and Somersalo, 2007), the reduced number of technology transfer professionals (Ramakrishnan et al, 2005), the brand value of the institution and the lack of previous connections with industry (Harmon et all, 1997). Other obstacles associated with the universities technology transfer practices include: information deficiencies, insufficient technology watch, deficient marketing strategies, difficulties in finding business partners with adequate capacities and resources for

further technology developments, the lack of entrepreneurial initiative, their inability to determine the technologies investment risk, and the lack of administrative support on the elaboration of financial applications and in project management (Arvanitis et al. 2005).
The early-stage of technology development, the inexistence of a final product, the uncertainty in cost estimates or profit margins, the lack of TTUs commitment in a line of business, and the mismatch between the technology specifications and industry requirements (Kristofferson and Jonsson, 2003) are additional barriers to technology transfer.
References about the lack of engagement between university researchers and industry, and the lack of research programs devoted to technology study and transfer, as well as, the lack of an integrated management of the protection, transfer and entrepreneurship activities among the universities and the lack of a proof-of-concept fund in some universities, are other obstacles appointed by the TTUs.
In short, it's important to understand the technology transfer and licensing barriers, in order to find efficient solutions and alternative ways to surpass them. Understanding the invention and its market and the identification of suitable firms seem to be important components to overcome some barriers. Another important factor is related with the assessment of the industry motivations to collaborate with universities and with the demonstration of the engagement advantages.

EVALUATION METHODS

The technology evaluation and the assessment of its commercialization potential is a transversal task that sweeps across the technology transfer process, allowing us to surpass some of the referred obstacles. Since the invention disclosure until the patent license or assignment several evaluation methods can be used. At an initial stage of the invention evaluation process, the TTUs tend to use quick evaluation methods, based on checklists and on the preparation of short reports about the invention market and return on investment. At a posterior stage, a more in depth evaluation is carried, and comparable agreements, royalty standards and cash flow projections are used. The more in depth study is usually initiated when the TTUs receive a manifestation of interest or when the TTUs need to obtain additional information to strengthen the technologies presentation to potential investors. During this evaluation process we want to know and understand everything about the technology, and no one understands it better than the inventor (Di Sante, 2007), being the inventors engagement essential throughout the entire technology transfer process.
Among the most important TTUs activities to understand the invention are the analysis and description of the technology, its attributes and claims, the identification of new development stages and the definition of an action plan or an industrial map specifying what to do and what can be done to bring the technology to the market. It's also important to identify competing patents with the same purpose of the invention, and to identify all the invention applications for the patent protection to be as wide as possible and to identify the strongest link between the invention, its solutions and its market. To enhance this link and the engagement with industry it's important to build applied R&D projects on a clear identification of the targets and markets to be met, knowing what are the applications to be built and what's the added value against existing solution, in this way, we can define, from the beginning, clearer research lines which might lead to technologies and patents with higher profit potential, and as a good practice, we should always base a research project on a deep patent search, this procedure may reduce to half the project duration and it usually brings, on average, a 40% reduction on the research costs (Smith, 2005).
The identification of competing R&D teams, the analysis of alternative technologies likelihood to show up and the assessment of the possibility to redesign the invention through reverse engineering are also assumed by the TTUs as important activities.
In this stage of technology understanding and evaluation, we want to know every aspect of the invention and to clarify all the tasks which are necessary to obtain the invention proof of concept (if not already attained) and to obtain a complete commercial product. The proof of concept is essential to develop products based on the technology. The lack of a proof of concept national fund is a weakness remarked by many of the Portuguese TTUs.
After all aspects of the invention have been understood, and after the assessment of existent resources for new development stages, it's important to select the invention most promising applications to deepen its market study. The market research is the starting point to analyze the relationship between the technology, its applications and its market, identifying its final consumers, needs, competitors, and the relevant firms and actors, so that an adequate market position can be found. It also enhances the invention value proposition and diffusion strategy. The market research is initiated, by the TTUs, at the moment of the invention disclosure and it's usually deepened during the period that's between the patent registration and the PCT requests or when a manifestation of interest is received.
To obtain data about the invention and its potential market there are several methods with different levels of depth which can be applied at different times of the evaluation process.
The most common methods are:

- Pre-defined evaluation models and matrices;
- Comparable licensing agreements and the observation of royalties practiced in industry;

- Evaluation based on development costs;
- Discounted cash-flow method;
- The 25% rule;
- Real options and Monte Carlo simulation methods;
- Patent auctions.

