Identifying Critical Factors in Managing University Technology Transfer and Commercialization Units

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Abstract

Given the increasing interest worldwide in the growth of new technology-based companies, the aim of the present paper is to contribute to the future design of patent commercialization and spin-off creation units on behalf of university authorities and national or regional innovation agencies. Our analysis was based on 52 public technology transfer units. Six unit typologies were identified in the analysis. From the results, the proposed recommendations are focused on some critical factors such as a university's research mass, specialized personnel of the technology transfer units, their profile, expertise and cost, as well as ideas collected from some experts in the field.

Keywords: *university, Science Park, technology transfer, commercialization, spin-off.*

JEL classification: I23, M20.

Introduction

The increasing interest worldwide to transfer scientific and technological knowledge into valuable economic activity has become a high priority for many national and regional governments.

Is well known that universities are one of the most important sources to generate and spread knowledge in middle-GDP regions (Solé, 2003). Thus, university technology transfer models are under a fine tooth comb by academics and politicians. Nowadays, university technology transfer tends to employ three main strategies: patent licensing, company creation (spin-offs) and R&D contracts between academia and business. In the particular case of the spin-off modality, many governments spur on universities to create new ventures because spin-offs are not only seen as contributors to a regions' economic development but also as sources of employment (Pérez and Martínez, 2003), as mediators between basic and applied research (Autio, 1997) or as change agents of the economic landscape moving towards a knowledge based economy.

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For this reason, universities are living under a continuous pressure to foster links and cooperation with the business sector. In turn, business is increasingly keen to harness the outcomes of public research. Internally and externally generated knowledge now plays a fundamental role in achieving competitive advantage. Businesses now have important in number and wide in scope reasons to wish to harness public research results (Nightingale, 1998; Forbes and Wield, 2000).

Slaughter and Leslie (1997) defined the present situation as a move towards "academic capitalism". Others see the "new university" emerging from this context as the "entrepreneurial university" (Mian, 1997). Whatever the case, one thing is clear: the university is increasingly bound up with its surrounding industrial-entrepreneurial context and with commercial application of research outcomes. In this scenario university technology transfer and commercialization units (TTU) play a central role. TTUs facilitate technological diffusion through the licensing to industry of inventions or intellectual property resulting from university research (Siegel, 2003 based on Geroski, 2000).

Still, little attention has been paid to which critical factors influence in the success of creating and managing university technology transfer and commercialization units. In such a framework, the main objective of the present paper is to present critical issues detected in the analysis of some of the most successful worldwide university transfer units that can facilitate future creation and design of technology transfer and commercialization units.

The paper is organised as follows. After the introduction, in Section 2 we briefly define the concept of technology transfer and present the market push and pull models. In Section 3 we describe the methodology, followed by Section 4 where the results are presented. Finally, Section 5 concludes and highlights the main recommendations for the creation and design of TTUs.

1. Managing the technology transfer and commercialization process

According Bozeman (2000) the study of the technology transfer concept is very complex due to at least three causes: first, the difficulty of limiting the term technology, second, the difficulty of outlying the technology transfer process and finally, the difficulty of measuring the impacts of the transferred technology. All these circumstances are still open challenges for both scholars and evaluators towards conducting more research in the technology transfer and commercialization field. Although technology transfer is a conceptually broad activity, the technology transfer literature is dominated by research on the interaction and communication processes between transferor and transferee (e.g., Lin, 2003).

The demand for technology can be classified as market-pull or market-push (Bozeman, 2000). Both types of demand are important factors that determine the strategic direction of R&D and innovation (European Commission, 2002).

Market pull demand consists in firms contacting universities in their search for solutions to their innovation necessities. R&D contracts are the predominant technology transfer modality characteristic to this pull category. R&D contracts, which have traditionally played an important role in the university technology transfer (Link, 1996; Hall et al., 2000; Cohen et al., 1998; Caloghirou et al., 2001), are a pull approach in which knowledge is transferred on the company's initiative. Companies contact the university to meet their innovation needs. In this bottom-up approach, it is the market that directs the technology transfer process. Companies seek solutions in public research which will enable them to cut their production costs and/or improve product quality.

