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Full Length Research Paper

The commercialisation process of patents by universities

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The commercialisation process of university patents and how the decisions were made to patent new scientific discoveries and to commercialise them have not been studied extensively. This paper attempts to understand in detail, the process of commercialisation of university patents from the initial scientific disclosures through patent filings to the choice of commercialisation routes. A series of interviews were conducted with seven directors of technology transfer offices (TTO) of UK universities. The interviews were structured in a way so as to discover how new disclosures in their universities were chosen to be patented and how the patents were commercialised. The interviews were recorded, transcribed and analysed with the help of Nvivo software. Then, case and cross case analysis were done. The result of the study showed that there are variations in practices between universities in how they decide to patent and in the routes of exploitation. Universities do differ on which inventions need to be patented and which route to go for their commercialisation. Universities that practice very highly selective procedures would only patent an invention after a very thorough market analysis. But there are universities that practiced low selective procedures; as such, they file for patent as long as the invention fulfils an expectation of potential value. Decisions on which route to commercialise are sought after the patent filings. Overall, only one university practice a very systematic selection procedure, from which, inventions were patented and specific route of commercialisation was chosen. Most of the universities based their selection criteria on motivations of the inventors, either to patent and which commercialisation route to utilise for their inventions.

Key words: University commercialization process, invention disclosure, patent filing, commercialisation route.

INTRODUCTION

The commercialisation of technologies within universities is increasingly important to generate university income and in the creation of new businesses and jobs (Shane, 2003, 2004, 2005; O'Shea, 2005). Despite the importance of commercialisation to universities as well as to local economic development, there is little systematic understanding of institutional practices in the commercialisation process of university technologies (Harmon et al., 1997; Ndonzuau and Surlemont, 2002; Shane, 2004). This paper answered the research question 'how do universities get involved in the decision making and what are the decision criteria in the commercialisation processes'? In order to increase the effectiveness of the commercialisation processes, it is important to understand who are involved in the decision making and the criteria used, to transform the ideas from the laboratory into commercially viable products. This paper examined those who are involved in the decision making processes from the disclosure of the scientific discovery, the decision criteria used and the route of exploitation.

This paper presents a literature review to understand the general commercialisation process followed by the commercialisation process as practised by universities in

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the United Kingdom. The similarities and differences of the practices between the UK universities are highlighted as the finding of the study.

To understand the processes in depth, interviews have been conducted with seven directors of technology transfer offices (TTO) of United Kingdom Universities. In addition, annual reports and universities' web sites were used to gather rich information on the process.

The discussion on the processes focused on institutional factors such as sources of funding for research and availability of the capital for spin-offs, how the decisions to seek patent protections was arrived at, how the decisions as to which route to exploit the patents were reached, networking and the search for licensees, universities' policies, ownership and overall management of the IPRs.

It was found that only one university practice a very systematic selection procedure, from which, inventions were patented and from which specific route of comercialisation was chosen immediately after the technology disclosure. Most other universities based their selection criteria on motivations of the inventors, either to patent and which commercialisation route to utilise for their inventions. Some others do practice the 'last resort' commercialisation route when no licensees were found after a time.

The finding of the study would enhance the understanding and the effectiveness of the commercialisation process and would benefit university policy makers and TTO managers.

LITERATURE REVIEW

General model of university commercialisation process

The general process of commercialisation of university technologies starts from the scientific discoveries in the university laboratories. Generally, inventors disclose their inventions to the TTO, although, universities do not give any incentive for them to disclose their inventions to the TTO. Thursby et al. (2001) found that only half of the inventions that have economic potentials were ever disclosed to the TTOs. In some cases, a faculty may not realise the commercial potential of his ideas. However, very often, they are unwilling to disclose it to the TTO because they are afraid the application for a patent will delay their journal publications.

The TTO then evaluates the disclosures to determine if the inventions need patent protections. The TTO, based on the information from the inventors, will evaluate the market potential for the inventions and how to exploit them. If there are potential licensees for the inventions, global protection will be discussed depending on the market for the inventions. If there are still no takers after the filing date, the TTOs and the inventors will continue to try to commercialise the invention for a period of up to one year. After that period, attempts to commercialise the inventions would normally be abandoned.