In the following sections we address each method separately.

Pre-defined evaluation models and matrices

Methods based on checklists and on pre-defined models speed up the evaluation process and facilitate the consideration of multiple dimensions of the invention, from its intrinsic quality to its market potential and profitability. These methods are the most widely used instruments in the evaluation of invention disclosures. Some of those instruments are:

- COAP – *Commercial Opportunities Appraisal Process*, developed by Warwick University, in which ten evaluation criteria are scored;
- *Rapidscreen*, it's a process supported by a web service to discover the opportunities associated with early stage technologies, which involves conducting interviews with the research team and with experts in the technical field under analysis;
- *IPscore* 2.2. developed by the European Patent Office, was designed to identify potential gains and opportunities, and to reduce the evaluation time and costs, and can be used to study ideas, R&D projects and patents providing us reports about a patent or a set of patents and presenting a forecast of the net present value of the assets under analysis.
- *Commercialization Quicklook Assessment*, developed by the University of Texas, consisting in a four steps study allowing the collection of information to prepare a final report about the technology commercial potential.

Beside these matrices some TTUs have built their own evaluation methods which usually group a set of indicators into four major categories: the technology stage of development, the innovation potential, the market potential, and its strategic importance.

Comparable licensing agreements and the observation of royalty standards

The analysis of previous licensing agreements and the observation of royalties practiced in industry (royalty standards) may provide guidance to define and defend the payments structure and its value during the negotiation of a technology transfer agreement (WIPO/ITC, 2005). The search for comparable license agreements and royalty standards is an effort that usually pays off (Razgaities, 2003), although the specificity of each technology doesn't call for standard agreements. But it's important for the TTUs to build and maintain a portfolio of reference agreements 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 to understand the invention value and potential return. The "Royaltystat" of the US Securities and Exchange Commission, based on the Edgar Archive, is a well known database where payment structures for many technologies acquired by US firms can be consulted.

Evaluation based on development costs

Evaluation based on development costs is rarely a base on which firms negotiate license agreements (Razgaities, 2003). Firms are interested in obtaining technology in an easy and cheaper way than it would cost if they developed the technology by themselves, and the cost of creating a technology has nothing to do with its value (Speser, 2006). The market value is a more appropriate metric for evaluating a technology (WIPO/ITC, 2005). The evaluation based on development costs shouldn't be used to put a price on a technology, instead, it should be used before the start of a project as a way to estimate future costs and future investment.

Discounted cash-flow method

The discounted cash-flow method is widely used by organizations who deal and license technology (Degnan and Horton, cited by Kemmerer and Jiaquing, 2008). The discounted cash-flow calculus is important for business profitability discussions and to provide a basis for setting up royalties and other payments. It's also important when the deal involves a single 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 equity participation.

The 25% rule

The 25% rule is usually applied to the EBIT – Earnings before interest and taxes, and was defined by Goldscheider et al (1970) according to Kemmerer and Jiaquing (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 (Razgaities, 2003).
The rule is a good starting point, adopted by licensors and firms, for royalties' negotiation, thanks to its simplicity, intuitive reasonability and diffusion by several authors (Razgaities, 2003; Grandstand, 2006; Parr, 2007; WIPO/ITC, 2005, Kemmerer and Jiaquing, 2008).

Real options and Monte Carlo simulation methods

The real option method allows the separate evaluation of all the assumptions involved in a cash-flow projection, each assumption having a different level of uncertainty for which different risk-adjusted hurdle rates are defined. This is a more complex and time consuming approach, but it contributes to a more complete and exact analysis of the investment return (Soares et al, 2007). The Monte Carlo simulations are more frequently used than the real options method. The probabilistic model generates multiple scenarios regarding the profitability of the investment and the probability of attaining a predefined critical value.

