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Opportunity recognition in technology transfer organizations

Five case studies from UK and Italy

Chiara Franzoni

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Abstract The task of recognizing valuable technological opportunities is crucial for the organizations in charge of transferring technology from universities and publicly funded research institutes to the market. Difficulties in understanding the true commercial potential of an application result in failed subsequent commercialization and excess costs of technology transfer. This paper describes how the task of opportunity recognition is performed in five Technology Transfer Organizations (TTOs). The analyzed TTOs had different degree of independence to the structure of the parent and make use of information and competencies acquired through their formal and informal network ties.

Keywords Technology Transfer Organizations · Academic Patenting · Opportunity recognition

JEL Classifications O3 · L2

Organizing technology transfer

This work aims at contributing to the understanding of the mechanisms of technology diffusion from science to market by looking at the intermediate actors that are in charge for making knowledge transfer effective. These actors are Industrial Liaison Offices, Campus Ventures, Offices for Technology Transfer, and so on, which in the following will be more generally referred as "Technology Transfer Organizations" (TTOs).

TTOs acts as an intermediary between the Faculty members, which are expected to produce inventions and disclose them, and the firms or other potential investors in the high-tech market, which are interested in acquiring the technological assets. The

C. Franzoni (✉)
CERIS (Istituto di Ricerca sull'Impresa e lo Sviluppo)-CNR, Via Real Collegio 30, Moncalieri (Torino) 10100, Italy

job of TTOs ranges from the receipt of disclosures to the commercialization of technological assets and normally consists of screening of prior-art, filing patent applications, licensing, procurement of research sponsorships or other research agreements with firms, and sometimes comprises the creation of spin-off companies and their incubation or early growth, including taking equity positions.

Although exchanges and interactions between science and industry have always occurred, perhaps in a less visible way, only in the latest years the policies of universities for the transfer of technology have become deliberate. The creation of dedicated units for technology transfer is just the most visible of the actions taken in this direction.

In the USA, the creation of dedicated TTOs internal to research universities has became more and more common during the 1970s and 1980s and after the Bahy–Dole Act, as opposed to the previous period, when the management of Intellectual Property Rights (IPRs) was mostly delegated to external institutions, acting on behalf of many different universities, such as the Research Corporation (Sampat & Nelson, 1999). In Europe, a considerable attention was given to the commercial activities of universities by the national and local governments, which sow technology transfer as a way to sustain the competitiveness of national industries. In Italy, the interventions of policy makers in this field were mostly inspired by concern of regional development and have very often focused on the creation of Incubators and Science Parks around the universities or in critical regions. In the UK, a regulation similar to the Bahy–Dole Act, which assigned the IPRs of publicly sponsored research to the universities, was introduced in 1984. Besides, many actions planned for universities were inspired by the idea of filling the funding gap in the market for innovation and were aimed at encouraging the research institutions to take equity positions in high-tech ventures. For instance, the University Challenge Fund scheme, launched in 1998 (and later repeated in 2001), devoted over 60 million of British Pounds to finance universities initiatives and resulted in the creation of 15 seed funds companies owned by all the major UK research institutions.

This extensive policy intervention have considerably contributed in shaping the characteristics of the TTOs, which vary significantly from one experience to the other, with regard to their focus of intervention, their mission, their relationship with the university administrations and faculties.

Broadly addressed, the critical task of TTOs can be seen as one of providing coordination in the market for technological opportunities and innovation. The problem with coordination of demand and supply in this market has been the focus of an impressive stream of literature, which have stressed the public good characteristics of innovations (Arrow, 1962) and the uncertainty of high-tech investments (Nelson, 1959). The intermediaries that operate in this market have to cope with several major problems. A first problem relates to assessing the market value of a technological asset: for technologies with a strong knowledge-base, especially those that have been developed outside the commercial sector, the market applications may not easily be found. The inventors themselves fail in seeing potential applications or find it hard to communicate them to the investors (Martin & Scott, 2000). Additionally, the closer is the technology to the state-of-art; the higher is the asymmetry of information between the inventor and the potential investors, which raises the expectations of opportunistic behavior. A second problem consists

in the limited appropriability of the innovations, which, from the one side, requires the establishment of IPRs in the form of patents to enable transactions and, from the other, obliges the inventor to get involved in the process of technology development.

Consistently with this, TTOs perform extensive search of innovations and technological opportunities within the pool of new knowledge developed in the research departments of their parent institutions and designs around this technological core a product or a business idea capable of capturing its market value. This process is not just abut searching for innovations in the knowledge base of research departments, but is about contextualizing the technologies within profitable market applications by matching technological solutions and market needs. Moreover, effective transfer of technologies requires the selection and design of an appropriate ownership structure to organize the development of products and sell them, for instance a research joint venture, a new company, or a patent licensed (see Bray & Lee, 2000; Feldman, Feller, Bercovitz, & Burton, 2002).

