TECHNOLOGY TRANSFER UNITS AND MARKETING OF UNIVERSITY TECHNOLOGY +

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This paper sets out the results of analysis of fifty-two units whose mission is to transfer technology that is generated in the public sector. The objective of the analysis was to provide information and knowledge aimed at facilitating the design of units for marketing patents and spin-offs by university authorities and innovation agencies in our milieu. This project was financed by the Catalan Autonomous Government's Centre for Innovation and Business Development (CIDEM).

Contents

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1. Introduction: University technology transfer

Universities, through the research activities carried out there, generate knowledge and results that the entrepreneurial milieu can turn to its advantage. This process of transference of knowledge and results from the public sector to private enterprise is known as technology transfer.[1]

Technology transfer operates through two main channels. In the first (technology pull), enterprises approach universities seeking solutions to their needs in respect of production. They ask those public research centres for experts to help them solve their production problems and provide substantial improvements to their products. In this case, it is a question of a problem for which a solution is sought. The types of technology transfer that fit into this "pull" category are the accomplishment of R&D projects commissioned by enterprises, the use of scientific infrastructure existing at universities and the supply of advice and consultancy services by university lecturers.

A different approach to technology transfer, which we will deal with in this article, is that of "technology push". In such an approach, an innovative lecturer pinpoints an opportunity in a technology for which there is, at the time, no clearly defined market. In fact, this is an approach that, depending on the potential of the technology, can give rise to a whole new market. In this case, therefore, it is the invention that is looking for a market. Consequently, it is the research institutions themselves that attempt to transfer to the market any results produced by undirected research that they believe might have some commercial value. The two types that fit into this "push" category are grant of licenses for university patents to industry and the creation of new enterprises promoted by the research institutions themselves, the so-called spin-offs.

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The university systems of the more advanced countries have adopted those approaches more or less progressively, from simpler to more complex, in the following stages: first of all, collaboration with enterprises on the basis of research agreements (pull), then marketing of research results on the basis of patent licenses (conventional license), and finally, support for enterprises created by the universities themselves with the aim of exploiting those patents directly (spin-

1 Obviously, technology transfer is an activity with a much broader conceptual scope. It includes the transference of technologies from producer to recipient, both of which are normally enterprises. In this article and in the context of its focus, the term is used strictly to refer to the transference of research results from the public sector to the world of business and the market.

offs). This last stage involves active and resolute implication on the part of the universities. In fact, it constitutes a function that, rather than transference, consists of marketing of technology.

2. Management of technology transfer and marketing

Knowledge is produced at universities by lecturer-researchers, who are normally grouped in research teams, and the promotion, management and marketing of that knowledge is the responsibility of what are known as technology transfer offices or centres.

In Spain, where the university research system and the corresponding support network for technology transfer are a much more recent development, at least in terms of their current dimensions and activities, the three progressive stages of adoption of the different approaches to technology transfer have not been so clearly defined. In fact, we have gone directly to the third stage (spin-offs) without having made any substantial use of the second (patents).

Technology transfer centres in Spain are known as *Oficinas de Transferencia de Resultados de Investigación* (OTRI). As a rule, they are units with a wide range of functions. On the one hand, they administrate the main source of financing of university research, namely grants from the European Framework programme, the Spanish national R&D plan, the regional governments' different research programmes, foundations, and so on. In that respect, the OTRIs' role is basically to inform researchers as to available opportunities and the corresponding calls for applications, provide them with advice on how to apply, and manage outlays and subsequent justification of the funds obtained. From that standpoint, they function as research management offices.

In addition, OTRIs are also responsible for the promotion and management of the transfer of the knowledge and results obtained through research. Until quite recently, Spanish universities had made use only of the "pull" approach (agreements with enterprises). Now, patent license agreements and creation of spin-offs are gradually gaining ground, particularly the latter.