On the other hand, patent licensing and spin-off creation, represent a push strategy. The technology push model occurs when a public centre researcher identifies a possible technology based entrepreneurial opportunity but not a clearly defined market. In fact, depending on the technology's capacity, it can create a completely new market. It is a top-down approach.

Technology transfer via spin-offs is the most complex form of university-market technology transfer (Brett et al., 1991). This complexity mainly arises from the twofold role played by the researcher: as generator and applier of the technology. In this second role, i.e., commercial application of the research, researchers do not normally have the necessary entrepreneurial experience. The same is true for universities. Providing support to and managing fledgling companies has not been central to the traditional university remit.

The university's technology transfer unit plays a highly active role and develops a body of skills and knowledge in the area –they "push" the process. In other words, it is a top-down approach; the innovator identifies an opportunity for technology, for which there is not yet a clearly defined market. To succeed, public scientific institutions need to understand the scope of the technology they develop and its future potential, they must detect possible uses and markets and confirm that their technology is valid for these purposes; they should be able to convince the manufacturer (and also the end user) of its value and, finally, provide support for the process of adaptation and uptake.

There is a clear strategic implication for technology transfer effectiveness regarding a market push or pull model (Gander, 1986). Nowadays, most of the TTUs focus their efforts on technology push models, as many as public sector technology transfer practitioners (Piper and Naghshpour, 1996). However, TTUs should not underestimate the value of business experience and market knowledge. In order to build stronger and more balanced entrepreneurial teams between business entrepreneurs and technical entrepreneurs, TTUs could also be important agencies to facilitate a market pull modus by first attracting and subsequently matching needs among end users.

In advanced countries' university systems the previously presented modalities followed a certain sequence. University-industry contract research (*market pull*) was followed by the commercialization of research results through patent licensing and then by science based new ventures created by Public

Research Institutions (PRIs) to exploit these patents. This last phase referring to the spin-off modality assumes and implies that universities will be involved in an active and directed way in the process. By going beyond transfer activities, these modalities are also a strong proof of PRIs' technology commercialization function. Managing each of the previously presented technology transfer modalities – the *pull* and the *push* – involves a specific set of characteristics, issues and challenges.

The "pull" function basically requires promoting and managing relations between the enterprise, on the one hand, and the corresponding research team, on the other hand. In that connection, technology transfer offices (TTOs) have a variety of functions. These functions include: to perform the dissemination task of the potential of their institution's research groups, to promote encounters between the university and private enterprise and to manage the established relations, executing agreements, applying for government funding for agreed projects, among others. In most of the cases, TTOs efforts are remunerated through a relative charge on the price of transaction between the enterprise and the research group.

The "push" approach entails commercialization. In that connection, TTOs need to pinpoint market opportunities by examining and selecting from all the research projects carried out at their universities. Once they have identified results with potential commercial value, they need to assess them (market studies, determination of the value of the technology, etc.) and, if necessary, protect them by patenting.

Lastly, TTOs need to bring their patents to the marketplace. One possibility is to do so through existing enterprises (conventional license). Another possibility is to help the researcher to create a new enterprise to exploit the invention (spin-off). In this case, the technology transfer office experts need to draft a business plan, carry out market studies and financial planning, help to finalise partners' agreements, negotiate with seed capital and venture capital companies, apply for government grants for technology-based enterprises, and so on. In this "push" approach, technology transfer offices also seek to obtain certain financial return for their services and for the technology. Thus, they normally keep a percentage of the revenues obtained through patent license agreements. Some of these institutions also obtain a stake in the share capital of the spin-offs that they help to create.

The functions and problems faced in each case are so different that sometimes, in the framework of the same university, different units are assigned to each. More specifically, in Anglo-Saxon countries the following types of institutions can be found in the field of technology transfer:

- *Industrial Liaison Offices*, primarily dedicated to promoting academia-business interactions (commercial function)
- *Research Offices*, also called *Contract and Grant Offices* or *Sponsored Research Offices*, manage public support mechanisms available for researchers and business collaborations (administrative function)

- *Technology Transfer Offices* aim to commercialize technology through patent licensing to established businesses (classic licence) or to technology based new ventures (spin-offs) (commercial function)
- *Entrepreneurship Centres* have as their main target the promotion of entrepreneurial culture, teaching entrepreneurship and courses related to new venture creation, planning investment meetings and entrepreneurial idea contests, giving support to the entrepreneur in writing the business plan, etc.