Normally, the decision to commercialise is either through a license to established companies or as a license to spin-off companies. These would normally be the result of joint decisions between TTOs and the inventtors. Basically, for all the universities, the decision as to whether to file a patent application are generally based on at least three main questions, which are similar to those practiced by US universities (CORG, 2000; Rootner, 2004). They are:

i. Do the inventions have no prior art?
ii. Do the inventions have commercial value to attract commercial investments?
iii. Are there funds available within the institution or prospective licensees to pay for the patenting cost?

If the answers are yes to all three questions, then, universities will normally take positive steps to patent the inventions, even though at that time, they have to make difficult decisions due to the uncertainty of the potential products that will utilise the technology, and their associated markets. Delaying the decision to patent will affect publications, and competitors might be the first to file for patent for the same or similar inventions. If the inventors published a paper on the invention, the patent application can no longer be filed, as it is considered that the invention now has prior art. Some of the universities file for patents as quickly as they can, after the disclosure, or immediately after a board meeting. Prospective licensees are sought immediately after patent applications are filed.

Networking and license to established companies or to spin-off companies

Networking is a crucial aspect in the choice of comercialisation route. According to Colyvas et al. (2002), and Hsu and Bersntien (1997), early network with industry give greater chance the invention will be exploited. Industry could advise and monitor the project according to the market needs. These personal contacts are an effective way to attract companies to university technologies (Kneller, 2000; Thursby et al., 2001; Colyvas et al., 2002; Thursby and Thursby, 2004). Universities' technologies are unproven and normally need further investment before any product utilising them can really sell into the market. In addition, due to the technology being in its early stage, it is very high risk. Moreover, some of the technologies have a market that is so broad, that it is difficult to identify which market to target. Thus, network and collaboration with industry is important. Inventions that receives early funding from established companies and where the inventors work together with industry teams, have greater chance of being licensed

to established companies.

Pressman (1999) explains why marketing university inventions are so difficult:

> "... University inventions are 'embryonic'. At the time a university is ready to hand over its inventions to industry, most have not even reached the prototype stage, much less demonstrated manufacturing and practicality in the market. These inventions will require substantial investments in product market development, and many will never succeed. Thus, the task of the university is to find industrial licensees willing to make the high risk investment …"

Informal and formal networks with individuals and organisations are important for spin-off formations (Birley, 1985). These networks link new firms to resources providers such as venture capitalists, business angels, banks and advisers as well as to potential customers. Shane and Cable (2002) pointed out that informal networks are important means of accessing finance, thereby giving more chance to spin-off formations. Shane (2003, 2004) further suggests that the link to financiers give a better chance of founders' access to a broader network such as suppliers, customers and other resources that a new firm requires.

The decision to form a spin-off company depends on various other factors. According to a survey of TTO directors, the decision to form a spin-off company depends on the following factors (Minshall and Wickteed, 2005):

i. technologies are considered as platform technologies,
ii. the inventors are very keen to commercialise the technology themselves,
iii. when the idea needs to attract substantial investment to develop more IPs relating to the initial technology for subsequent licensing,
iv. when the technology is not readily licensable, and
v. the technology is a generic technology with many different applications.

Spin-off formation needs technologies that have made significant advances in a scientific field and will have significant economic value (Shane, 2004) although they are at the very early stage of development. The technology needs to be cutting edge and do not duplicate existing technologies (Shane, 2004). Furthermore, the technology must be in demand and it is expected to bring in substantially more profits than alternative technologies (Amit et al., 1995). Small and newest spin-offs always invest in uncertain technologies (Shane, 2002, 2004). Lowe (1996) also found that most of the spin-off companies at the University of California were founded because established firms were unwilling to license these technologies. Thursby et al. (2001) surveyed 62 TTOs in US and they found that established firms tend to license university inventions at the later stages.

Most universities also have links and investments in their incubators. The role of the incubators is to nurture spin-off companies until they are mature and ready to compete in the open market. The incubators provide common facilities for new firms with a lower market price than other places and management support services. Various studies have reported on the direct and indirect roles of incubators in spin-off formations (Rogers et al., 2001; Phillips, 2002; Grimaldi and Grandi, 2003; Georghiou, 2001; Markman et al., 2005b; Siegal, 2006).

Some universities are now creating holding companies for their spin-offs such as Qubis Ltd in Queen's University in Ireland (Blair and Hitchen, 1998; Leitch, 2004; Leitch and Harrison, 2005). This specific company is a wholly owned subsidiary that invests in first order and second order spin-offs from the university. It is not only a support mechanism but is "doing business" by establishing businesses (Leitch, 2004) and taking equity in them. In addition, the company provides incubation facilities, management support and help with running the company.