In the present study, the activity of TTOs of searching for valuable technological applications and designing a viable route to deliver those applications in the form of tradable products and goods is addressed as that of "opportunity recognition." In the economic literature, "opportunity recognition" is described as a distinctive entrepreneurial skill, which leads from the research phase to the framing of a business idea (Vohora, Wright, & Lockett, 2004). High performances in opportunity recognition derive from the posses of idiosyncratic information and knowledge, for instance in the form of superior understanding of a technology or a market need (Shane, 2000).

This paper aims at increasing our understanding of how universities and research institutes that are extensively funded by public money can perform the job of opportunity recognition, which enables bridging technological solutions and market needs. In order to do so, an in-depth analysis was conducted on five TTOs operating in UK and Italy. Central to the analysis is the way TTOs organize their activities to reach this end, namely how do they search for technological opportunities within the research departments, evaluate their market potential, take decisions on whether or not to invest in a technology and if so, set the steps to achieve the commercialization.

The case studies allow identifying some of the organizational variables affecting the effectiveness of opportunity recognition and technology transfer activities (Siegel, Waldman, Atwater, & Link, 2003a). It suggests that TTOs organize their activities in various ways and that a critical issue is their capacity to access and make use of valuable information and competencies. Besides, the more integrated a TTO is to its university's research departments, the easier is the circulation of information and the share of competencies, which enable better opportunity recognition. Some insights for the effective management of technology transfer will be suggested.

Methodology

The information presented in the following paragraph have been collected by interviewing extensively the personnel working in three UK and two Italian TTOs, in charge of transferring the results of universities and other publicly funded institutions: the University of Cambridge, the University of Manchester, the UMIST, the San Raffaele Hospital Foundation and INFM–INSTM–CSGI (three large

networks for hard sciences and engineering operating in Italy). These institutions have all an established reputation for research in some of the key areas having the highest potential for producing technological applications, namely Life Sciences, Chemistry, Physics, Computer Sciences, Engineering and New Material Sciences.

The TTOs described in the present section represent some of the most remarkable experiences in both countries in terms of the magnitude of the transfer activities performed and the results achieved. While choosing the case studies, some degree of excellence in technology transfer was needed because this kinds of activities are still considerable erratic in both targeted countries (see UNICO, 2003). Furthermore, so far, the universities that have performed comparatively better in the commercialization of technology have been generally those having also the most established reputation in research and teaching. Despite a strong political intervention and the considerable attention of the media, in the majority of universities, technology transfer activities are still very erratic and only the minority of institutions in both countries reached a critical mass that is worth studying.

Although the small number of cases presented in this study does not advise any generalization of the results, it is withstanding that the information collected pointed to a considerable degree of variance of TTOs in terms of organizational structure, implemented processes and relationships established with firms and with faculties.

In order to collect the information presented herein, a number of interviews were scheduled with selected members of the TTOs during the spring–summer 2003. The interviewed people were generally Project or Unit Managers and, depending on the size of organization, between two and four interviews were conducted, lasting from 15 to 105 min. The notes and materials collected in the interviews were then transcribed.

After a first contact with the target TTO, public information and available data were searched through the web and a draft of questions was sent to prepare for face to face meetings. Interviews were conducted in a semi-structured form. The staff was initially asked to give a general description of the activities of the unit and its position with regard to the central administration. Specific questions were then asked on the way they organized the reception of disclosure from the research units and the way they took decisions on whether or not to invest in a particular technology or business idea, for instance: how do they started to work around a technology, which information and aspects did they consider when evaluating to take up a project, who had the responsibility to take a final decision, how did they decide if filing a patent, start-up a company and so on. During the meetings, interviewed people were allowed to focus on aspects that they considered of special importance and examples were asked to illustrate the points they wanted to make.

Opportunity recognition in TTOs: Five case studies

For reasons of space, some general information on the TTOs studied, on their activities and policies have been summarized in Table 1. The content of the interviews that is relevant for the purpose of this study is presented in this section.

After a brief introduction, for each of the cases, the descriptions were organized into “disclosure” of technological opportunities and “investment decision,” in order

to highlight how those different key moments of opportunity recognition are performed by different organizations.

A summarize of the described processes is reported in Table 2.