Patent auctions

Patent auctions are gaining increasing importance on technology transfer processes (Ciardullo and Evans, 2006). Auctions are a quicker way of commercializing patents, provided they are of high quality (EPO, 2008). Auctions can be a way to license patents that otherwise would fall for absence of payments of patent fees, or to commercialize and define territorial extension rights of patents which are in the final stage that precedes the PCT applications stage. The planning of auction events requires a considerable organization and publicitation effort and it's not easy to have several bids for just one piece of technology (Tansik, 1991).

Evaluation methods in use and not in use by the TTUs under consideration

Checklists and pre-defined models are the most frequently used evaluation methods, which are followed by the analysis of previous agreements and cash-flows projections when there's a firm manifestation of interest or when considering the creation of a new spin-off company.
The 25% rule isn't in use, because its application isn't well understood, and because there are doubts on whether the value of 25% is adequate, since this value can vary according to the rights conceded, the patent stage of development, and the production and distribution requirements. This rule is based on an average distribution of license agreements, but because each agreement is unique the rule may cast some doubts on its effectiveness (Speser, 2006). However, it may serve as a starting point for the negotiation process.
The real options and Monte Carlo simulation methods aren't in use because the TTUs prefer evaluation methods which allow a quick inspection of several variables, instead of analyzing whole scenarios that may affect the invention profitability. Patent auctions are also not in use, since the value of the technology relies exclusively on investor bids, where there's no space for negotiations, but they can be useful for some technologies as previously discussed, and one TTU is considering the use of this technology transfer method.

Articulation between the evaluation methods

The methods presented above can be used in different stages of the evaluation process. In a first stage, preparatory for the submission of a patent application, patent databases are extensively used, to understand the invention and the state of the art related to it, and scoring matrices and rapid report models are used to understand the invention market potential. In a second stage, usually when there's a firm manifestation of interest, the technology transfer professionals, to define the agreement payments structure and to prepare the negotiations tend to recur to comparable agreements, royalty standards, discounted cash-flow projections and some may also recur to the 25% rule, the real options and Monte Carlo simulation methods. Simultaneously to 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 the access to equipments or materials external to the university which are necessary to achieve the invention proof-of-concept and proof-of-market. Contacts may also be established with potential end users of the technology. After the patent registration, auction patents may also be used, in this case the payment structure negotiation is relieved because the value is decided by the highest bid. The use of these evaluation methods will support the draft of an agreement which can be seen positively by both parties, and a balanced distribution of the gains may be achieved, although, to understand this process we also need to know the different possible payment modes that should be considered in this kind of negotiations. The next section addresses this issue.

TYPES OF PAYMENT USED IN LICENSING AGREEMENTS

The definition of the payment structure must consider different dispositions which may influence the licensing agreement value. Some of those dispositions are:

- At technology level: the invention scope, territorial rights and protection length, the level of exclusivity conceded to reproduce, modify, make further R&D or to develop new products based on

the invention, the stage of technology development, the level of complexity and the skills required to use it, its robustness to operate in different environments, its friendly use, easy and intuitive reproduction and packaging, the number of technologies that must be integrated with the invention to obtain a full commercial product, the possibility of mass production, the compatibility with existing systems, the risks and the costs inherent to future developments, and its social and environmental impact;
- At market level: the present and emergent competitive technologies, the technology strategic importance, the differentiated applications resulting from the invention and the industries envisaged, the applications market size and growth rate, the emergent and declining costumer segments, the strength of existing firms and brands, the marketing, distribution and sales complexity, the applications life cycle and their revenue streams.

These are some disposition affecting the payments value, but there are other dispositions which also deserve attention, such as the rights over the improvements made with or on the technology, the possibility of sub-licensing, the payment of patent fees in several countries, the agreement length, and the exclusivity of rights granted, the inclusion of technical services, the provision of equipment or other resources from the part of the university or the firm, the existence of projects and competing R&D teams, the value of the royalties practiced in the industry and the potential gains from the technology commercialization.
All these dispositions must be considered or appraised so that the nature, the circumstances and the terms of the agreement are reflected in the payment values and in its structure, which can be divided in fourteen categories:

- Single lump sum payment or paid-up license – a single payment for a determined period of time;
- Fixed fee per sold unit or technology utilization;
- Earned royalties, running royalties or pure royalty licenses - royalties based on a percentage of sales or technology utilizations;
- Up-front payment or up-front fee;
- Minimum (annual) cash payment - minimums or minimum royalties or license maintenance fees;
- Stage payments or milestone payments;
- Option agreements and options payments;
- Royalty adjustments;
- Deferred royalty calculations;
- Late payment penalties;
- Termination fees or kill fees;
- Sub-licensing payments;
- Equity payments;
- Support payments.