A university spin-off also enhances economic growth by transforming university technologies into business opportunities. Forming spin-off companies will have multiplier effects, provide jobs to the local people and stimulate the local economy (Tornatzky, 2000; Pressman, 2002; Shane, 2004; Smailes and Cooper, 2004), as they usually locate their operation around the university.

METHODOLOGY

This research adapted case study approach to understand the process of commercialisation, as suggested by Yin (1984, 1994, 2003). The main argument for choosing case study as the research strategy is the descriptive nature of the research, which does not require control of behavioural events but rather documents them. The dominance of 'how' and the exploratory 'what' requires an insight to answer the research question of 'how has the commercialisation process of university patents taken place?" Particularly, the question of what explains why some university patents are exploited, and why some are not exploited. How universities decided to patent and commercialise their patents were asked during the interviews. In qualitative studies, the nature of research question often starts with a "how" or a "what", so that it will give an initial general description on what is going on (Yin, 1994; Miles and Huberman, 1994; Creswell, 1998; Patton, 2002).

To understand the process in practice, interviews with seven directors of technology transfer offices (TTO) in UK universities were conducted. The 'how' and 'why' questions on the commercialisation process were asked during the interview as suggested by Yin (1994). Four are from Scotland and three from England. Scottish and English universities were chosen to get a holistic view of the process in the UK, and to see if there is any difference in the Scottish and English practices. The interviews were recorded, transcribed and analysed using Nvivo software.

Within case analysis, it typically involves a detailed case study write-up for every case (seven universities). Eisenhardt (1989) contended that there is no standard format for this analysis, and it often involves pure descriptions to help researchers to get insight of the early analysis process. Miles and Huberman (1994) suggested that case analysis involves going back and forth through the interview transcripts to compare the data from different transcripts and to repeat examples of the themes and sub themes (Miles and Huberman, 1994). Cross case analysis were then conducted to

understand the process and identify salient points in the practices of each TTO.

FINDINGS

The invention disclosures

Disclosure to the TTO would normally briefly describe the idea of the new discovery, technology or invention, on what platform it has been developed and so on. Other types of information included in a disclosure form typically are:

i) Name of the inventors.
ii) Who funded the research that led to the inventions?
iii) Has there any publication on the inventions?
iv) Potential commercial market.
v) Companies that may be interested in licensing the discovery.

The University of Southampton is proactive and is quite different from the other universities studied. The Centre for Enterprise and Innovation (CEI) at the university has a group of managers recruited from industry. These business managers will seek out a business partner, identify opportunities, and then draw up business plans for technologies they selected for commercialisation. The CEI will then bring the resources required from within the CEI to implement the plan (Minshall and Wicksteed, 2005). In addition, it has an academic representative within every department and these representatives give specific briefings to the academics on patenting activities and the role and importance of patents to encourage academics to disclose their inventions. Courses are also given to the academics to familiarise them with the patenting activities and procedures.

How the decision to patent arises

The decision to patent and how they were arrived at are different among universities. The differences are due to the supportiveness and selectivity of the TTOs, depending on who is involved in the patenting process, the resources available to them, and the skills and experience of the TTO staff. Most of the universities, especially Warwick University, University College London, Glasgow University and Southampton University, are very selective on what types of inventions they patented. Some of the TTO directors have full control over which invention is going to be filed for patent and which exploitation route to take, even though the views of the academic inventors are always sought.

The inventions will be evaluated for potential applications and patent protection potential. At this level, the personnel who are involved in the decision to proceed, or otherwise, to patent application, and how to conduct market research differ between universities. Initially and generally, inventors and the TTO directors or the TTO Director himself will decide whether or not to patent the inventions.

In some cases such as the University of Edinburgh, the discussion initially is between the inventors and the business development managers of the TTO. These people would decide whether the inventions should be patented. They would also discuss the initial possible applications and markets for the inventions. Their decisions are then reported to the Director of the TTO and the Director will decide whether to patent the inventtions and whichever route to exploit it. On the other hand, at Herriot Watt University, inventors and board members will have a meeting together to decide, the board consists of six internal members and a few experts external to the university. At the University of Glasgow the Business Management team is involved at this stage. The team is made up of nine members and one secretary. Some universities like the University of Strathclyde have a second meeting with committee members. The university has a small committee comprised of the TTO Director, IPR officer or the TTO representative and a patent agent.