UMIST Ventures Ltd. (UVL)

UVL is a TTO located in the city of Manchester within the metropolitan campus area. It was established by the administration of UMIST, with the purpose of helping the commercialization of innovations produced by its research departments. As opposed to the policies of almost all the British universities, UMIST does not claim IPRs on the results of its employees' work; hence scientists have no duty of disclosure to the university administration. Given so, UVL is meant to facilitate the commercialization of inventions for those scientists that require employer's assistance. At the time the interviews were made, UVL non-administrative staff was organized in three functional units, reflecting their main goals: 'Intellectual Property and Licensing,' 'Venturing and Spin-off,' and 'Collaborative Research and Contract Management.'

Disclosure The UVL staff interviewed reported that at the beginning of every academic year, a calendar of appointments for research auditing was scheduled, with the purpose to have an overview of the projects that were going on in the Faculties, remind about the services offered and give an opportunity for people to come to a first contact. As we asked, the UVL associates reported that, although this activity was producing good results, with on average one/two contacts immediately following each meeting, some cultural resistance from the members of the faculties was perceivable, both in the process of scheduling the meetings and in the actual participation of researchers. The idea of making a commercial use of research was still disturbing for many people in the departments, even though "younger people are definitely more interested in what we come to offer"—they said.

After a fist contact, scientists are asked to set an appointment and normally sign a confidential agreement, which aims at allowing a first full disclosure of the innovation, while protecting the prior-art, in the interest of the scientist. Interestingly, the interviewed staff reported that, at this stage, many scientists were concerned that their disclosure was kept confidential to their faculty, partially because of fear of circulating the results and partially because they did not like the idea of telling the colleagues about their intentions to use their research for commercial purposes. Clearly, the scientists knew that they had to refer the project to the chief of their department at some point, but they were concerned to do it as late as possible and only in case a final decision of filing a patent or funding was taken.

Decision to invest After a disclosure, UVL has to take further steps to decide whether or not the invention has some commercial potential and, if so, to make the scientist an offer on behalf of the UMIST, which might imply that they also think about what would be a viable option to commercialize the invention. The interviewed staff reported that, in order to do so, they firstly had a brainstorming

with the responsible of the unit, which served both to get a first appreciation of the feasibility and to plan some actions to be taken next.

The associates of the "IP and Venturing" group at UVL had all marketing and communication backgrounds and some of them held a degree in Biochemistry, Electronic Engineering and Physics. Although the innovations proposed involved sophisticated technical solutions, the interviewed staff claimed that evaluating the technical side of proposed technologies was normally not the key issue. As a matter of fact, they were considerably more concerned about the true and immediate commercial potential of an innovation. In order to get a feeling of that, what they usually did was contacting a bunch of firms which might have an interest and propose the invention under a confidential agreement. Potentially interested firms were selected either from the UVL network of established collaborations or among the contacts the scientist already had or was able to indicate, from her experience. They reported that a final decision of investment depended considerably from the interest manifested by firms in this first screening and that the information gathered was also helpful to set an action plan. The solution of promoting a joint research agreement with some interested firm was especially signaled by UVL as one giving good results, especially in the frequent cases that the technology needed further development. A joint research agreement gave the advantage of having a firm involved in the project from the beginning and generally encountered little resistance by the scientists.

Overall, the unit seemed to be run quite independently from the UMIST research departments. When we asked the staff if they used to gather information or consult people from the UMIST Faculties, they answered that they didn't. Moreover, they reported that in many cases they wouldn't be supposed to do so, as part of the non-disclosure agreement they use to sign with scientists. Only in few cases they reported to have made use of consultants to support their decisions, but only in later stages of development and to solve specific problems.

Cambridge Entreprise (CE)

Cambridge Enterprises was recently created by merging four previous organizations that variously dealt with technology transfer and university–industry collaborations within the University of Cambridge: Cambridge Technology Transfer Office, Cambridge Challenge Fund (in charge of the early finance of technology ventures), Cambridge Entrepreneurship Centre (in charge of continuous education on entrepreneurship and firm creation) and Cambridge University Technical Services Ltd. The merge was recently occurred at the time of the interviews, hence the personnel answered the questions largely on the basis of the set of guidelines and action plans recently developed, which largely reflected the best practices developed in the past experiences.

University of Cambridge excellence in research and teaching needs no presentation. Perhaps less known is that at the time this study was conducted, a major debate was going on for a reconsideration of the university policies in matters of professors' IPRs. This debate ended up in approving a rule that assigns the

ownership of IPRs to the university for all externally funded research,[1] but under a "fair use" policy, which put "the good of society," rather then profit, as the key goal of any commercialization of academic research.