An agreement may include multiple modes of payments and the above categories are not exhaustive. In the subsequent sections we address each payment type separately.

Single lump sum payment or paid-up license

This single payment, for a determined period of time, is typical in agreements whose risk is relatively small (Johnson, 2007) and they provide advantages for both parties. The TTUs administrative control and communication costs are reduced or eliminated and the firm isn't forced to expose sensitive information, and it provides to the licensor, in a single moment, a significant amount of financial resources. To determine the payment amounts, it's advisable to make a discounted cash-flow projection, to estimate the profitability of a single payment compared to a series of deferred smaller annual payments (Pressman, 2009), and to establish the amount of payment to be made, taking into account the return on investment.

Fixed fee payment

A fixed payment per sold unit or technology utilization may be established. This value must be updated every year by reference to inflation rates (Howard and Johnson, 2001; Poddar and Sinha, 2002).

Earned royalties or running royalties

Running royalties are based on a percentage of the price of the licensed product, or on a percentage of the product sales operational results. This mode of payment shares the risk between the licensor and the licensee, since the licensor receives a larger or a smaller payment depending on the sales success (Wada, 2004). The running-royalties are an important licensor signal of confidence in the invention commercialization success. (Jonhson, 2007). The running-royalties are often used when the uncertainty in forecasting the sales volume is very high and when the technology and its applications are still in an early-development stage and it's believed that the involvement of both parties can positively affect the commercialization success. To establish the royalties percentage to be paid, discounted cash-flows, the 25% rule, royalty standards, or the real options or Monte Carlo simulation methods can be used.

Up-front payment or up-front fee

An up-front payment is a payment required by the licensor whose purpose is to assure the licensee commitment in the invention commercialization success. Up-front payments are obtained in exchange for a reduction in the royalties percentage (Thalhammen-Reyero, 2008). One common rule, used on this modality, is the definition of a payment based on the estimative of the value to be obtained in a year where the project is already well under way (Razgaities,

2003). It's thus necessary to recur to discounted cash-flow projections, but the value of the up-font payment may also reflect the adequate amount that each party deems necessary to keep the project on track towards its commercial success.

Minimum cash payment

Minimum annual payments are required by the licensor for the licensee to maintain its exploitation rights. The aim is also to assure that due diligence is being taken by the licensee in the invention commercialization success (Kim and Blacklock, 2009). Its value can be established based on a conservative or optimistic scenario resulting from the sales estimative and it can correspond to one quarter or two quarters of the projected royalties for a certain year (Razgaities, 2007).

Stage payments or milestone payments

These are payments required to the licensee each time certain development or commercialization objectives or milestones are successfully attained (Wood, 2004; UMIP, 2005; Leone and Oriani, 2007), such as, the conclusion of an R&D stage, the beginning of sales or the development of a new application based on the technology.

Option agreements and options payments

An option is the right to make future decisions relative to the acquisition or exploitation of a technology. Options can be very useful for the development and validation of the technology and its market, and the investors are able to make an informed decision about the acquisition of rights. If an investor wants to conduct additional research and development, the option may include an exclusive right, and in this case, an initial payment is defined. This payment compensates the licensor for deferring its search for licensees during the time the option takes place. Options that imply exclusive rights may condition other opportunities, and in the case the option is not activated, it may affect future deals. Thus, in the option agreement, its duration must be clearly defined, as well as the obligations of each party and the consequences in case the option is not taken (Razgaities, 2003). Option agreements generally last for 6-12 months and they are very useful on the creation of new enterprises (Franko and Ionescu-Pioggia, 2006). Other options are possible, such as the option to obtain a non-exclusive license after an experimentation and testing period.