In the selection process, the University of Warwick has the most systematic method and is very selective with regard to the characteristics of the inventions that would influence the decision to file for patent or otherwise. The University of Warwick also has a special and comprehensive evaluation form compared to other universities. It uses a scoring system to identify the market potential of the inventions with 10 dimensional rating scales.

Each project should be scored from 5 (excellence) to 0 (very poor) on each dimension. Scores on each of the ten scales can be totalled and doubled, to give a score out of 100. If the marks scored were more than 56%, the inventtion will be filed for patent. University of Southampton and Warwick University would normally have identified the market size and the potential value of the inventions, and also identified who are the players in the field and their potential customers before filing for patents. Other universities totally rely on their inventors for market information on the inventions. Only inventions that have commercial value and that need protection are patented.

Finding licensees and networking

Most of the universities only start to find licensees immediately after the patent is filed, for the obvious reason of prior art. Several strategies are implemented. The strategies are similar to those in US universities. The strategies implemented and how licensees are chosen is explained further.

Licensing strategies

Most of the universities applied similar methods in their

marketing strategies to find licensees. Involvement of the inventors from the beginning is important until the identification of the specific market for the inventions. Usually, the universities together with the inventors will identify the prospective licensees immediately after they file for patents. Universities use their web sites, flyers, conferences and seminars to advertise technologies that are patented and available for licensing. On the web sites, the general background and the potential applications of the technologies are explained. However, the web sites do not work very well. The most effective strategy was to find all the active companies involved with particular technologies and approach them either by mail or direct personal contacts. A face-to-face meeting will then follow if the company is interested in the technologies. One of the TTO directors commented:

> "… all universities use the initial contact of academics to market their technologies. The TTO will assist them in negotiating contracts and contract agreements. The TTO will study what are the commercial values of the technologies and how much time they [need to] spend to bring the inventions to the market. The value of technology becomes higher when the period to produce is shortened. The product [could] become a market leader before other companies could introduce their products [using the same technologies] …"

> "… The difficult stage is to find the companies that could be the potential licensees and who are willing to give support to the technology. Most of the licensees are from US companies. Companies in the United Kingdom are poor in R and D and are much less likely to support technologies from universities [this is supported by Steil et al. (2002) and Bower (2003)]. In addition universities target few potential licensees and tend to build long-term personal contacts in the industry. At this stage, universities always have a problem convincing the prospective licensees of their technologies."

Universities usually target worldwide markets for licensing, especially when licensing to established companies. The University of Southampton has an invention involving infrared (IRed), which attracted interests from major companies around the world, especially Korean and Japanese. The same thing happened to the University of Strathclyde with its anti obesity drug, which was granted a patent in 1995/1996. This patent attracted one Korean company to collaborate and to conduct further research into the drug and invest to the tune of £ 1 million.

Exclusive or non-exclusive license within a field (or in all fields) and the distribution of royalty

A licence granted by a university may be non-exclusive (licences may be granted to a number of companies) or exclusive (granted to one company only). Universities grant exclusive licences when the investment to develop the technology is high-risk. Exclusive licences are granted to permit licensees the right to develop the technology without fear of competitors. The patent can also be licensed exclusively, but limited to certain applications or methods of use of the technology, or limited to a certain geographical area or nations. Universities sometimes grant exclusive licences where the industry funded the research. The University of Southampton for example, gives exclusive licenses to Glaxo who funded research on pharmaceutical products.

If an exclusive licence is granted to a company, the university must monitor and ensure that the company works hard to develop the invention and not just shelve it. Some companies may want to license the invention in order to prevent the invention from threatening their existing products.

Diligence provisions are an important part of any negotiation with licensees. In these provisions, the company is required to specify the number of people in the company assigned to develop the invention and the amount of funding it will commit. It must also specify the date when the prototype of the product will be completed, the date when the first product must be sold, and dates by when sales levels must be achieved. Diligence provisions are a mandatory contractual commitment. If these terms of the provision are not met, the university may cancel the licence or the university may make it non-exclusive, thereby regaining the option to grant licences to others (CORG, 2000).

The distribution of royalty incomes varies across universities. Revenues are generally distributed according to a formula that has been adopted by the university. Most of the universities implement sliding scales, with a higher share for the inventors in the early years of a licence when the royalty returns tend to be lower. The royalties will be distributed between inventors, inventors' faculty and to the university general funds.