Disclosure With regard to the search of opportunities and the process of disclosure, CE staff made a distinction between the innovations coming from the Faculties and those coming from their postgraduate students. For what concerned the faculties, CE staff was firm in replying that, as an internal policy, they did not do research scouting and search for disclosures. "We would never go around the departments, soliciting disclosure or fishing for innovation. Besides, we would never commercialize a technology if a professor gives a negative opinion." CE staff claimed that any scouting of technologies within the research departments would have been perceived as disturbing by the professors and that they preferred it was the scientist doing the first move. An additional source of disclosure they seemed to rely on was the business ideas proposed by the students in the MBA program offered by University of Cambridge, which is highly focused on Entrepreneurship. They reported that many students in their programs were particularly happy to work on business ideas, and the program did encourage them in doing so, helping them to establish contacts with people developing technologies and with business angels in the Cambridge area. CE just stood as a one of the possible partners in promising projects and their knowledge of the most promising students' projects was ensured by strong ties between the transfer unit and the centre for Entrepreneurial Studies.

Decision to invest Each business idea or disclosure received by CE is assigned since the beginning to one of the associates, who becomes the project manager. The goal of a manager is to develop a feasible idea and to formulate an evaluation of its potential in 4 weeks time. A feasible idea may simply be the file of a patent, in which case the manager is normally expected to outsource a prior-art screening and foresee a commercialization strategy, but it may also require working around the business idea or the product concept, including some technical development, market screening and so on. In this case, the manager generally builds up a network of potentially interested people and works at the development with them. If the final idea is feasible and the manager finds support to the idea, the informal network of people consolidates in a project team that will continue working at the development.

The dimension of the team and the role of the people involved vary from case to case, depending on the nature and on the complexity of the project. The team typically includes the professor or the would-be-entrepreneur and a number of people that may provide critical competencies or assets for the development of a project, as market experts, potential investors or managers of partner companies and so on. When asked about how they found those partners, CE associates said that, thanks to the reputation and to the rich network established around the University of Cambridge, they could rely on around 120 "mentors" willing to take a role in their projects. A full-size team for a complex project, for instance one that involves the

[1] But all IPRs of innovations produced as part of the normal employment agreements so far remained to the professors.

creation of a new venture, was described as having a member of CE staff, responsible for coordination, IPR protection and legal consulting, the inventor or a person having strong technical skills, an expert in company creation, as a business angel or a serial entrepreneur operating in the Cambridge area, and a professor from the Business School, serving as an expert of marketing or business finance. The ability of the manager of building the right group of people and the capability of those people were described by CE personnel as a crucial point for the success of the initiatives.

Manchester Innovation Ltd. (MIL)

Manchester Innovation Ltd. is a campus venture fully owned by University of Manchester (UoM) and it is located in the middle of Manchester campus area, in the same building that also hosts a campus incubator specialized in Biotech, which is hence one of its main areas of interest. MIL is in charge of managing the university's IPRs, under a policy of institutional ownership of professor's inventions, which UoM seems to enforce quite neatly. Professors are explicitly asked to refrain from all actions/behaviors that can prevent UoM from exerting its rights and to collaborate with MIL for all the operations that this may require.

The University of Manchester has excellent research ratings for a number of scientific fields that are fertile soil for innovation, like Life Sciences, Computer Sciences, Mathematics and Physics.

Disclosure The interviewed staff reported that MIL normally devotes a considerable amount of time and effort to organize a series of internal events and a scouting campaign which have the purpose of increasing the rate of disclosures of new inventions and establishing strong ties between the TTO and the Faculty. A newsletter was diffused periodically and several events were organized to circulate information on the ongoing projects and on the results achieved. The communications included success story telling and reports on the results achieved, which were described as having considerable influence on the propensity of the professors to enable the commercialization of research.

The staff also reported that it was crucial to them to establish some enduring collaboration with the personnel in the departments, especially with directors and other key people. The collaboration of the Heads of departments and their inclination to welcome the commercial activities was reported as crucial to enable a smooth collaboration between TTOs and faculty members. "Having a good talk with a Head of Department makes our job easier. [...]We keep in contact for updates on the projects and in many cases it was the Head of the department that rang us and said some of his guys came up with something or people came and said they were advised by their Head of department to come."

Decision to invest For what the implementation of projects concerns, MIL relied mostly on its internal personnel. The unit had five Business Development Managers in charge of the evaluation of technological assets, development, management and commercialization. Those managers had all a background in hard sciences, namely a Ph.D. education in Life Sciences, Chemistry or Physics and in some cases a

background or previous experience in business or an MBA and, as a general rule, they tended to assign the managers to projects according to their competencies.

The staff interviewed reported that, in many cases, the potential invention really needed some further development and laboratory experiments before any decision on the technology could be taken. The job of MIL in those cases was mainly that of defining a strategy for completing the experiments, which had to be negotiated with the professor.