Moreover, there are other innovation support providers such as technology parks and incubators that play an increasingly important role in the creation and reinforcement of the relationships between industry and public research organisations (European Commission, 2004).

During decades, USA universities were a reference in technology transfer although in some circles have been criticized for being more adept at development new technologies than moving them into private sector applications (Siegel, 2003) . But in general, these institutions have been pioneers in establishing dynamic research collaborations with industry. Moreover they have been active in licensing public technology (classic licence), mainly after the legislative changes introduced by the Bayh-Dole Act (1980). More recently, spin-offs have emerged as an additional form of technology transfer. Units supporting spin-off creation, going beyond patent licensing units, are specialized in commercializing technology.

In conclusion, the management structures of the public sector technology transfer process have evolved. In the beginning the offices were primordially designed to manage the R&D contracted by the private sector and later became units of patents licensing. As a result of a complex evolutionary process, nowadays they are both technology transfer and commercialization units.

2. Qualitative research method

At present in Spain, at both the level of the central government and that of agencies and offices of the regional governments in charge of steering innovation and entrepreneurship policy, there is a desire to continuously foster the transfer of the results obtained through publicly-funded research in academia to business. The aim is to promote innovation, enhance the competitive edge of enterprises and foster economic development. In certain milieus, there is a drive to establish new forms of organisation to stimulate and facilitate the technology generated by research at universities by means of patents and spin-offs.

Within that framework, the Centre for Innovation and Business Development (CIDEM) located in Catalonia, Spain, commissioned a project for the design of a single unit aiming to serve various universities simultaneously. Within the framework of that project, a study was made on how technology transfer and commercialization is organised in different countries having a grounded and solid entrepreneurial activity sustained over time. Positive role models are extremely well-come in certain geographic settings and/or at a determined moment. They often serve as starting point of a complex adaptation process according to local circumstances, cultural values, formal and informal patterns of behaviour.

In this article we set out the results of a study conducted on fifty-two university technology commercialization units and research centres in twelve countries: the United States, the United Kingdom, Switzerland, Sweden, Germany, the Netherlands, Italy, Belgium, France, Spain, Canada and Israel (Appendix 1).

In a first step we identified available public access information regarding the units operating as intermediaries between universities and enterprises. In a second step, we contacted with the people in charge of those units for the purpose of obtaining in-depth information in respect of five units, each of them representative of one of the different models identified. The specific aim of this part of the study was to find out how the commercialisation of research results at universities and other public centres producing knowledge was managed through patents and spin-offs, to identify the different models of units and to discern the factors that influence the definition of those models.

3. Results

In the first place, the results of the study comprise a description of each of the fifty-two units studied and their respective operations and results. Then, the information in those descriptions was used as the basis for a process of deliberation and synthesis that gave rise to a set of concepts and recommendations. In this section we sum up some of those perceptions.

3.1 Prevailing views on technology transfer

This study has pointed up the following overall notion: the concept of university technology commercialization is a global one. In conceptual terms, there is scarcely any difference between countries insofar with regard to objectives, systems and procedures used for the commercialization of university research results. Furthermore, it could be stated that the slight differences that do exist between countries in this regard tend to diminish over time so that it could easily be assumed that in the very near future all universities will operate in the same manner.

Nevertheless, the detailed analysis shows that there are variations in the approaches followed by different countries in reference to university technology transfer and commercialization. These slight differences are the logical, natural result of the context in which corresponding systems of research and technology transfer have developed. The following is a very brief summary of the essential elements of the different ways approaching the same concept.

3.1.1. University technology commercialization as seen in the United States

Contrary to what is generally believed, it is clear that the USA model for research results' commercialization is of a highly legalistic nature. A great deal of emphasis is placed on all aspects relating to conflicts of interest that may arise for lecturers in their activities in connection to industry, resulting into a system highly vigilant on the compliance of such regulations in order to avoid possible conflicts of interest. On the other hand, it is a system that clearly gives priority to patent license agreements with existing enterprises (conventional licenses) over spin-offs.