The management of each of these approaches to technology transfer, namely "pull" and "push", involves a specific set of characteristics and problems. The "pull" function basically requires promoting and administrating relations between the enterprise and the corresponding research team. In that connection, the technology transfer offices perform the task of dissemination of the potential of their institution's research groups, promote encounters between the university and private enterprise and manage the relations that are established, executing agreements, applying for government funding for agreed projects, and so on. The efforts of the technology transfer offices are remunerated through charge of a percentage of the price of the transaction between the enterprise and the research group.[2]

2 Universities provide a part of the financing required for the operation of their technology transfer offices. However, since they are expensive undertakings, university management bodies require them to contribute at least a portion of their own budgets. Consequently, university technology transfer units everywhere are business oriented and charge for their services in one way or another. In the case of research agreements between research groups and enterprises, the charge normally consists of a percentage of the price of the transaction, in the case of patent licenses it will be a percentage of the royalties, while with spin-offs it is usually a stake in the company's share capital.

The "push" approach entails marketing. In that connection, technology transfer offices 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 them.

Lastly, technology transfer offices 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 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.

We see, therefore, that there is such a substantial difference between the functions and logistics involved in the two main approaches that in other countries the responsibility for management of each of the different technology transfer routes lies with separate units within the same university. Specifically, for example, in the English-speaking world the different types of university units operating in this area include the following:

- Industrial liaison offices, dedicated to promoting relations between the university and private enterprise (commercial function).
- Research offices, also sometimes known as contract and grant offices or sponsored research offices, dedicated to managing government grants to researchers and agreements with enterprises (administrative function).
- Technology transfer offices, whose mission is market technology through patent license agreements, whether to existing enterprises (conventional licenses) or through newly incorporated technology-based enterprises (spin-offs) (marketing function).
- Entrepreneurship centres, dedicated to fostering entrepreneurial culture, giving courses on creation of enterprises, organising investment forums and seminars and competitions for entrepreneurial concepts, providing support for entrepreneurs in drafting their business plans, and so on (awareness function).

American universities have long been the leaders in the area of technology transfer. Those institutions have always been dynamic and carried out research in collaboration with industry. In addition, they have been very active in connection with public technology patent licensing (conventional licenses), particularly subsequent to the promulgation of new law in 1980 (the Bayh-Dole Act). In recent years, spin-offs have also emerged as another alternative for technology transfer (although to a lesser extent than in other countries). The type of unit that supports spin-offs is different from the type that promotes patent licensing, since they are in fact technology marketing units.

We see, then, that the concept of the public-sector organisations that manage technology transfer is currently in flux. The process began

with the offices dedicated to managing the R&D contracted by enterprises, which were then joined by patent license agreement units, and now by technology marketing units.

3. Problem, aim and method

At present in Spain, both at the level of the central government and that of agencies and offices of the regional governments in charge of steering policy on innovation, there is a desire to augment the transfer of the results of publicly-funded research 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 marketing of technology generated by research at universities by means of patents and spin-offs.

Within that framework, the Catalan Autonomous Government's Centre for Innovation and Business Development (*Centre d'Innovació i Desenvolupament Empresarial* - CIDEM) of the Department of Labour and Industry, commissioned a project for design of a single unit to serve various universities simultaneously. Within the framework of that project, a study was made of how technology transfer and marketing is organised in different countries. In this article we set out the results of that study.

First of all, the project made use of information available on the Internet to study fifty-two university technology marketing units and research centres in various countries. This study also included units operating from the private sector as intermediaries between universities and enterprises. Then, the people in charge of those units were contacted 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 marketing of research results at universities and other public centres producing knowledge is managed through patents and spin-offs, identify the different models of units and discern the factors that influence the definition of those models.

The project did not attempt to obtain statistical results through application of a scientific methodology. Consequently the choice of the units studied was made on the basis of each unit's known activities in the field of technology transfer. Various sources were used for identifying the units and determining their activities, namely bibliographical references (which also allowed contextualisation of the milieus in which the units operate), presentations of transfer units made at conferences, national and supranational technology transfer associations,[3] and so on.

The units studied are located in the following countries:[4] the United States, the United Kingdom, Switzerland, Sweden, Germany, the Netherlands, Italy, Belgium, France, Spain, Canada and Israel. Those units are listed in Table 1 below, grouped according to the different types identified in section 4.2.