In this case, if they believed in the potential of a project, they normally proposed to continue the development in the incubator's lab, which allowed postponing the decision of a larger investment to a later stage. In this case, the conclusion and exit from the projects often became the crucial issue. For incubated projects and startups, the staff reported that the success of a project in many cases depended on availability of a valuable "project champion," i.e., a person that believes strongly in a project and acted as an entrepreneur committed to bring a product on the market (see Franklin, Wright, & Lockett, 2001).

Rete Ventures Scrl (RV)

RV is a joint venture created by three Italian research institutions INFM (Italian Institute for the Physics of Matter), INSTM (Consortium of Italian Universities for the Science and Technology of Materials) and CSGI (Inter-university Consortium for the Development of Big Interphase Systems) to provide technology transfer services. Each of the partners that jointly own RV is organized as a small research institute that runs a no-profit network of research units and independent researchers hosted by or working within the research departments of state universities in Italy. Overall, the research units involved in the networks are nearly a hundred; they are spread all across Italy and specialized in the fields of Material Sciences, Engineering, Biophysics, Computing and Microelectronics.

RV was founded as a private company in 2000, but it largely inherited the experiences of a project internal to INFM, which later was spun-off and sponsored by other networks. The headquarter is now based in Turin, but two operative bases are also placed in Genoa and Florence. The commitment of RV is to offer technology transfer services to all members of the networks, including IPR protection, licensing and creation of ventures. According to the Italian law, the professors own all the IPRs of their research; therefore they do not have any duty of disclosure to their institution. They are allowed to patent and sell or license their IPRs in private negotiations to their universities, or they can negotiate directly with firms, although in case of profit they own their employer a compensation.[2] For these reason, it is very common for the professors that work frequently with firms to sign a standard clause in their contracts for sponsored research, assigning all IPRs to the latter. Giving so, only a few universities until recently have offered IPR services to their employees. Besides, for all non-sponsored research, it is often the case that

[2] This law was revised in 2004. In the new arrangement, the professor's privilege is confirmed, but the inventors of patents have a formal duty of informing their institutions. Additionally, the latter have a march-in right in case one of those patents is left unexploited.

professors would not find any support in case they want to patent or attempt some commercial development. RV was then established with the purpose of filling this gap; it can be activated by any researcher member of the partner's networks and takes a compensation only in case of profit. In order to overcome the funding gap for early stages applications, which is a serious problem in the Italian financial markets, in 2002 RV additionally created a Seed Capital Company (Quantica sgr), which is meant to partner its most promising initiatives. In just a few years of operations, RV was able to gain an established reputation for technological transfer. At the time the interviews were conducted, it was considered a key organization for the commercialization of academic inventions in the field of Physics, Biophysics and Material Sciences and constituted the only reliable partner for all the people working in smaller universities.

Disclosure The interviewed staff reported that their work on disclosure was mostly one of increasing the awareness of professors on the potential exploitability of their research. In order to increase the awareness of scientists and promote their activities, RV schedules annually a communication agenda in collaboration with its partnering institutions. During the meetings, general information on the policies for academic patenting and spin-off companies are generally coupled with success-story telling or the presentation of ongoing projects. These meetings are both scheduled within universities or in coincidence with other events, which are likely to attract the interest of scientists, as conferences and other meetings.

These initiatives were reported to be quite successful and give some good results in reducing the retention of innovations due to the lack of entrepreneurship or information "In some cases—they reported—the professor has an idea, but does not take the initiative to contact us until we go to their department and talk about our projects. Some even started or planned to start their project on their own but later realized that we could do something for them."

Decision to invest During the process of disclosure, the staff o RV described its role as one of helping the researchers to disentangle the technological core of their innovations in order to understand their key value and potential applications. They described the process of disclosure as a key stage in which the knowledge of the scientist is used as the basis to orient the search for potential applications and partners. Based on the disclosure, the staff evaluates the technological opportunity, by looking jointly at the technological content, the state-of-art of the available industrial applications and the potential markets. Among the three project-managers currently working in RV, two have a scientific background in Physics and Chemistry, which facilitates the understanding of the technological content, and one has a business and marketing education. The evaluation phase is often helped by informal discussions with technical and market experts contacted through the network of its partners.

In case they see the opportunity of filing a patent, a prior-art screening is conducted internally or in collaboration with external consultants. For complex projects, as the creation of spin-off companies, the staff of RV reported that the motivation and the entrepreneurial attitude of the researcher-inventor and his/her willingness to become the project leader were crucial. In these cases, the role of RV

was mainly to find external support to the venture, in terms of industrial partners and founders.