This is a model in which conventional licensing to existing enterprises has worked very well for a long time and generated huge figures in comparison with the situation in Europe. To a great extent, the efficiency of this approach to technology transfer has been due to the quality of the inventions generated, which is clearly related to the amount of resources invested in generating those inventions. The substantial investment in R&D, rather than the efficiency of the technology transfer offices, is the basic trait of the American system of university technology transfer.

Owing to the good results that have been obtained with the conventional licensing of patents, many American technology transfer offices see spin-offs not as an opportunity, but rather as a threat. Where a lecturer demonstrates an interest in creating a spin-off to exploit an invention, the decision is based on purely financial considerations, on the cost of opportunity and on the risk posed by the spin-off in comparison with "safe" commercialization by means of a conventional license.

Thus, until the beginning of this century, spin-offs were not actively promoted by American universities. Even at Stanford University itself, the cradle and kernel of Silicon Valley, spin-offs have not so much been promoted as tolerated by the institution as a lesser evil. Nevertheless, that stance is beginning to change. The Association of University Technology Managers (AUTM), which groups the technology transfer offices of the leading American universities, taking into account the references offered by Europe and Canada, have begun promoting, through seminars, courses and publications, an active and proactive vision of proposals for spin-offs. In any event, the reactive view of spin-offs as a vehicle for technology transfer is clearly held at important institutions in that country. In the followings we provide an example.

University of California

This is the largest university in the United States, with 200,000 students and a staff of 120,000 at ten campuses at different locations in the state of California. The Office of Technology Transfer (OTT), with its central structure and decentralised units, provides services to the system's researchers. It has some sixty professionals who are sectorised by areas of knowledge. Insofar and concerning spin-offs, one fact is particularly revealing of the attitude and approach of the University of California to such initiatives: where an enterprise of this type is chosen to market a technology developed at the university, but the OTT considers that the institution will not obtain an appropriate return on the basis of royalties, the office may then accept shares (known as an equity transaction) in lieu of royalties, although, in any event, the university does not accept over 10% of a company's shares under a technology license agreement. In addition, acceptance of an equity transaction must be made subject to conditions of transparency and objectivity in the decision. Furthermore, the university can not accept a seat on the Board of Directors of an enterprise in which it is a shareholder nor exercise any sort of option for voting rights in those governing bodies.

The OTT has a policy to the effect that any researchers at the university who have created a spin-off in which the university has acquired shares and who wish to enter into a research agreement with the spin-off, the transaction must have the approval of the corresponding internal institutional body.

3.1.2. An approach to university technology commercialization in Europe and Canada

3.1.2.1. United Kingdom

Unlike the situation in the United States in the area of technology transfer described above, there has been a clear trend in recent years in the United Kingdom to a preference towards the use of spin-offs rather than conventional licensing. In fact, some recent studies of the British system indicate that excessive use has been made of spin-offs and that greater efforts need to be made in conventional licensing. In any case, technology transfer units in the United Kingdom provide substantial support for the commercialization process. In addition, commercialization units perform complementary functions to facilitate the technology transfer process, For example, Manchester Innovation, in addition to managing support services for university entrepreneurs, also manages the Manchester Incubator Building, a business nursery for biotechnology enterprises. The United Kingdom is also one of the countries with the greatest number of private businesses working in the area of technology transfer. Lastly, this milieu is also witnessing the development of what is, in our opinion, one of the latest stages in the evolution of the university technology transfer management process, namely Techtran, a company whose mission is to market the research results of the Leeds University.

In short, in view of the authors of this article, the technology transfer system in place in the United Kingdom can be taken as the clearest point of reference at worldwide level. In fact, American universities are also steering their development in the same direction. A piece of example reflects this model.

A good example of this model is Isis Innovation, the technology transfer unit of the Oxford University, one of the leading universities in the United Kingdom and among the most prestigious in the world. Oxford University has twenty-five departments that are ranked as the best in the British assessment system. The Oxford University created Isis Innovation in 1988. It is a private company owned by the university and its mission is to manage lecturer consultancy, patent licensing programmes and spin-off support.

