Theme: Circle Workshop

Technology Transfer and Entrepreneurship: IP and academic spin-offs in Sweden and the UK

Keywords: university; entrepreneurship; spin-off; patent; technology transfer

JEL: O32, L26, L32, L24, R12

1. Introduction

The triple helix model in Europe in practice can be seen as being less successful than the best US models of Stanford and MIT. This is argued to be because Europe's research and industrial base has a comparatively limited capacity to convert scientific breakthroughs and technological achievements into commercial successes (e.g. the EU White Paper 1993). The perception of a strong European science base which is not translated into economic growth is often labelled the "European Paradox" (EU 1995). Over time, the focus has turned to the commercialization of publicly financed R&D. Even though some reports (Arundel and Bordoy, 2008; Bergman, 2010) have pointed to positive trends in, for example, efforts to encourage the creation of university spin-offs, there is a strong belief that the EU under-performs in the commercialization of publicly funded science.

The discussion of academic entrepreneurship often concentrates on faculty efforts to commercialize inventions appropriated within the intellectual property (IP) system organised by university administrators e.g. Technology Transfer Office (TTOs). There has also been an assumption that academic entrepreneurial activities are reflected through the disclosure of patents via TTOs. However, studies in the U.S. have shown that a

substantial amount of academic entrepreneurship happens outside of the formal IP system (Fini, Lacetera and Shane, 2010; Markman et al, 2008) (by-passing) and which might suggest an unravelling of the triple helix model because of the potential for collective loss to the university helice which relies on systemic interaction. Possibly then, similar processes may exist also in Europe. This has clear implications for normative assumptions about the seamless linear processes of research to commercialisation within the context of now worldwide societal (political objectives) on capitalising on knowledge (see Etkzowitz and Klofsten 2005). However, if the triple helix model could be seen as the imperfect cooperation between university innovators (researchers) and managers (or administrators) and entrepreneurs or industry (non-academics who manage university spin-offs) within a political environment with priorities set by government, then the practice of bypassing becomes more understandable. Moreover, how the performance of those spin-offs formed within the system compared those formed outside is of interest.

The specifics of the political context are, however, crucial. For example, while in the UK, since the mid-1980s, each university has been able to set its own rules on ownership of IP, in a few other European countries, like Sweden and Italy, an inventor ownership model is dominating. There is a lack of studies of European academic entrepreneurship that happens outside of the formal IP system; and accordingly there have been few possibilities to analyse the effects of different institutional set ups within a triple helix model.

To fill this gap, this paper asks the question, *how do different triple helix institutional settings affect the commercialization/exploitation of university research in Europe*? In order to answer the question, we empirically investigate university technology transfer at two universities in two countries with a different inventor ownership regulation. The two

cases are Oxford University in the UK and Chalmers University in Sweden. The Oxford case will be used to illustrate the university ownership model, while the Chalmers case represents the inventor ownership model. Our empirical data allow us to compare the formation of academic spin-offs at the two universities, including the degree of bypassing activities in the Oxford case. We investigate and analyse whether Oxford academics involved in spin-off companies disclose or exploit patents inside or outside the formal university IP system. In the Chalmers case we have identified a high number of spin-offs, both by faculty leaving the university and by faculty keeping their university positions. Our comparisons will add further insights to the comparisons of the impact of different intellectual property ownership regimes in six universities in Canada and the U.S. conducted by Kenney and Patton (2011), by highlighting the issues that arise in the European context. By analysing both patents and university spin-offs we are able to shed light on two processes through which the commercialization of university research occurs.

The paper begins with explanations of the university spin-off phenomena within the triple helix model. It focuses particularly on institutional conditions which influence the formation of university spin-offs. Next the methodology and results are presented. The results provide new insights and perspectives on technology transfer processes through university spin-off firms. In the last section, some conclusions are drawn and some limitations and recommendations for further research are discussed.

2. University-spin-offs, technology transfer and the triple helix model

The effort to create a knowledge-based economy has significantly emphasized the role of universities in commercializing new innovations including scientific and technological discoveries from the research laboratories (O'Shea *et al.*, 2004). In addition, the

importance of technology and knowledge transfer from university to industry including the necessity to build closer association between science/technology and its application and exploitation have driven the development of numerous entrepreneurial initiatives inside universities (Allen, 1995). The term, "the entrepreneurial university" (Etzkowitz 1983), was an early recognition of universities acting entrepreneurial, including a growing number of academic scientists in the US who were forming their own companies.