Royalty adjustments

An agreement may include the possibility of readjusting the royalties' value. A scale of reductions in the percentage of the royalties may be introduced to reflect some circumstances, like the reduction of the invention value due to new competing technologies, production and commercialization costs higher than expected, due to the impossibility of obtaining the rights in a certain region or due to the change of an exclusive license into a non-exclusive one (UMIP, 2005). The reduction of royalties may also serve as an incentive to increase the production and the sales. The definition of a lower value of royalties, that increases if certain commercial objectives are met, are usually called, kicker royalties (WIPO/ITC, 2005), this increment scale of the royalty values may also be introduced to reflect the circumstances of a favorable reality to commercialize the invention due to the greater product absorption or due to low production costs, or other favorable commercialization events.

Deferred royalty calculations

When there's high uncertainty over the technology development results and commercial success and there's a reasonable amount of trust between the parties, it may make sense to define the royalties and other forms of payment after the technology and the market validation has occurred. When payments are set *a posteriori*, it's important to define deadlines to achieve certain results or to communicate certain objectives, so that the results can be analyzed and the payments defined according to those results. This payment type is mostly used among university spin-off firms where a relation of trust has been built and is present.

Late payment penalties

The date for each payment must be well defined in the agreement and penalties must be established in case of default, to discourage future defaults (Razgaities, 2003).

Termination fees or kill fees

A license presupposes a fixed duration. If a contract is broken, fees must be paid to the institution, to compensate for lost opportunities. This type of payment is usually used as a measure of licensees' credibility.

Sub-licensing payments

Sometimes the licensee has access to large networks and is interested in distributing the technology to third parties, which enhances its sales and liquidity. These contracts must preview how the gains will be distributed among licensors, licensees and sub-licensees. Sub-licensing is common in exclusive licensing agreements (Franko and Ionescu-Pioggia, 2006).

Equity payments

The university may opt for an equity participation in a firm, assuring financial support for the firm or technology transfer without or at reduced cost for the firm. The most successful universities in terms of technology transfer have always some form of equity in

spin-off firms and have explicit and proactive measures directed towards its development (Lockett et al, 2003). The financial return via equity participation is generally higher than the one obtained via licensing, and universities seem to be more engaged in equity if they are more experienced in technology transfer (Bray and Lee, 2000, Feldman et al, 2002).

Support payments

The licensor support in terms of technical assistance is particularly important for sophisticated technologies and during the license early years where the licensee goes through a learning curve process, and they can have a positive impact in terms of investment risk reduction, and for the licensor they are an important source of revenues and they enhance the relationship with the licensee and the possibility of establishing new commercial and investment relations.

Types of payment used by the TTUs in licensing agreements

A license agreement creates contractual obligations between the licensor and the licensee, and several modes of payment, that reflect several considerations whose nature may be economical, technological, legal or commercial, may be included on the contract. The most frequent modes of payment in use by the TTUs are the running royalties, but other modes are frequently included on technology transfer agreements, such as the up-front payments and the minimums, but there's usually a concern in assessing the firms position and there's also a concern on establishing a mutual relationship, especially when the firms have previous relations with the university or when a new firm is established to exploit an invention. This concern is also reflected on the frequency of payments established after a period of experimentation and tests (deferred royalty calculation) - some TTUs express apprehension on establishing this type of payments because of potential conflicts that posteriori payment agreements may generate. In what concerns to support payments for scientific and technical services they're quit frequent on the TTUs license agreements. These services, a mixture of maintenance and technical assistance, increase the licensor revenues, and they also have the advantage of keeping the relationship with the licensee enhancing the possibility of transferring other solutions. The grant of sublicensing rights is also common, in what concerns to stage payments or milestone payments they're not frequent, the same happens with equity participation, single lump sum payment, option payments and termination fees. Among the types of payments not in use by any TTU are the fixed fees, the royalty adjustments and the late payments penalties.

EARNINGS DISTRIBUTION

Each university has its own rules or set of principles that define how the gains from licensing agreements is distributed within the university stakeholders. Higher fees paid to the inventors seem to be positively related to the number of inventions, to the financial return of the licenses and in the attraction of abler researchers (Lach and Schankerman, 2003) and universities tend to pay larger percentages to inventors that take the initiative to create their own spin-off firm, these higher fees are aimed to compensate the inventors initiative and risk taking attitude (Lockett et al, 2003; CEC, 2007). In what concerns to the TTUs, they typically receive 10% to 25% of the license revenues and the university tends to subsidize directly the TTU activities during several years, until it becomes self-sufficient (young, 2007). Many years can pass before self-sufficiency is attained, and the TTU must reach a balance between the resources available and what they can protect. As a rule of thumb, only one in ten invention disclosures' is patentable, and only one in ten patents is licensable (Dodds and Somersalo, 2007). Evaluation practices are thus essential in the process of decision making regarding patents and in the marketing and licensing of inventions.