Project managers appear as key figures in the structure of Isis Innovation. These are professionals whose profile is based upon two fundamental characteristics: they must understand research and consequently must hold a doctorate, and they must also understand the technology commercialization process and consequently must have experience in business. Each spin-off has its manager, who works closely with the entrepreneurs, to the extent that some managers eventually become directors of the enterprises to which they have provided support.

3.1.2.2. Germany, Sweden and Canada

Continental Europe and Canada take an approach and a standpoint that differs substantially from those of the United Kingdom and the United States. Although there are certain differences between countries, in all cases the level of activity and the maturity of the system for public research results' commercialization are less advanced than in the United Kingdom or the United States.

In Germany, up until 2002, the results of research carried out by university lecturers belonged to the lecturers themselves. Thus, the situation was similar to that in the United States prior to enactment of the Bayh-Dole Law of 1980: the law did not favour an active approach by universities in the area of technology transfer by means of patents and spin-offs. The consequence has been that, with promotion by the federal government and the governments of the *länder*, centralised units have been created that simultaneously serve different institutions. This is clearly one of the main characteristics of the German network of technology transfer support. TLB and Provendis are examples of this type of unit.

Furthermore, unlike the United States and the United Kingdom, the status of German researchers as civil servants meant that it was difficult for them to undertake outside professional activities or create their own businesses. Consequently, very few spin-offs have been generated by that country's academic system. What is more, technology transfer offices have not taken a commercial approach.

The situation in Sweden is similar to the one found until only recently in Germany, i.e. researchers own their results. Consequently, universities have made no efforts to create support structures for technology transfer. Initiatives in that direction came from the state level. Some examples are the Teknikbrostiftelsen and the Technology Link Foundations.

Lastly, in Canada each university establishes its own policy in respect of ownership of research results. At some institutions researchers own their results, while at others their results are owned by the university. In any case, Canadian universities have created efficient technology transfer structures that place a great deal of emphasis on the use of spin-offs. In addition, the Canadian private sector has also been very active in this area and a number of enterprises dedicated to the commercialization of technology generated by the public sector have emerged.

3.2 Types of technology transfer units

According to the previous, we have identified the following types of technology transfer units:

1. Internal or external units (with their own legal personality), promoted by universities and serving their parent institutions.
2. Organisations promoted by universities and serving more than one institution.
3. Units serving universities but that have been created by governmental organisations.

4. Private enterprises operating on the market with a clear commercial intent.

5. A unit (*Techtran*) created by the private investor sector with a commercial intent but addressing initially just one single university.

6. A commercialization unit at a research institute that is seen more as a technology centre than as a university.

The first group comprises the conventional university offices that are active in patenting and commercialization inventions and that, in general, also provide support to spin-offs as a means of technology transfer. Within this group we find, on the one hand, offices that are part of the university structure itself, a type that is very common in the United States, with examples such as MIT's TLO, the University of California's OTT and the Stanford University's OTL. Most of the technology transfer offices of Spanish universities are of this type. Another subgroup is formed by units with their own legal personality. The United Kingdom is one country that has favoured this type of approach on a largely majority basis. Examples of external units are Isis Innovation, at Oxford University, Imperial College Innovations at the London's Imperial College, Sheffield University Enterprises Ltd. (SUEL) at the Sheffield University, and Ventures & Consultancy Bradford Ltd. (VCB) at the Bradford University.

The second group, including three units of our analysis, is made up of initiatives promoted by more than one university that provide services to various institutions simultaneously. One example is Unitectra, which was established and is managed jointly by the universities of Berne and Zurich.

The third model comprises units that serve more than one university but are government-promoted. As we have noted, examples conforming to this model are found in Germany and Sweden. Such is the case with Provendis, in the German *land* of North Rhine-Westphalia, TLB in the *land* of Baden-Württemberg, and Sweden's Teknikbrostiftelsen or the Technology Link Foundations.

The fourth group is made up of private enterprises operating on the market as intermediaries with a clear profit oriented motive. Examples of this model in Europe include Zernike Group in the Netherlands, the British Technology Group (BTG) and UTEK-Pax in the United Kingdom; in the United States we find Falco-Archer, Competitive Technologies and Research Corporation Technologies, and in Canada, University Technologies International, MedTech Partners and MedInnova Partners.