3 For example, associations such as ASRC, ASTP, AURIL, AUTM, EARMA, EARTO, LES, PROTON, TII, UNICO, etc.
4 In numbers varying greatly from one country to another; for instance, in the cases of some countries, only one unit was studied.

Table 1
List of the fifty-two technology tranfer units studied

UNITS SERVING ONE UNIVERSITY	
Universitaty of California	Office of Technology Transfer (OTT)
University of California - Berkeley	The Office of Technology Licensing (OTL)
University of California – Los Angeles (UCLA)	Office of Intellectual Property Administration
Massachusetts Institute of Technology (MIT)	The Technology Licensing Office (TLO)
Stanford University	Office of Technology Licensing (OTL)
University of Wisconsin - Madison	The Wisconsin Alumni Research Foundation
Harvard University	Office for Technology and Trademark Licensing
Virginia Polytechnic Institute and State University	Virginia Tech Intellectual Properties, Inc.
Columbia University	Science and Technology Ventures (S&TV)
University of New Mexico	Science and Technology Corporation
Pennsylvania State University	Tech Transfer
Michigan State University	Office of Intellectual Property (OIP)
University of Michigan	UM Tech Transfer
University of Washington	UW Tech Transfer
Oxford University	Isis Innovation, Ltd.
University of Manchester	Manchester Innovation, Ltd.
University of Manchester Institute Science-Technology	UMIST Ventures
Imperial College of Science, Technology and Medicine	Imperial College Innovation, Ltd.
University of Warwick	Warwick Ventures
University of Bradford	Ventures and Consultancy Bradford, Ltd.
University of Sheffield	Sheffield University Enterprises, Ltd.
Simon Fraser University	University/Industry Liaison Office (UILO)
University of Alberta	TEC Edmonton
Université Joseph Fourier (Grenoble)	*UJF - Industrie*
Université de Génève	*UNITEC*
Katholieke Universiteit Leuven	K. U. Leuven Research & Development
Technion Israel Institute of Technology	Dimotech, Ltd.
Universitat de València	*CTT*
Consejo Superior de Investigaciones Científicas (CSIC)	*Oficina de Transferència de Tecnologia (OTT)*
Politecnico di Milano	Technology Transfer Center
UNITS SERVING SEVERAL UNIVERSITIES (SELF-PROMOTED)	
Washington State Public Universities (EUA)	Washington Research Foundation (WRF)
Universities of Zurich and Berne (Switzerland)	Unitectra
University of Calgary (and other Canadian universities and centres)	University Technology International, Inc.
UNITS SERVING SERVERAL UNIVERSITIES (GOVERNMENT-PROMOTED)	
North Rhine-Westphalia Universities Group	*Provendis*
Baden-Würtemberg higher learning institutions	Technology Licensing Bureau (TLB)
Spanish research units dealing with genomics	*Fundación Genoma España*
Network of seven foundations promoted by Sweden	*Teknikbrostiftelsen*
COMMERCIAL ENTERPRISES	
Zernike Group	
British Technology Group (BTG)	
Research Corporation Technologies (RCT)	
Angle Technology Group	
Competitive Technologies, Inc.	
Drug Royalty Corporation, Inc.	

COMMERCIAL ENTERPRISES
Falco-Archer, Inc. UTEK Corporation UTEK-Pax, Ltd. University Medical Discoveries, Inc. MedInnova Partners, Inc. MedTech Partners, Inc. Science Ventures Techtran
OTHERS
Stanford Research Institute

4. Results

The results of the study comprised, in the first place, 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.

4.1 Prevailing views on technology transfer

This study has pointed up the following overall notion: the concept of marketing of university technology is a global one. In conceptual terms, there is scarcely any difference between countries insofar as regards objectives, systems and procedures used for marketing the results of university research. Furthermore, it could be said that the slight differences that do exist between different 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 variations in the approaches followed in different countries in the transfer and marketing of university technology. Those slight differences are the logical 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 those different ways of approaching the same concept.

Marketing of university technology as it is seen in the United States

Contrary to what is generally believed, it is clear that the American model for marketing research results 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 with industry and the system is highly vigilant of compliance with the regulations applied by the institution to such 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" marketing 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.[5]

In any event, the reactive view of spin-offs as a vehicle for technology transfer is clearly held at important institutions in that country. The following are a few examples.