Decision to commercialise through spin-off or licensing

Academic staff aspirations and interests are considered when deciding the route for the exploitation of intellectual properties. There is a similar process in the US universities.

Most of the universities have discussions with the invent-tor as to which route they want for the exploitation of their inventions. However, in certain cases, the TTO Directors have the final say as to which route is to be utilised, such as Edinburgh, Southampton, Strathclyde and Warwick Universities.

Some universities preferred to license their intellectual properties to established companies rather than to form spin-off companies, for example, the University of

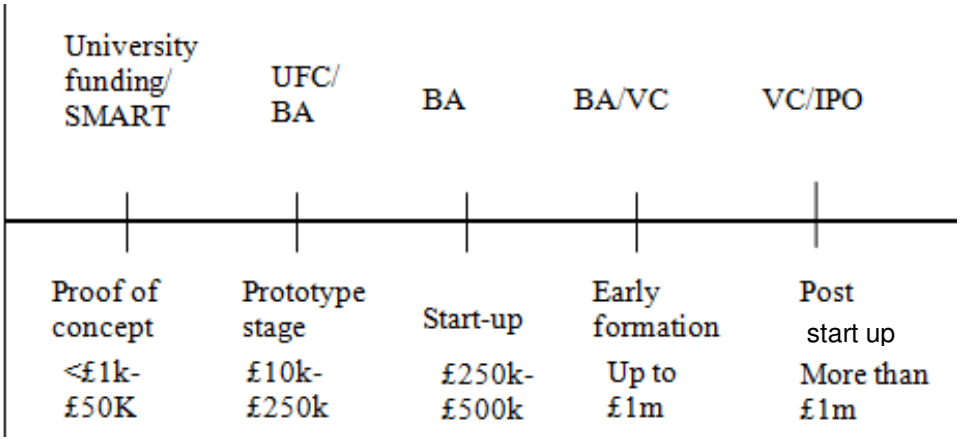

Figure 1. Stages of funding in spin-off development.

Glasgow and Heriot-Watt University. Similarly, the University of Glasgow prefers to exploit their technologies by licensing to established companies because it is less risky. However, based on the interviews with the TTO directors for this study, generally, it is apparent that several other factors influence the universities' decision to form companies. Many universities consider that if the technology is of advanced type, at a very early stage, has potential value, together with the availability of resources and when there were no licensing takers, then, universities have to take the risk of forming a company. The details factors are discussed further.

Academics commitment

Academics' aspirations and commitments are very important and are the main factors considered in forming a company. At the first stage, universities consult with academic inventors as to which route to the market they prefer to exploit. Then, market analysis would be conducted: who the competitors are, market accessibility, and the market size. Inventors are not necessarily equity members of the company but their minimum involvement is required to ensure the development of the technology, such as being a consultant to the spin-off company. The academics' commitment is crucial if the licensing route is chosen when the technology is at an early stage. Without the academic's contribution and involvement, the chances of success are limited. As one of the TTO directors reported:

> "… The report comes to the Director of ERI and that report makes recommendations as to whether we should protect, how we should protect and how to exploit the inventions. The technology exploitation route can be to set up a company, to license the technology through existing firms, or may be to take some contract research and to continue research with support from the existing companies. The decision as to which route to go forward, is basically decided by the Director. The decision always takes academics' wishes into account because they have to work with us to exploit the technology …"

Another TTO director said:

> "… The decision to form a spin-off company is made based upon discussions with academics and one of the university signatories. This is due to the cost involved in the formation of spin out company. We then quickly look for outside funding and investors. Sometimes academic staff can bring in investors and put their own money into the company …"

Spin-offs funding

Universities need external funding to form spin-off companies. These funding come from either government or industry. However, since the patents licensed to spin-off companies are usually early stage technologies, most of the funding for seed monies comes from the government. The UK Government has set-up the University Challenge Funds (UFC) to encourage universities to exploit research output and fund the early stage of commercialisation projects. Scottish enterprise has set up proof of concept fund to support spin-off companies. Business angels and venture capitalists are also important for start-ups. For post start-up, the companies would seek capitals for further growth from venture capital companies or go to initial public offering (IPO). Figure 1 shows the stage of technology development and the amount investment required for each stage in a spin-off company. It also matches the potential source of fund for the development of the technology.