Numerous explanations of factors contributing to the formation of university spin-offs as well as other forms of commercialization through such as patents and licenses have followed. Four are highlighted. Firstly, legislative initiatives are widely regarded as contributing to an acceleration of the formation of spin-off ventures. For example in the UK, from 1985, universities were given autonomy to arrange their own rules and policies on IP ownership (Lawton Smith and Ho, 2006). Secondly, universities with cultures that embrace entrepreneurial activity not only have better rates of commercialization through patenting but also have high numbers of academic spin-offs than those which do not (O'Shea et al., 2004). Earlier Roberts (1991) proposed that a university's social norms and expectations are key factors in encouraging commercial activity. Thirdly, reputations including research prominence of universities are strongly linked to the rate of spin-off creation (Di Gregorio and Shane, 2003). Fourth, the regional knowledge infrastructure plays a vital role in supporting university spin-offs activity. Saxenian (1994), for example, illustrated that the formation of university spin-offs are more likely to happen in high-technology clusters because of easy access to local expertise, networks and knowledge.

The potential monetary, political and social pay-offs from such activities have motivated policy makers and university administrators to support these entrepreneurial activities,

the government element of the triple helix model. For instance, in the U.S., legislation was enacted to best to manage inventions that were created with the billions of dollars invested in government sponsored R&D. Of particular importance was the 1980 Bayh-Dole Act, which permitted a university, small business, or non-profit organization using Federal Funds to produce an invention to retain the title on any patent issued for this invention [1]. Subsequently, the commercialization of innovations developed by universities has surged from less than 3,000 in 1996 to over 10,000 in 2006 (Association of University Technology Managers (AUTM) 2006).

The ownership of academic IP is inconsistent across countries. For instance, unlike in the UK, universities in Sweden and Italy do not have the rights to IP of their staff (the Professor's Privilege). Additionally, the UK government has provided financial and political incentive structures to support R&D based entrepreneurial activity. By the year 2000, the number of spinoffs began to rise substantially in the UK. This was associated with an increase in the number of personnel working on technology transfer UK's universities (Lawton-Smith and Ho, 2006). In 2007/08, spin off companies from higher education institutions (HEIs) employed almost 4,500 people, had a turnover of more than £73 million and had acquired over £52 million in external investments (BIS 2009).

While many European nations have now abandoned the "Professor's privilege" (Geuna and Rossi, 2011), some US researchers, for example Kenney and Patton (2009), have criticized the university-ownership model in the US, and suggest instead an "Alternative model" with inventor ownership. Indeed, comparing the inventor ownership model of the University of Waterloo in Canada with the university ownership model of five US

[1] http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-901-inventions-and-patents-fall-2005/projects/bayh_dole.pdf

universities, Kenney and Patton (2011) conclude that this: "*...showed that the inventor ownership regime strikingly dominates the better funded, more highly rated, and much larger university ownership universities*."

They conclude that inventor ownership has a positive effect on entrepreneurship, and indeed their work is part of a growing literature in the US that critically addresses institutional ownership. The argument is that it is not necessarily the case that a Bayh-Dole-type institutional change will have a positive effect on technology transfer and economic growth. Kenney and Patton (2011) provided three examples where adopting a Bayh-Dole-type model has not been successful: Cambridge, UK (Breznitz, 2011), Japan (Carraz, 2008; Takahasi and Carraz, 2009) and Denmark (Valentin and Jensen, 2007). Of these, the University of Cambridge is the clearest case for showing that an inventor ownership model can be successful for transferring technology and encouraging entrepreneurship (Breznitz, 2011). Abandoning this model, to mimic the US Bayh-Dole model, in this case did not lead to increased technology transfer or entrepreneurship. Instead, there are indications that entrepreneurship, particularly in biotechnology declined.

In addition, most often, the academic entrepreneurial activities revealed by official statistics agencies are those that arguably take place inside the formal IP system such as industrial collaborations or consulting (Jensen and Thursby, 2001; Mansfield, 1995, 1998). In the U.S, the process of academic entrepreneurship is most often envisioned as a practice that begins with a disclosure of new invention to a TTO, which then turns into a patented discovery that is either licensed out to companies or exploited to create a new company (Fini *et al*, 2010). This process has received attention from scholars, including

studies of invention disclosure (Thursby and Thursby, 2005), patenting (Henderson *et al*., 1998; Mowery *et al*., 2002; Mowery and Ziedonis, 2002; Sampat *et al*., 2003), licensing (Jensen and Thursby, 2001; Jensen et al., 2003), and the exploitation of university-assigned IP to form new companies (Markman et al., 2004; Mustar et al., 2006; Nerkar and Shane, 2003, Shane 2004).