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),[6] with its central structure and decentralised units, provides services to the system's researchers. It has some sixty professionals who are sectorised by area of knowledge. At the middle of 2003, the OTT had a portfolio of 5,948 inventions and 2,753 patents. That same year, the Office received 1,027 notices of new inventions (70% of which were in the field of life sciences) and applied for 323 new patents in the US and 423 internationally. In respect of marketing, in 2003 it executed 325 patent license agreements and obtained $81.3 million in revenues from royalties. The OTT has executed a total of 1,356 patent license agreements.

The MIT Technology Licensing Office (TLO) markets technology through two channels, namely license agreements and creation of spin-offs. Nevertheless it gives priority to patent license agreements.

Insofar as concerns spin-offs, one fact is particularly revealing of the attitude and approach on the part of the University of California to such initiatives: where an enterprise of this type is chosen to market a technology developed at that university but the OTT considers that the institution will not obtain an appropriate return on the

5 SANDELIN (2003a and 2003b). See also AUTM's website: http://www.autm.net/index.cfm.
6 The University of California's website can be visited at: www.ucop.edu/ott.

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 cannot 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 body of the institution.

Massachusetts Institute of Technology (MIT)

This institution has a yearly research budget (including funds from public and privates sources) of around $500 million. Its Technology Licensing Office (TLO),[7] with a staff of some thirty employees, has a portfolio of over one thousand patents for the United States and each year it receives approximately 400 notices of new inventions, applies for around one hundred new patents and executes some 90 license agreements.

The MIT TLO markets technology through two channels, namely license agreements and creation of spin-offs. Nevertheless, like all other technology transfer offices of American universities, it gives priority to patent license agreements. Just 20% of licenses are granted to spin-offs, while the greater security of established enterprises is sought for all the rest. In addition, MIT does not provide incubation space for its spin-offs and does not allow them to be established at its laboratories. The TLO provides spin-offs with very few support services: it does not help them to draft their business plans, or provide assistance in training the management teams of the new enterprises, or contribute investment capital.

When the TLO grants licenses to spin-offs, it normally acquires shares in those enterprises, as an alternative to royalties. As a rule, MIT acquires a small stake, but, depending on the technology being marketed, that stake is not diluted in the first round or first two rounds of incorporation of share capital. The TLO takes no part in management of such enterprises and does not hold a seat on their boards of directors. MIT lecturers can obtain stakes as large as they wish in the spin-offs that they promote, but researchers who own shares in a spin-off cannot enter into research agreements with that enterprise. In addition, the acquisition of shares in spin-offs by the institution must be authorised by the academic department.

Harvard University

The Office for Technology and Trademark Licensing (OTTL)[8] is the unit responsible for marketing the results of research at Harvard University. The OTTL has sixteen professionals who work both through conventional licenses and spin-offs. Between 1980 and 2003 it provided support to

7 Website of the MIT TLO: http://web.mit.edu/tlo/www/.
8 The name was changed in 2005 to Office of Technology Development (OTD). The website of the OTD of Harvard University is at: http://www.techtransfer.harvard.edu/.

fifty-five new enterprises. Here, only 3% of licenses have taken the form of spin-offs. In 2003, the OTTL received notices of 118 new inventions, applied for fifty-four new patents for the United States and executed sixty-eight license agreements, which provided it with $24 million in royalties. Also in 2003, the institution created five new spin-offs and acquired shares in two of those enterprises.

The policy of Harvard University is to own a minority share in spin-offs, generally under 15%. Furthermore, that stake is progressively diluted as further capital is obtained. In fact, it is not the institution itself that owns such shares, but rather an intermediary company, namely Harvard Management Company (HMC). The university does not wish to form part of the boards of directors of spin-off companies in which it holds shares. If lecturers wish to acquire shares in a spin-off, they must apply for permission and abide by the regulations established in the institution's Conflict of Interest in Licensing Policy.