The SMART scheme and UFC provides inventors with seed money to develop their inventions to prototype stage and to cover patent costs, business assessment, market research, and business plan development. The

initial amount given is less than £ 50, 000 for each new company. Universities normally provide £ 5, 000 to 10, 000 to the inventors for these activities like the University College London, University of Warwick and University of Strathclyde. University of Strathclyde has the commercial development fund, which is controlled by the BVG (business ventures group). Any returns from spin-offs are invested straight to the fund.

University challenge funds (UFC) basically funds university spin-off companies, with amounts between £ 10, 000 to 250, 000. For example, the University of Edinburgh has its own internally managed fund called the Integrated Company Development Scheme. The grant is given during the pre-incubation stage. The total fund is £ 4 million and each company receives a maximum of £ 75, 000. The funding is given for the first-year and includes the cost of market survey, prototyping and additional lab works. The university takes 10% of equity per £ 50, 000 investments. Other universities take 10 to 20% equity in the companies.

Further development of the product or additional investment is likely to require funding from venture capitalists and business angels. Business angels and their network also provide the money as investments, typically in the range £ 50, 000 to 250, 000. Venture capital firms fund university spin-offs at early stage of formation with amounts up to £ 1 million, which is called venture capital Series A. For further growth, venture capital Series B and C could come in with amounts of up to £ 5 million and up to £ 10 million subsequently.

Networking

Universities that have built formal networks with venture capitalists and business angels have an advantage in helping to narrow the market of the university inventions. As one of the TTO assistants said:

> "… We seldom go out to market the technology. We have marketed the technologies based on having good relationship with financiers, which includes business angels and venture capitalists. VCs and BAs help in narrowing the market. They will identify the potential market before they invest in the company. … The London Technology Network is a good channel to link the potential industry and the technology. It is very rare that the TTO goes to the general market …"

In order to access more sources of capital and future investors, universities have built external linkages. For example, the University of Strathclyde has strong links with Scottish Enterprise Glasgow. The University of Southampton has a different strategy. CEI has built strong links with a number of early stage investment funds, including SULIS (£ 9 million), WessexBio (£ 400, 000) and IP2IPO (£ 5 million) and runs its own presentation day annually in London. Universities have also developed specific mechanisms to build strong networks with industries.

Other universities have links through particular mechanisms. The University of Warwick and Midland universities have access to Connect Midlands and universities in Scotland have access to Connect Scotland. These are designed to connect technology-based companies or inventors to potential financiers and investors. These organisations were established with the main objectives of generating a network for entrepreneurs, drawing together people such as investors, business service providers and regional key players. Events, seminars and conferences aimed at investors are held to present the new ideas and the latest technologies from the spin-off companies and the universities and to build networks. Connect events are designed to add value to technology companies at different stages in the business and investment life cycle. The exchange of ideas, networking with peers, facilitating technology transfer opportunities, meeting potential non-execs and/or potential investors are some of the opportunities created by such events.

Beside external links or formal networks, most universities have internal links in order to support spin-off companies or to give access to sources of investment and other resources. Most of the universities have strong internal links with their own business schools or their Centre or Institute for Entrepreneurship, their Alumni and incubators as suggested by Minshall and Wicksteed (2005).

The entrepreneurship centres focus on entrepreneurship education that provides entrepreneurial awareness to students and faculty. Universities alumni also give access to a broader network for new firm resources such as the Strathclyde 100 event in the University of Strathclyde.

When technology is radical, unique and has market potential

Consistent with the literature reviews, most of the TTO directors agreed that a spin-off formation is imperative when the technology is the core resource and is of major innovation. One TTO Director said:

> "… if there is a core technology, and it represents a big jump in technology or is a revolutionary technology or will create major turbulence rather than an enhancement of an existing technology, then we look to form a spin-off company …"

Universities also consider setting-up a company, when the technology is at a very early stage of its development cycle, and is unique with high potential value that can be utilised in many products. Shane (2004) also found that university spin-offs are effective vehicles for

commercialising uncertain and early stage technologies.

Where the technology is too advanced and the potential value is uncertain, some universities will form a spin-off company as a last resort action, especially when there are no licensees came forward for the inventions. For example, where the technology really has potential value, the University of Glasgow, will spin-off a company, although no licensees are interested in the technology, or licensees are difficult to find.