For the reasons set out above, the British enterprise *Techtran* would be in a class of its own. The same could be said of Stanford Research Institute. In fact, SRI, with its totally applied and client-oriented research, could hardly be classified as a university at all.

3.3 Private technology transfer enterprises

We distinguish between three main types of private enterprises operating in the area of public technology transfer, depending on the orientation, strategic approach and business models: supply, demand and services.

3.3.1. Supply-driven

Supply-driven enterprises analyse the milieu of public research with the aim of identifying technologies and good business opportunities. Once they have identified such a technology, they reach an agreement with the university and undertake to transfer it to the market, while assuming the financial cost involved in the process. Their business model is normally based on keeping a part of the royalties, in the case of a conventional license, or a stake in share capital, in the case of a spin-off. Companies that operate along the lines of this model include Research Corporation Technologies (RCT) in the United States, British Technology Group (BTG) and Techtran in the United Kingdom, and MedInnova Partners and MedTech Partners in Canada. Their approach to operations can be summed up as the search for worthwhile technologies and the accomplishment of actions to place those technologies to market.

A highly representative example of this category is the British Technology Group (BTG). BTG originated with a public initiative in the United Kingdom, namely the National Research Development Corporation (NRDC), created in 1948 with the aim of commercializing public research. In 1975, the British government created the National Enterprise Board (NEB) to provide support for the private sector and to channel resources to the manufacturing industry. Shortly afterwards, the two organisations, NRDC and NEB, were merged to form the British Technology Group. In 1990, BTG opened a branch in the United States, in 1992 it went private and in 1995 it was listed on the London Stock Exchange.

At present, the enterprise operates mainly in the United States, Japan and the United Kingdom. It has also carried out transactions in Spain.

3.3.2. Demand-driven

Another type of private enterprises that operate in the area of technology transfer is the demand-driven type, i.e. those that are oriented towards businesses. Their aim is to identify the technological needs of enterprises (referred to as wish lists). On the basis of those lists of requirements, they approach the public research system in search of technologies that can satisfy those requirements. Enterprises that operate in this manner include Competitive Technologies and Falco-Archer in the United States and UTEK Corporation and UTEK-Pax in the UK. A variety of business models may be applied; some of these enterprises charge for their intermediation services, others keep a percentage of the royalties payable under the agreements executed between the parties, while others obtain stakes in the enterprises that exploit the technologies.

A representative example of this model is Competitive Technologies, Inc. (CTT). This enterprise was created in 1968 and has been listed on the American Stock Exchange (AMEX) since 1971. Both its clientele and its operations are worldwide. On the basis of identification of the technological requirements of its client enterprises and making use of both its portfolio of technologies and its extensive network of contacts at universities and other research centres, it works to

identify and supply final solutions to its end clients. Since its creation, CTT has assessed over 25,000 technologies and executed licenses for more than 500 of those technologies with some 400 organisations. UTEK is another demand-driven enterprise, although it follows a different approach. First of all, UTEK executes a strategic agreement with an enterprise; then it familiarises itself with the enterprise's business and it ascertains its technological needs. The next step consists of searching the world's leading universities for research groups that are capable of developing a solution for those needs. UTEK commissions the project and finances its accomplishment. In short, it adopts the position that would correspond to the enterprise with which it has established an alliance and assumes the corresponding risks. When the technology has been developed, UTEK assigns it to its ally in return for shares. For that reason, it operates exclusively with enterprises that are listed on stock exchanges.

3.3.3. Service-driven

In many of the units of both the types discussed above, services play an important role in the generation of revenues. What is more, some units have made services a core element of their businesses. Such is the case, for example, for Zernike in the Netherlands. Its line of business consists in the management of technology parks and business incubators, as well as the supply of services to such structures. It is also the case of the British enterprise Angle Technology, very active in its consultancy business in respect of actions to foster economic development.

4. Conclusions or considerations for the design of a technology commercialization unit

As a result of the benchmarking analysis of the 52 units a series of considerations are possible. These considerations are structured in three subsections, namely research critical mass, personnel profile required in TTUs and cost of the units. In addition, we present some experts' recommendations and other considerations that have been collected during the course of this analysis and that we strongly believe that can be an additional contribution of this paper.