Office of Biotechnology Transfer (OBT) of Science Park Raf spa (SPR)

Science Park Raf spa (SPR) is the limited company created by San Raffaele Hospital Foundation to manage the science park hosted within the San Raffaele Hospital (SRH). The SRH area is located just east of Milan town centre. The campus presently includes a clinical unit, a basic research unit, a Medical School and University ("Vita-Salute San Raffaele University") and a small science park, called "Biomedical Science Park RAF." The Office for Biotechnology Transfer (OBT) is part of the Science Park, together with a conference meeting centre and ten private company labs. The SRH is a private no-profit foundation with excellent research ratings in Molecular Biology and Genetics and good reputation for clinical trials and drug testing. According to the private nature of SRH Foundation, the IPRs on the results of all internal research belong to the institution and all scientists have a contractual duty of disclosing inventions to their employer and are compensated with a share of the profit. The OBT is in charge of administrating the IPRs, managing the spin-off activities and help in the design of joint research agreements.

Disclosure Interviewed staff reported that the disclosure of innovations from the scientists was never particularly problematic and they considered the voluntary retention of relevant information almost negligible. OBT personnel reported that meetings were organized periodically between the chief of the technology transfer unit and both the Head of the Clinical and the Basic-Research Unit. Although those meetings are meant to keep the committee updated and discuss the progress of the ongoing projects, they are generally the occasions to speak about early results and new discoveries that might be interesting in the near future. This informal communication allowed the OBT to be current on the progress made in the clinical and research units, without having the need to push for disclosures.

Decision to invest When a new application is developed and the OBT is called to express an opinion on its commercial potential, both the research and clinical units are again asked to contribute substantially in gathering the information needed and supporting the final decision. Their collaboration with the OBT is systematic and derives from the formal responsibility of the directors of the units for the success of commercial activities and from the intense collaboration with the technology managers.

The staff reported that their procedure for corporate funding requires the scientist to present her discovery to an internal board in charge of the final decision. Promising projects can receive additional financial or facilities support to complete the development activities. The OBT board is composed by five permanent members: two people from the OBT, the general director of SRH, the Heads of both the Clinical and the Basic-Research Units, each accounting one vote in the final decision.

Interestingly, when a meeting is scheduled to discuss a discovery with the board, the OBT staff asks to an invited member, selected case-by-case from the Clinical or the Basic-Research Units, to prepare a critical discussion of the report and give his/

her opinion on feasible industrial applications. This procedure works similarly to a scientific discussion. The discussant is called to give an opinion both on the point of view of the scientific discovery on which the application is based, and on the potential for industrial development and commercial success, as compared to alternative methods and so on. Thanks to the relatively narrow focus of SRH research, said the staff, many scientists working in the Clinical and Basic-Research units were able to provide a minded opinion and many thoughtful insights, for instance in terms of knowing which firm was investing in a subfield, what technological trajectories were considered most promising and so on. The discussion that takes place allows taking a decision on whether or not to file a patent application, but in the meantime helps the scientist to define which laboratory experimentations are needed to test the applications and proceed with the development.

Discussion and conclusion

A key challenge of all Technology Transfer Organizations (TTOs) is to identify technologies with high commercial potential and to design viable routes to bring the innovations to the market. In the absence of a wise transfer policy, technologies with a strong knowledge-base developed outside the commercial sector, may not find a market application and remain unexploited. The critical task of Technology Transfer Organizations (TTOs) is to perform effective opportunity recognition, i.e., to identify available technological opportunities, and frame them in a way that matches technological solutions and market needs.

The five case studied presented in the previous section have shown that TTOs organize their activities in different ways to perform their task of opportunity recognition. A common option for commercializing a technology is filing a patent and selling it to a firm in the form of a license. Yet, for many results of the scientific research, a profitable industrial application is not immediately visible and the commercialization would only be possible at the condition of developing the technology in a convenient way (J. B. Thursby, Jensen, & M. C. Thursby, 2001). Consequently, a critical task of a TTO is also that of organizing the development of technological applications in a way that maximizes the chances of commercial success (J. G. Thursby & M. C. Thursby, 2002). Sometimes the development work can be done by the scientist in his or her lab, it can be sponsored by a firm or it can be organized in an independent unit in the incubator or a spin-off company. All of those steps considerable discretionality: TTOs may or may not take actions to encourage disclosure, they have policies for IPRs which may or may not enforce and they take decisions on whether or not working on the commercialization of a technology. When they take up a project, they work around a product or a business concept to design a viable market opportunity, which requires substantial efforts from both the sides of technology and marketing. The case studies presented have helped to shed light on the organization of those activities.