High expected level of return

Another consideration is the expected annual income from a spin-off company. One of the TTO directors reported that the university would form a spin-off company when the expected income is more than USD 100 million per annum. If the company is projected to bring less than that, they would find trouble finding investors, as venture capitalists would usually refuse to make any investment:

> "… we do the technology review; for example the modification of a microprocessor. It is not sensible to set up a company to compete with Intel. We rather license to Intel. We carry out the technology review; we look at the industry; who are the competitors, market accessibility, and the size of the market. We are looking to build a company that at least gives turnover of USD100m per year. That is the target. If [it is projected to bring in] less than that, we will not form a company. We have to look for a unique market. … If the company is not worth more than USD100m dollars, you cannot get investors …"

External factors

Economic factors are another consideration in forming a spin-off company. TTO directors of the University of Strathclyde and the University of Edinburgh both mentioned this objective. Government or local authorities require the development of their local economy. However, if the universities license their technologies to international licensees, it will reduce the chances and opportunities to develop the local economy as mentioned before. Another factor is the geographical position of the market, which can lead to another reason for the creation of a spin-off. This depends on whether the technology has a local or international market. A local spin-off company will directly and indirectly stimulate local economic development, as was concluded in other studies (Tornatzky, 2000; Pressman, 2002; Shane, 2004;Smailes and Cooper, 2004).

If the market is outside the United Kingdom, licensing is preferred. However, the local population does not benefit from the development of the technology through job creation. Moreover, the type of technology and the cost incurred if the technology is further developed also has to be taken into account. After consultation has been carried out with the inventor, the university will study the amount of finance required to create the company. What is the cost to transform the product into the next stage; the time line involved to take the product to market; and whether or not the technology could be incorporated into a single or multi products. Licensing to an established company is safer than taking the risk of forming a spin-off company where the costs to take the product to market are huge or it takes a long time to harvest. A good example is the development of new drugs or compounds.

Ownership of IPR

Universities differ in terms of their practice of the ownership of IPR. The University of Strathclyde, the University of Glasgow and University College London retain their ownership of the intellectual property (IPR) even though industry funds the research. At the University of Warwick, Heriot-Watt University and the University of Southampton, the IPR is retained by industry if the industry funds the research. However, universities still earn the royalties subsequently paid by licensees (which may include the companies that funded the research).

Whether the IPR is owned by industry or the universities, there are advantages and disadvantages. One of the advantages of industry retaining the ownership is that they own the technologies, such that they would be more willing to invest more for further development. In addition they can sell the patent if the venture fails (Levie et al., 2003). The disadvantage is that the university does not have a final say in the development of the technology that was initially invented by them.

The University of Edinburgh, the University of Strathclyde and Glasgow University have different systems to other universities on students' IPR. Undergraduate or postgraduate students can retain ownership of the IPR if the student does the research in the university. Most of the universities interviewed retain the ownership if a member of staff does the research, even though industry funded the research, but the industry that funded the research has the first option to license the technology. Joint IPR between students and academics are allowed if the project is sponsored by industry. Strathclyde University so far, does not have any established system for students who are doing research in the university. According to the TTO Director, it is good practice to oblige students to sign IP agreement if the university funds the research.

DISCUSSION

The universities' approach to commercialisation and their decision making process has not been intensively scrutinised in academic literatures. This study attempts to understand in detail the process of commercialisation

from the initial scientific discovery and who made the decisions as to the choice of commercialisation route. The findings of this study enhance the understanding of the process as preliminary steps to understanding the specific processes of commercialisation of university technologies.

The findings revealed that there are differences between universities in how they decide to patent and in the route to exploitation.

It is a normal practice among all the universities for the inventors to bring their inventions to the TTOs. None of the universities scout for invention disclosures although inventors are encouraged to disclose inventions to their respective TTO offices. This is because most of the TTOs do not have enough staff to scout for the inventions. Universities or TTOs also believed that the inventors should be highly enthusiastic if they want to see their inventions implemented. So, it is normal for them to expect the academic inventors to bring their inventions to the TTO, not the other way round.

Universities differ on the need to patent an invention. Even though the inventors are involved, the final decision is up to specific committee(s) or the TTO. Some universities practise low selectivity and patent as long as the invention fulfils the patenting criteria and is expected to have a potential value ('patent first and find licensees later'). The licensee is immediately sought after the patent filings as there is a need to patent before general disclosure of the inventions, and to avoid competitors from copying the inventions. Other universities license the invention to established companies, if the technology requires further development, needs intensive investments and the market is world wide like a drug discovery. Drugs need intensive investment and testing which involves a huge amount of money. With these types of inventions, the university usually licenses them to established companies.