The OTTL is not particularly active in the field of spin-offs. Nevertheless, as is common in the English speaking world, Harvard University has a centre that promotes entrepreneurship, the Technology and Entrepreneurship Center (TECH), whose mission is to educate and train entrepreneurs. It offers training, networking, mentorship, space and assistance in drafting business plans.

Stanford University

The Office of Technolgy Licensing (OTL) of Stanford University was created in 1969. It has a staff of some thirty professionals who handle over 1,300 technology transfer dossiers. By 2003 the unit had examined approximately 5,000 notices of inventions and executed around 2,000 license agreements. Of those agreements, approximately one thousand are still in force at present. The office receives five or six notices of new inventions each week, patents half of those and places about 30% on the market. In 2002, the OTL executed 110 license agreements. However, of the 385 inventions that generated revenues that year, only forty-two produced over $100,000 (in aggregate). It is estimated that only one of each 4,850 inventions is what is known as a "big winner". In the entire history of the OTL, only thirty-one cases of licensed technology have generated total royalties of over one million dollars.

Insofar as concerns spin-offs, in 2003 Stanford University held shares in sixty-six enterprises. The financial return obtained on those shareholdings totalled $22 million, which was provided by fifteen enterprises. The most successful transactions were Abrizio (acquired by PMC-Sierra), generating revenues of $10 million for Stanford University, and Amati (acquired by Texas Instruments), generating $8 million. Three quarters of Stanford University's spin-offs have been incorporated in the past five or six years.

The OTL's approach in connection with spin-offs follows the same lines as already outlined for the American university system. When a lecturer creates an invention and wishes to exploit it through a spin-off, the first step is to analyse any conflict of interest that might affect that lecturer. Then, before a license is granted to the spin-off, the technology is presented to other players who might be interested in marketing it. Lastly, if no preferable opportunity is found, the spin-off is asked to submit a viable and credible marketing plan. When the terms of the agreement between the spin-off and Stanford University are established, the OTL recommends that the lecture delegate an expert to handle the negotiation and

that they do not personally undertake the negotiation of the terms of the agreement.

Stanford does not promote entrepreneurial culture. The OTL states textually that it is privileged to operate in a highly entrepreneurial milieu and that, consequently, Stanford University does not need to promote entrepreneurial culture among its lecturers or students.

Approach to marketing university technology in Europe and Canada

United Kingdom

Unlike the situation in the United States in the area of technology transfer described above, there has been clear trend in recent years in the United Kingdom to a preference for 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.[9] In any event, technology transfer units in the United Kingdom provide substantial support for the marketing process. They are highly proactive and take a very direct role in entrepreneurial projects. The support network is not limited to the marketing units. Programmes such as the University Challenge Seed Fund Scheme are a good example of the government's commitment in this regard.

In addition, marketing 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 bio-technology 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 the opinion of the authors of this article, one of the latest stages in the evolution of the process of management of university technology transfer, namely Techtran, a company whose mission is to market the research results of Leeds University.[10]

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 the worldwide level. In fact, American universities are also steering their development in the same direction.

A good example of this model is Isis Innovation, the technology transfer unit of 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. In 2003 the university had 3,700 lecturer-researchers and 5,000 doctoral students. Outside funding for research amounted to £228 million for the 2002–2003 academic year.

Oxford University created Isis Innovation in 1988. It is a private company owned by the university and its mission is to manage lecturer consultancy and patent licensing programmes and support for spin-offs.

The key figure in the structure of Isis Innovation is the project manager. These are professionals whose profile is based upon two fundamental

9 LAMBERT, 2003.
10 See below, in section 4.5.

characteristics: they must understand research and consequently must hold a doctorate, and they must also understand the technology marketing 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.

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 marketing the results of public research 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.[11] Thus, the situation was similar to that in the United States prior to enactment of the Bayh-Dole Act 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 support for technology transfer. 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.

Technology transfer units in the United Kingdom provide substantial support for the marketing process. They are highly proactive and take a very direct role in entrepreneurial projects.

At present, German universities can acquire the rights to inventions generated by their lecturers. In February 2002, a new patents law provided that researchers must give notice of their inventions to the institutions where they work and the university can either claim intellectual property rights (in exchange for the corresponding financial consideration) or assign those rights to the researcher.