With regard to the process of search of technological opportunities and disclosure, the case studies have highlighted that there is still considerable resistance of the Faculty members in supporting the commercialization of research, although in one

case technology managers reported that this resistance was declining among younger scholars. The problem of cultural resistance has been documented in previous surveys (Owen-Smith & Powell, 2001; Siegel, Waldman, & Link, 2003b) and widely discussed in the light of the social norms governing the scientific community (Dasgupta & David, 1994). There is evidence that the degree of acceptance of the commercialization of research among US academics has increased over time, as the commitment of universities increased (Lee, 1996) and it is plausible that a similar trend is in place in the European countries.

In the case studies, the technology managers interviewed seemed to attribute cultural resistance both to the strength of the traditional social norms that discouraged scientists from making a commercial use of their discoveries, and to a lack of understanding on the opportunities and facilities available or to the poor initiative of faculty members. As a result, TTOs may not be informed of many technological opportunities available in their research departments, despite being part of the same organization.

Hence, having access to the inventions developed by members of the faculty emerged as a critical issue for many TTOs. In this respect, the case studies have shown that some TTOs try to perform a research screening by scheduling internal meetings and seminars with the Faculties. These meetings are meant to inform scientists on the opportunities of commercial exploitation and typically serve as an occasion to contact the technology managers. This practice however may give several disadvantages: first, it cannot be performed often and second is normally not welcomed by scientists, pressured by time-constrained agendas.

Besides, some TTOs relied on their tight relationships with the departments to stay current on the new discoveries and opportunities for commercialization. For instance, MIL staff reported that the most effective results on the side of disclosures were achieved when there was a good collaboration between the TTO and the faculties. In those cases, disclosures had often been urged by the scientists, advised by their Department Head. In the case of OBT this mechanism was even stronger, because the Head of the unit held a responsibility for the success of technology transfer too. Besides, CE relied on the joint work done with the centre for Entrepreneurship Studies to access the most interesting business ideas proposed by the students in the MBA program.

A second issue emerged in the case studies is that the evaluation of an invention was always reported as a critical issue. After a technological application is disclosed, the TTO has to take a decision on whether to invest on its commercialization or to quit it and release the IPRs. Even for the spin-offs and for the projects that require further development, the TTO has to set milestones and has to decide periodically whether to continue or to abandon the venture. All of these decisions require by and large a deep evaluation of the project and the ability to recognize the hidden market potential of a technology in a context of high risk and asymmetric information.

In the case studies, we found that some TTOs make a great effort in gathering information and getting involved knowledgeable people in their evaluation process, by making use of their informal networks. For instance, UVL was largely delegating the problem of understanding the market value of an application to its industrial partners. Before deciding to file a patent or to invest in a project, the technology managers used to discuss the proposal under an agreement of confidential disclosure

with a small number of potentially interested firms, which they choose among their established network of partners. This practice allowed them to get an ex-ante feeling of the market value and reduce the losses of their patent portfolios. Similarly, CE and RV made always use of the rich network of their parent institutions to bring competencies on their project and help to evaluate the opportunities and to frame them into profitable businesses.

Besides, some TTO were also making a systematic use of the competencies available inside the organizational structure of their parent institutions, in addition to using external networks. For instance, CE created a tailored team of people around each project, which included technology and market experts, some of which were chosen from the faculty of University of Cambridge. OBT relied systematically on the competencies of scientists working in their Clinical and Basic-Research Units, by largely delegating to them the evaluation of the scientific and technological robustness of the findings and the assessment the their commercial value, vis-à-vis alternative technologies.

Overall, the case studies suggested that TTOs worked in different environments and have put in place different organizations to perform their task of opportunity recognition. As literature on venture capitals and finance of high-technology ventures have broadly discussed, the problem of opportunity recognition is particularly crucial in the market for ideas, characterized by limited and asymmetric information, knowledge-intensive goods and state-of-art discoveries (Roberts, 1991; Murray & Lott, 1995; Cable & Shane, 1997). In this context, agents that have a superior set of competences and information both from the side of the technology and the market are likely to see opportunities for products and business that cannot be seen by other actors (Shane, 2000). Besides, because the universities conduct research in very different fields, a large portfolio of competencies is required in order to handle applications of different technologies and for different industries and market goods.