The distribution of licensing agreements revenues among the inventors within the universities at study range from 30% to 60% and, these universities, do not specify the earnings distribution among their TTU and when a new spin-off firm is created by university personnel. The remaining earnings are used to support the research centre where the invention took place, to acquire equipment and materials and to make further research work on the technology having in mind future gains. Revenues are also used in transversal activities, mainly in the management and reinforcement of intellectual property rights and in the development of strategic R&D projects.

Tabel 2: Structure of earnings distribution within the universities involved on this study

University	Earnings distribution
University of Aveiro (Universidade de Aveiro)	40% for inventors 60% for the University (negotiable)
University of Beira Interior (Universidade da Beira Interior)	55% for inventors 45% for the University, of which 25% for the Department or Centre 20% for the Central Executive Services
University of Coimbra (Universidade de Coimbra)	55% for inventors 45% for the University, of which

	30% for the Faculty 15% for the Central Executive Services
University of Minho (Universidade do Minho)	45% for inventors 45% for the University, of which 15% for the Department or Centre 15% for the Faculty 15% for the Central Executive Services 10% for remuneration of risk capital (central services)
New University of Lisbon (Universidade Nova de Lisboa)	30% - 55% for inventors, depending on the profitability Remaining for the University, to be distributed by the departments, on a case by case manner
University of Porto (Universidade do Porto)	60% for inventors 45% for the University, of which 30% for the Faculty or Department or Centre 10% for the Central Executive Services
Technical University of Lisbon (Universidade Técnica de Lisboa)	50% for inventors 50% for the University

CONCLUSIONS AND FURTHER RESEARCH

To understand and improve the information and knowledge about technology evaluation and licensing methods and strategies this paper has formulated a series of research questions allowing the identification and description of technology valuation practices in use by university technology transfer units.
From the empirical results obtained several conclusions could be reached. The following is a summary of some important ones, grouped according to the main concepts developed on this paper:

Selectivity on patent protection

- The size of the patent portfolio is not directly related to the number of licensing agreements;
- Different degrees of selectivity in terms of patent protection are assumed:
  - The less selective TTUs seek to increase the number of patents to motivate the researchers' productivity and their culture and experience on writing patent applications.
  - The more selective TTUs devote more time and resources on a smaller number of high-potential inventions and they prefer to patent by making a previous estimation of future patent and management costs to protect future dividends and to avoid copy and they also take into account the probability of finding suitable partners; others are selective only when considering the expansion of the patent rights on a geographical scope.

Origin of technology transfer agreements

- The majority of the university-industry relations are established through the inventors and TTUs informal networks;
- Informal networks have an important role in assessing the invention technical and market potential, on the identification of suitable partners and funding sources, on the support to new spin-off firms, on the identification of the geographical scope for patent protection and on the definition of new product innovation strategies;
- The development of tailor-made technology according to the firms requisites is one of the main sources of licensing agreements (these projects arise either by the firms, the TTUs or the researchers to solve specific problems and to take advantage of programs supporting R&D activities), other sources are the contact with Portuguese firms of national dimension knowing that the international contacts are assuming increasing importance, the prior industry connections and the inventors engagement and predisposition to create a company;
- The existence of an integrated management of the IPR protection, entrepreneurship and licensing activities improves the relationship between the TTUs and the researchers and the definition of commercialization strategies;
- The existence of a structured management to monitor the development of projects since their inception until their diffusion can have a positive impact on the attainment of transferable patents and on the reduction of costs and time to accomplish the project desired results, this structured management is also meant to articulate the particular characteristics of one project with the needs and interests of the firms economical development;
- The effective internal and external communication is what's behind the growth and success of the universities technology transfer units;
- Many patents were licensed not because they embedded an innovative technology, but because there was a complete product, which included a patent, whose functionalities were demonstrated on the ground;
- TTUs also seek firms that commercialize similar and predecessor solutions as a faster route to commercialize the university intellectual property rights;
- The countries with which there are more licensing agreements are the Portuguese speaking countries,