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. On the other hand, there have been initiatives by the state in that direction, namely the Teknikbrostiftelsen or Technology Link Foundations.

11 ROURE *et al.* (2005), p. 34.

Lastly, in Canada each university establishes its own policy in respect of ownership of research results.[12] At some institutions researchers own their results, while at others their results are owned by the university. In any event, 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 marketing technology generated by the public sector have emerged.

4.2 Types of technology transfer units

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 government 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 university.
6. A model marketing 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 marketing 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 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 London's Imperial College, Sheffield University Enterprises Ltd. (SUEL) at Sheffield University, and Ventures & Consultancy Bradford Ltd. (VCB) at Bradford University.

The second group, of which only three units were studied, 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 Technology Link Foundations.

The fourth group is made up of private enterprises operating on the market as intermediaries with a clear profit motive. Examples of this mo-

12 OECD (2002), p. 51.

del in Europe include Zernike Group in the Netherlands and 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 classed as a university at all.

4.3 Private technology transfer enterprises

It is possible to distinguish between types of private enterprises operating in the area of transfer of public technology, depending on the orientation and strategic approach and their business models: supply, demand and services.

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 operation can be summed up as the search for worthwhile technologies and the accomplishment of actions to place those technologies on the market.

A highly representative example of this 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 marketing public research. In 1975, the British government created the National Enterprise Board (NEB) to provide support for the private sector and channel resources to the manufacturing industry. Not long 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 was privatised, and in 1995 it was listed on the London Stock Exchange.

It is possible to distinguish between types of private enterprises operating in the area of transfer of public technology, depending on the orientation and strategic approach and their business models: supply-driven, demand-driven and service-driven.

At present, the enterprise operates mainly in the United States, Japan and the United Kingdom. It has also carried out transactions in Spain. In 2004 it had 170 employees and a portfolio of 280 technologies protected by 3,800 patents. On the basis of that portfolio, it was able to exe-

cute hundreds of license agreements and create some thirty technology-based enterprises.

That same year, it acquired thirty-four new technologies from different research centres, invested £5.4 million in new enterprises and executed seventeen new patent license agreements. BTG applies a highly demanding process for selection of technologies. In 2004, it identified 700 technologies, of which it only eventually studied half, while the rest were ruled out after a rapid initial assessment. Of the remaining 350 technologies that it did study, only the aforementioned thirty-four went on to form part of its portfolio, representing approximately 5% of the technologies originally identified.

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 Britain. 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). That 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 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. Even so, from 2001 to 2003 the company returned losses for three consecutive years, although its performance in 2004 suggests a recovery.

UTEK is another demand-driven enterprise, although it follows a different approach. First of all, UTEK executes a strategic agreement with an enterprise and then familiarises itself with that enterprise's business and 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.

Service-driven

In many of the units of both the types discussed above, services also play an important role in the generation of revenues. What is more, some units have made services into a core element of their businesses. Such is the case, for example,

with the Netherlands enterprise *Zernike*, whose line of business consists of the management of technology parks and business incubators and the supply of services to such structures. This is also the case with the British enterprise Angle Technology, which is very active in its consultancy business in respect of actions to foster economic development.

4.4 Failures

It would not appear to be easy to operate in the area of public technology transfer from the private sector. Very few enterprises are found in this field of endeavour and assuring their survival is a complex task. We have already mentioned that Competitive Technologies Inc., a company that was founded in 1968 and has been listed on the American Stock Exchange (AMEX) since 1971, recently returned losses for three years running.

An even more extreme example is that of the British company Science Ventures, which was a clear failure in this line of business. At the beginning of 1998, the University of Glasgow created a new in-house unit in the Department of Research and Business with the aim of stimulating the marketing of the university's research results. The institution's efforts and enthusiasm were commendable. A budget of £5 million was provided for the first three years of operations, a manager was hired externally for the new unit and they were given total liberty to recruit and hire a team of a dozen professionals for the field of business consultancy. During its first years of operation the new unit scored some important successes, including the spin-offs Kymata, Intense Photonic, Actis, QT Opto, Chariot and Crusade Laboratories, and the University of Glasgow obtained huge revenues from the sale of its shares in those companies. In addition, the team implemented a new approach to marketing the institution and led such programmes as the Scottish Enterprise's Proof of Concept Fund. The unit thereby succeeded in establishing a high profile and great prestige, including on the international scale. In 2000 it even opened a branch office in Silicon Valley, the first of its kind to be opened there by a European University.