To cope with the need of diversified competencies, the technology managers typically have both marketing and technical backgrounds. Nonetheless a deep understanding of a value of a technology is hard to achieve and the job of all TTOs in many cases deals with gathering information and bundling the right mix of competencies. Valuable knowledge for opportunity recognition is of different kinds: information on the characteristics of a technological application, on the comparative advantages it ensures *vs*. alternative technologies, on the investments made by the market incumbents and a deep understanding of the market trends already in place. Additionally, when evaluating the technology is too expensive, the eminence of the scientists that worked at an invention, their reliability and their true interest in carrying on the development can also serve as a signal for the value of a project (Jensen & Thursby, 2001; Shane & Cable, 2002; Shane & Stuart, 2002;).

In the case studies analyzed, it emerged that many TTOs made extensive use of external and internal networks of people in order to enhance their capacity to recognize and shape valuable technological opportunities. Internal ties may not only be useful as a source of competences for the evaluation and framing of opportunities, but also because they contribute in lowering the asymmetric information between the scientist-inventor and the investor. From the one side, the scientists working in the parent research institution may be a source of idiosyncratic knowledge for

opportunity recognition. From the other side, strong network ties between the TTO and the people in the research departments are likely to lower the expectations of moral hazard.

In conclusion, the idea suggested by our case studies is that information and competencies available within the research and teaching departments are not only valuable as a source of new technological applications, but also as a source of superior opportunity recognition. Besides, this use of the organization structure to reduce the asymmetry of information and to empower the evaluation of technologies gives the TTOs a considerable comparative advantage *vs*. external intermediary. If research-integrated TTOs can make use of information that is private to external intermediary, they can do a non-substitutable job in smoothing the market for innovation.

In recent years, policy makers and society more broadly are increasingly asking to university and publicly funded institutions to serve as facilitators in the market for technology (Etzkowitz, Webster, Gebhardt & Cantisano Terra, 2000). The traditional view of universities as providers of education and new knowledge in the form of publications has been challenged by the pressures for the production of technological applications and entrepreneurial ventures. Drawing on the case studies presented in this paper we should suggested perhaps that universities may answer this quests not just by taking some more steps in the development of technological applications and in the commercialization of innovations, but also by organizing their internal competencies to provide effective search and identification of technological opportunities.

Appendix

Table 1 Case studies: description

Case study	Ownership	Main activities	Share of revenures to researcher	Established	Patent licensed	Spin-off created
Umist Ventures Ltd. (UVL)	UMIST	IP/patent services; licensing; spin-off creation; research agreements	75% up to 5,000£ 60% up to 20,000£ 50% over 20,000£	1988	75	38
Cambridge Enterprise (CE)	University of Cambridge	IP/patent services; licensing; spin-off creation; investment in high-tec ventures; Entrepreneurship Education	90% up to 20,000£ 70% up to 60,000£ 50% up to 100,000£ 33.3%over 100,000£	2003	n.a.	n.a.
Manchester Innovation Ltd. (MIL)	University of Manchester	IP/patent services; licensing; spin-off creation; incubator management	negotiated case by case	2000	27	25
Reteventures (RV)	INFM (51%) INSTM (35%) CSGI (16%)	IP/patent services; licensing; spin-off creation; research agreements	always >85% negotiated case by case	2000	1	4
Office of Biotechnology Transfer (OBT)	San Raffaele Hospital Foundation	IP/patent services; licensing; spin-off creation; research agreements	50% up tp 500,000 25% up to 600,000 10% over 600,000	1995	45	2

Table 2 Case studies: summary

Case study	Disclosure	Decision to invest
Umist Ventures Ltd. (UVL) centralised unit in the campus; UMIST does not claim IPRs over research	agenda of meetings with faculties to encourage disclosure. Disclosure under confidential agreement.	independent unit; network of industrial partners is crucial to understand the market value of technological assets
Cambridge Enterprise (CE) centralised unit in the campus, grouping many functional units; no IPR over research of employees IPR over externally funded research	no search for proposal; only voluntary disclosures. Focus on business idea developed by MBA students	tailored project teams for evaluation and development. Key competencies accessed through a wide network of relationships with internal and external partners.
Manchester Innovation Ltd. (MIL) centralised unit in the campus incubator in charge of managing all IPRs on behalf of UoM.	auditings at the level of departments and periodical information; collaboration with head of departments facilitates disclosure	no competences borrowed from parent structure; good talk with heads of departments enables sharing of information
Reteventures (RV) decentralised unit outside campuses providing TT services on demand; no IPRs over research	promotion of activities and information within the departments. Success story telling and organization of events.	services provided on demand to scientists. projects discussed informally within the network of the parents
Office of Biotechnology Transfer (OBT) centralised unit inside campus in charge of manageing all IPRs. Focus exclusively on Life Sciences	research and clinical units share responsabilities for technology transfer. direct internal control of units over undue dissimination	scientists are expected to serve for informal consulting when evaluating projects

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