4.1. A critical mass of research

One of the issues that must be of concern to any organisation promoting a technology commercialization unit is the existence of a sufficient body of research. With the aim of getting more insights we present some figures relative to this topic. The critical mass of research provided by critical mass of researchers is measured on the basis of the amount of external funding for research obtained by universities (what is known as sponsored research).

Table 1: Indicators relating to generation of patents and spin-offs in four different university milieus: USA, UK, Spain and Catalonia

	Million dollars	Million euros		
	USA	UK	Spain	Catalonia
R&D investment to generate one patent	5	3.6	1.9	2.6
R&D investment to generate one spin-off	100	13.0	6.6	4.4
Ratio of spin-offs to license agreements	1:9 (1)	1:4	1:0.9 (2)	-

(1) One spin-off for each nine conventional license agreements
(2) In the case of Spain, there are more proposals for spin-offs than license agreements. This means that all license agreements have been executed with spin-offs and, in addition, some spin-offs have been created without any technology transfer agreement.

These figures show that the basis for the differences in the indicators relating to university technology transfer between our milieu and the United States has more to do with the volume of public funding for R&D than with the efficiency of the commercialization system. According to those indicators, the efficiency of the Spanish technology transfer units is very high (they obtain a very good return on very little investment in research). These offices can not reasonably be expected to perform better unless funding for R&D is increased.

4.2. Personnel required for technology transfer units

The MIT, with a structure gathering 30 persons and 454 inventions (2003 figures) requires a person for each 15 invention notifications. In the case of the Oxford University (2003 figures) there are 64 patents and 34 employees resulting in a ratio of one person per 2 patents. We found no available data on invention notification for this institution. Anyway, we assume, that as it happened in the United States, half of the inventions end in a patent. Therefore, this would result a person for each 4 inventions. It is a ratio very different from the case of MIT. However, MIT does not support actively spin-off creation, contrary to the case of Isis Innovation.

Table 2: Staff-activity ratios at different American university technology transfer offices at the end of the 1990s

Institution	Total staff	New inventions	Inventions-to-staff ratio	New US patents	Patents-to-staff ratio	New licenses	New licenses-to-staff ratio
MSU	7	83	11.8	61	8.7	9	1.3
MIT	26	360	13.8	200	7.7	75	2.9
Harvard	16	119	7.4	61	3.8	67	4.2
Stanford	19	248	13	128	6.7	122	6.4

Source: Condom (2003).

The profile of the technical personnel employed in theses offices often follows the same pattern. The employees are professionals having experience in the field of research (often holding a PhD) and they are also having a sustained experience in business, industry or consultancy.

4.3. The cost of units

As an initial point of reference for the cost of a technology transfer unit, we can take the Office of Technology Licensing (OTL) at the Stanford University. The budget for 2003 for OTL was $2.6 million. Given its staff of 25, that means a yearly cost of $100,000 per person (some €80,000). Legal costs amounted to $5 million, or $13,500 per notice of invention received. If we take into account that at OTL, as is the case of most technology transfer units, approximately half of the inventions for which notice is received are accepted and patented, this gives a cost of approximately $25,000 per patent.

In Europe, specifically at Oxford University's Isis Innovation, salaries amounted to £1,132,194 (approximately €1.7 million). That organisation had a staff of 28, therefore giving an average cost of €60,000 per person (including social charges), which is lower than at Stanford's OTL. In aggregate, the salaries of the unit's two managers amounted to €240,000 (including pension plan contributions). Figures for other units in the United Kingdom place experts' salaries working at technology transfer offices (project managers) between €60,000 and €90,000, depending on the different situations, including employers' contributions.

In the case of Germany, TLB paid a total amount of salaries of €750,000 yearly, which, with a staff of 14, gives an average of €54,000 per employee.