It would not appear to be easy to operate in the area of public technology transfer from the private sector.

In a spiral of dynamism, the university and the director of the unit decided to take advantage of what appeared to be a market opportunity. On that basis, in 2001 they founded Science Ventures. That enterprise did not have the mission of managing the transfer of technology created at the University of Glasgow. It was not an externalisation of the transfer function along the lines of Isis Innovation at Oxford,[13] since the internal unit continued to perform its functions in that connection. Instead, it was a total privatisation, a creation of an enterprise that had to try to take advantage of an opportunity in an industry that was highly dynamic at the time. Science Ventures was to seek clients among other research institutions.

13 Isis Innovation is a private enterprise, but its purpose is not the generation of income. Isis Innovation is wholly owned by the University of Oxford and it receives a sizeable financial yearly contribution from that institution. Consequently, it represents a model of externalisation of management rather than privatisation.

However, the reality of the situation did not conform to the initial plans. For a variety of reasons (the most important apparently being the bursting of the technology bubble, which led to a drop in the forecast number of spin-off projects), the enterprise failed to achieve the expected level of activity, went bankrupt and was forced to close in August 2004. This case is a perfect illustration of the difficulties that arise in the area of private transfer of public technology.

4.5 Collaboration with investors. A future model for management of public technology transfer?

British universities are very active in their collaboration with the private investment sector. This type of collaboration could give rise to a new model for the management of public technology transfer. The most notable example of this is to be found at the University of Leeds. That institution has traditionally been very active in the area of technology transfer. In 1970, it was the first university in the United Kingdom to create an external enterprise, Leeds Innovations, dedicated to the management and promotion of that activity. It was also the first university to establish a collaborative venture with an external investment entity to provide funding for researchers. In addition, in a joint effort with the universities of Sheffield and York, it obtained the most substantial support within the framework of the government-financed University Challenge Fund.

Taking those efforts a step further, in 2002 the university commenced a new phase that defines a different model for marketing the results of research at the institution, which consisted of entrusting its activities in the area of management of technology transfer to the private sector. Thus, Leeds Innovations no longer exists and the University of Leeds now works with the external enterprise Techtran Group Limited, founded in 2002 by Axiomlab Group plc with the aim of providing that university with external services for marketing of research. In addition, the university has created an internal office whose mission is to protect the intellectual property rights to its technologies. That unit acts as liaison with Techtran. The inventors, the university and Techtran all have shares in each new spin-off enterprise and share the revenues from license agreements. Another investment company specialising in the marketing of university technology, IP2IPO Ltd, recently acquired a stake in Techtran, namely 20% of its shares, in return for a contribution of £2 million.

IP2IPO Ltd is an enterprise whose corporate purpose is to establish long-term agreements with universities and other research centres. IP2IPO Ltd has executed agreements with several universities in the United Kingdom, for example the University of Southampton through its Centre for Enterprise and Innovation (CEI). That university holds stakes in its spin-offs through the company Southampton Asset Management Limited (SAM). In March 2002 IP2IPO created a seed capital fund of £5 million earmarked for those spin-offs. In exchange, it received a 20% stake in Southampton Asset Management Limited. In addition, IP2IPO works closely with CEI (an employee of the company is a member of that centre's permanent staff) to identify and facilitate the development of spin-offs at the institution.

IP2IPO also works in collaboration with Oxford University. In 2000 that university executed an agreement with IP2IPO under which the company contributed £20 million for construction of a new research building for the Chemistry Department with a total cost of £60 million. In exchange

for its contribution, IP2IPO received a half share in Oxford University's rights to stakes in all the spin-offs originating in that department in the next fifteen years.[14]

4.6 Considerations for design of a technology marketing unit

Research critical mass

One of the issues that must be of concern to any organisation that promotes a university technology marketing unit is the existence of sufficient body of research. We will now look at some of the figures relating to this issue. The 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).