Some universities practice a highly selective procedure and only patent the inventions that they believe have big market potential. This means market research is undertaken prior to filing for patent protections, as is the practice at Southampton University. This University also shares the cost of patenting with the inventor's department to ensure the involvement of inventors or faculty in the marketing and development of the invention.

The decision to choose which route to commercialisation also varies between universities. Some universities are very selective. The selection or due diligence process starts as early as from invention disclosure. However, the capability of the TTO to evaluate the inventions for a spin-off company also varies depending on the business and technical experience of the TTO. Some universities have experienced TTOs who are proficient in the spin-off process. University College of London has a strong network including investors, which helps the University evaluate the University's inventions. University of Warwick and Southampton University conduct thorough market research before they decide to form spin-off companies. Only Warwick University is very systematic in the patenting and commercialisation procedure. The University has a scoring system to evaluate disclosed inventions and which mechanism to exploit. In the case of Heriot-Watt University, they prefer licensing to established companies. The reason is that, many of their technologies have global applications and are very technical. Licensing the technology to an existing company that is already active in that field is considered the best mechanism. However, other factors such as resources and inventors' commitments are also taken into account. If the technology is at the late stage of development, the inventors will be encouraged to take the licensing route.

Other universities practise the 'last resort' decision when a licensee is not available. However, this practice is for the technologies that have an outstanding market value and the inventors have high motivations. Other factors such as characteristics of technologies, resource availability, expected return at specific time affect the decision making process.

The decision to award an exclusive or non-exclusive licence depends on the strength of the patents and the competence of the licensing companies. All the universities practice the same procedures. Granting non-exclusive licences mean universities can license to as many companies as they can. This could lead to new inventions or technologies, which could be patented and then further exploited, as broadly as they can and using multiple applications. However, royalty rates for non-exclusive licences are normally a lot lower than the exclusive licence rates. The royalty rates for exclusive licences in the University of Edinburgh for instance, are normally between fifteen and twenty percent of the turnover of the products compared to between five to seven percent for non-exclusive licences.

The ownership of the IPR varies between universities. Some universities retain their ownership such as the University of Strathclyde, the University of Glasgow and University College of London even though industry funds the research. On the other hand, for the University of Warwick, Herriot-Watt University and the University of Southampton, the IPR is retained by the industry if they fund the research.

Universities in England have easier access to venture capitalist companies compared to Scottish universities. To attract venture capital companies they have various links and events to exhibit their technologies. Certain characteristics of the technologies such as a clear route to market, size of potential market, strong management team, viable technology and level of patent protection are required by venture capitalists as reported by UNEI (2004) and Shane (2004). The TTO directors who have experience and come from entrepreneurial background influence how they network, and they employ different strategies in getting funding and building internal and

external networking. Finally, all the universities confirmed that commercialisation activities are not included in the academics' promotional exercise. If promotion incentives are given to the TTO or inventors who could commercialise their inventions, this might increase the number of invention disclosures to the TTO as argued by Thursby and Thursby (2001).

Conclusion

This paper revealed that universities are different in how they decide to patent and in their decisions of which route to exploit their technologies. Universities that practice very intense selection in their patenting and firm formation may discourage commercialisation activities. On the other hand, being less stringent, the universities may encourage the inventors towards more disclosures and patents, but they might not be successful in commercialising the patents. This wastes university resources such as time, manpower and money.

But overall, universities need to encourage disclosures and from them try to pick out the very high quality inventions to be patented and further on commercialised. Commercialisation success of their technologies would not only bring in monetary returns, but also prestige to the university and to its research efforts.

Implications of the study

Understanding the process of commercialisation will enhance the effectiveness of university TTOs in their decision making process to patent and commercialise university technologies. The findings of this research points towards specific god practices that could be adopted by university TTOs to increase effectiveness in technology commercialisation, and pitfalls to avoid.

Limitation

The study was conducted in seven universities in the UK. The UK patenting system and the general process might influence the result of the study. The study did not include the views from the inventors or the TTO staffs other than the directors. As such, the result might be biased.

Future research

Future research should include TTO offices from other countries, and the views of other TTO staff members should also be sought. This will give a broader view in understanding commercialisation process of university inventions. Inventors' views from the respective universities should also be considered, as this would give the view from the other side of the coin.

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