4.4. Expert's recommendations

The officers in charge of MIT's Technology Licensing Office state that any university should be able to reproduce their success. In any event, they make the following recommendations for any technology transfer office that hopes to follow in their footsteps:

- Start off with the exceptional people at the institution. They recommend focussing efforts on the university's best research groups and favouring them disproportionately.
- Set out clear regulations and adopt a flexible and responsive process for decision-making.
- Do not skimp on investment. They believe that it is essential to have substantial funds available for investing in patents and building a sufficient portfolio of inventions.
- Avoid rushing. Lastly, they point out that it is unrealistic to expect results until after the commercialization office has been operational for at least five years (or even longer).

4.5. Other considerations

In all the cases studied, the drafting and application for patents is outsourced. Those tasks are commissioned to external expert agents. It is advisable, as an essential factor, to take a very clear position from the outset in respect of ownership of the results of research.

Some units apply atypical management models during the initial stages of the process. For example, Sheffield University Enterprises, Ltd., at the University of Sheffield, and the Centre for Enterprise and Innovation (CEI), at the University of Southampton, create a company practically as soon as notice of an invention is received from lecturers. In this way they avoid potential misunderstandings or disputes in respect of the distribution of shares. The eventual route taken for transfer of the technology may be either a conventional license or a spin-off.

Finally, certain institutions and professionals in the sector (on an individual basis) offer services and advice for the design and start-up of technology transfer programmes in other milieus.

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Appendix 1: The 52 technology transfer units

Units at the service of one university	
Office of Technology Transfer (OTT) - University of California	
The Office of Technology Licensing (OTL) - University of California - Berkeley	
Office of Intellectual Property Administration - University of California - Los Angeles (UCLA)	
The Technology Licensing Office (TLO) - Massachusetts Institute of Technology (MIT)	
Office of Technology Licensing (OTL) - Stanford University	
The Wisconsin Alumni Research Foundation - University of Wisconsin - Madison	
Office for Technology and Trademark Licensing - University of Harvard	
Virginia Tech Intellectual Properties, Inc - Virginia Polytechnic Institute and State University	
Science and Technology Ventures (S&TV) - Columbia University	
Science & Technology Corporation - University of New Mexico (UNM)	
Tech Transfer - Penn State University	
Office of Intellectual Property (OIP) - Michigan State University	
UM Tech Transfer - University of Michigan	
UW TechTransfer - University of Washington	
Isis Innovation Ltd – The University of Oxford	
Manchester Innovation Ltd - The University of Manchester	
UMIST Ventures - University of Manchester Institute Science - Technology	
Imperial College Innovations, Ltd - Imperial College of Science, Technology & Medicine	
Warwick Ventures – The University of Warwick	
Ventures & Consultancy Bradford Ltd - The University of Bradford	
Sheffield University Enterprises Ltd - University of Sheffield	
University / Industry Liaison Office (UILO)- Simon Fraser University	
TEC Edmonton - University of Alberta	
UJF - Industrie - Université Joseph Fourier	
UNITEC - Université de Genève	
K.U.Leuven Research & Development - Katholieke Universiteit Leuven	
Dimotech Ltd - Technion Israel Institute of Technology	
CTT - Universitat Politècnica de València	
Oficina de Transferència de Tecnologia – CSIC (Spain)	
Technology Transfer Office - Politecnico di Milano	
Units at the service of more than one university (promoted by the university)	
Washington Research Foundation (WRF)- Public Universities of the Washington State	
Unitectra - University of Zurich and Bern	
University Technologies International Inc.- University of Calgary and other universities	
Units at the service of more than one university (promoted by the government)	
Provendis – group of universities in North-Rhine/Westphalia	
Technology Licensing Bureau (TLB) –higher education institutions in Baden-Württemberg	
Fundación Genoma España – foundation oriented to all research institutions in Spain	
Technology Link Foundations - Teknikbrostiftelsen – network of 7 foundations promoted by the government	
Commercial entities	
Zernike Group	UTEK Corporation
British Technology Group (BTG)	UTEK-Pax Ltd
Research Corporation Technologies (RCT)	University Medical Discoveries Inc
Angle Technology Group	MedInnova Partners Inc.
Competitive Technologies, Inc.	MedTech Partners Inc.
Drug Royalty Corporation Inc.	Science Ventures
Falco-Archer, Inc	Techtran
Others	
Stanford Research Institute	