The examination of figures for the United States shows that $2.5 million is invested in sponsored research at American universities for each invention that is generated.[15] Half of those inventions are patented by the corresponding technology transfer offices. This means that $5 million are invested for each patent. Only one of every 1.8 patents is eventually the object of a license agreement. An average of $12,000 in legal fee is spent on each invention. One spin-off is generated for each $100 million invested in research. Only one of every 30 to 40 inventions leads to a spin-off and only one of every 15 to 20 patents is licensed through a spin-off.

Figures for the United Kingdom for 2000 show that British universities executed 648 license agreements and generated 158 spin-offs. Those same universities applied for one patent for each £2.4 million of external research funding (some €3.6 million) and generated one spin-off for each £8.6 million (some €13 million).[16]

The overall figures for Spanish universities for 2003, provided by their network of research results transfer offices (OTRI) as follows:[17] the vo-

Table 2
Indicators relating to generation of patents and spin-offs in four different university milieus: USA, UK, Spain and Catalonia.

	Million dollars	*Millions euros*		
	USA	**UK**	**Spain**	**Catalonia**
R&D investment to generate one patent	5	3.6	1.9	2.6
IR&D investment to generate one spin-off	100	13.0	6.6	4.4
Ratio of spin-off 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-offfs 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.

14 CONDOM, 2003.
15 AUTM (several years) and own data.
16 CHARLES & CONWAY, 2001.
17 REDOTRI (2004), figures for 2003.

lume of external funding for research amounted to €579 million; applications were submitted for 304 new patents, 107 of them at the international level, 78 license agreements were executed; €1.7 million in royalties were obtained; and 87 new technology-based enterprises were created. In short, €1.9 million were invested for each patent and €6.6 million for each spin-off.

As for Catalonia's ten universities,[18] the figures for 2003 indicate that the total volume of funds managed by technology transfer centres amounted to €168 million, 65 patents were obtained and 38 spin-offs were created.[19] That means one patent for every €2.6 million of external funding for research and one spin-off for every €4.4 million.

Table 2 compares the figures for those different geographical areas.

Those 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 marketing 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). Those offices cannot reasonably be expected to perform better unless funding for R&D is increased.

Personnel required for technology transfer units

MIT, with a staff of 34 and 454 inventions (figures for 2003), needs one person for each 15 notices of invention. Oxford University (also figures for 2003), with 65 patents and 34 employees, requires one person for each 2 patents. No information is available for that institution in respect of notices of inventions, but in any event we can safely assume that, as in the United States, half of the inventions are patented. This would mean that one person is required for each 4 inventions. That ratio is very different from the one for MIT, but no active support is provided there for spin-offs as is the case at Isis Innovation. Table 3 shows further information for America.

Table 3
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 licences	New licences-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.

18 No figures are available for the International University of Catalonia (*Universitat Internacional de Catalunya* – UIC). Figures for the Catalan universities are included in the overall figures for Spanish universities.
19 OITT-UDG, 2004.

Table 4
Ratios between staff members and activities, expressed as the number of new patents, at Spanish and Catalan university technology transfer offices (figures for 2003)

Institutions	Total staff	New patents	Patents per staff member
Catalan universities	219	65	0.29
Spanish universities (not including Catalonia)	257	239	0.93

Source: OTRI, 2004.

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 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 with 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 has 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 salaries for experts at technology transfer offices (project managers) at between €60,000 and €90,000, depending on the different situations, including employers' contributions.

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

Profile of technical staff at units

The profile of technical staff at this type of office is the same in all cases, namely professionals with experience in the area of research (often holding a doctorate) and also experience in the world of business, whether in industry or consultancy.

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.[20]
- 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

20 This same approach is recommended in TANG *et al.,* 2004.

unrealistic to expect results until after the marketing office has been operational for at least five years (or even longer.

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,[21] 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.

21 CEI at Southampton is not included in the study set out in this article. This reference is from CONDOM (2003).

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