including Macau, but specially Angola, and the countries of Eastern and Mediterranean Europe, including Turkey, but many other agreements have been established with other countries such as the United States of America and many of the European countries;
- The TTUs general perception of a good partner is that it has the adequate technological capacities and competencies to further develop the technology and to initiate a large scale production, that has access to the networks that are necessary to address the relevant markets and, above all, is a credible partner, that respects deadlines and meets the defined targets and that negotiates fairly so that each partner feels that a balanced agreement is reached.

Obstacles to technology transfer
- Main limitations are associated with the difficulty on finding partners with adequate technological and marketing capacities, with cost uncertainties, with the technology development stage and with the time required to obtain solutions with the required industrial specifications;
- The lack of a national proof of concept fund is a weakness remarked by the majority of the university technology transfer units.

Technology evaluation methods
- Checklists and pre-defined evaluation models are the most widely used instruments on the evaluation of invention disclosures;
- Previous agreements and discounted cash-flow projections are mainly used when a spin-off firm is under consideration or when the TTUs receive an investor manifestation of interest;
- Royalty standards are also in use by a few TTUs to know the payments value range in certain industrial sectors to plan their negotiations with potential licensors;
- Invention comparative analysis and positioning against existent solutions that may overlap on its purpose without having the same characteristics is one of the main evaluation methods in use by the TTUs specially when considering incremental technical solutions.

Payment structure
- The more frequent modes of payment are the running royalties, but other modes are frequently included in the technology transfer agreements, such as the up-front payments and the minimums;
- Payment for scientific and technical support services increase the licensor revenues and they have the advantage of keeping the relationship with the licensee enhancing the possibility of transferring other solutions;
- Deferred payment calculations are in use especially when the firm has previous relations with the university or when a new spin-off firm is established to exploit an invention. Some TTUs express apprehension on establishing this type of payments because of potential conflicts which can be generated;
- With regard to the investment on new spin-off firms social capital we have noticed a lack of University technology transfer units on this engagement process, which does not mean a lack of participation by other university units that may be happening. We should remember that according to our literature review the participation on spin-off firms usually has a higher investment return than the own usually obtained with a licensing agreement (Bray and Lee, 2000, Feldman et al, 2002).

Earnings distribution
- Revenues from licensing agreements are mainly used to reward the researcher or research team who produced the invention and to support their unit of affiliation;
- Allocation of revenues to the inventors differs from university to university and has a range from 30 to 60 percent of the total revenues;
- University rules at study do not specify the allocation of revenues for the TTUs, nor do they specify the distribution of revenues when a new spin-off firm is created, knowing that universities tend to pay larger percentages to inventors who take the initiative to create their own spin-off firm as a means to compensate their initiative and risk taking attitude (Lockett et al, 2003; CEC, 2007).

It also came clear from these study that there is the need to create a regular communication process between the TTUs so that each unit can be aware of the practices of the others and learn with each other experiences by identifying successful actions and possible errors and areas where improvements can or should be done. In consonance with this technology transfer coordinated and planned approach which enables the replication, validation and follow-on innovation we can affirm that only knowing the economic value of an invention can we fully exploit its full potential and can we carry out an appropriate technology valorization strategy.

Outline of further research

The following research lines are examples of the need to deepen the problematic of technology evaluation and licensing, and to address some unanswered issues that came out of this articulation between the literature review and knowledge acquired in contact with the Portuguese university technology transfer units.

- Commercialization of inventions in the global market: indexes of geographical market penetration and the cost-benefit relation of technology licensing agreements developed by universities;
- Competitive watch and the university scientific and technological productivity: R&D centers practices and the TTUs contribution to identify and spread research lines and business opportunities;
- The technological production utility: the correlation between technology licensing and its impact on the research teams development, visibility, reputation and social and economical reward.

These research lines create the opportunity to better understand the application of technology evaluation and licensing practices, and to capture the meanings that lie in the evaluation and innovation procedures implemented by technology transfer professionals.

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