The narrow focus on academic entrepreneurship through the formal IP channel might significantly underestimate the entire amount of academic entrepreneurial activity and the pulsation of which academics involve in it (Fini, Lacetera and Shane, 2010, Jacobsson et al. 213). The multi-dimensional characteristics of university–industry linkages (Agrawal 2001; Bonaccorsi and Piccaluga 1994), which can also be considered as entrepreneurial activity, include a range of avenues (Cohen *et al.* 2002; D'Este and Patel 2007; Faulkner 1994) or 'mechanisms' (Meyer-Krahmer and Schmoch 1998) in which knowledge and resources are exchanged and co-created between universities and industry without any occurrence of IP disclosure through formal system.

In spite of such criticisms, there has been distinct move away from the Professor's privilege in Europe towards various systems of institutional ownership in the belief that the commercialization of research results will be facilitated (EU, 2007, 2008a; Geuna and Rossi, 2011). Sweden is now one of few European countries who have not abandoned the Professor's Privilege. This is so despite several national government investigations and repeated arguments by e.g. the OECD that Sweden should change this institutional setting. In a recent paper, Jacobsson, Lindholm Dahlstrand and Elg (2013) discussed this "dominant belief" and the commercialization of academic research in Sweden. They found strong indications that Sweden was performing quite well, both in terms of the

number of university sin-offs created and the amounts of patenting originating in Swedish Universities. They argue that in the Swedish case, where about 80 per cent of the academic patents were found to be assigned to industry, abandoning the Teacher's Exemption for a University ownership model could well have negative effects since it would risk disrupting the strong knowledge sharing networks. As Geuna and Rossi (2011, p. 1075) argue:

"In countries where university enforcement of IPR has traditionally been weak...because of the professor's privilege...academic inventors have...patented their inventions individually or assigned IPR ownership to collaborating firms. In these contexts, regulations ...enforcing university ownership may increase university-owned patents at the expense of university-invented patents. Care must be taken...not to disrupt pre-existing functioning knowledge transfer relationships between academic inventors and firms."

Jacobsson et al. (2013) concluded that there is strong evidence that a) substantial academic patenting activity takes place in Sweden, although 'invisible' without detailed scrutiny of patent data bases, and b) the IPR rests within the business community to a greater extent than in other countries – and that the transfer mechanism obviously works. They based this conclusion on a few earlier studies of academic patenting, e.g. Lissoni et al. (2009) which set out to specify this magnitude in several countries, including Sweden. In order to develop a database that captures patenting activity by academic researchers, they included academics not only as assignees but also as inventors. In this manner, they were able to capture patents held by individual researchers as well as by firms collaborating with an academic researcher who is the inventor, but not the owner. The share of academic patents, defined in that way, of total patents was found to be *at the*

same level in Sweden as in the U.S. (6 per cent) and higher than that of France and Italy.[2] The significance of this relatively high figure is magnified by the extensive patenting activity for Sweden as a whole. Hence, Swedish academics account for a high share of an internationally very high number of patent applications.

As mentioned, most of these Swedish patents are, however, *not* owned by the academics but by firms collaborating with Universities. Geuna and Rossi (2011, Table 5) point to a very high Swedish share of business ownership (81%), higher than other European countries. Moreover, the European shares are much higher than that of the USA. In the Swedish case, the top companies owning *academic* patents include the large multinational companies ABB, Ericsson, Pharmacia and UpJohn, Astra Zeneca, Telia, Siemens and Sandvik. These companies interact to a great extent with universities and obviously very often come out of that collaboration with the IPR.

In addition to patenting and university-industry networking, Jacobsson et al. (2013) also analysed different categories of university spin-offs. In earlier studies there is a great variety in definitions and measurement of university spin-offs. One main issue has to do with whether it is research/technology that is spun-off or if it is the individual researcher who leaves his/her employment to set up a new firm. In their definition of university spin-offs, Jacobsson et al (2013) included both direct university spin-offs and two categories of firms that involve spinning off *knowledge* from University research, see Figure 1. Direct university-spin-offs are established by university researchers themselves, both by researchers leaving the university and those staying and creating a side-line firm.

[2] The US share of 6 per cent is calculated by Lissoni et al., (2009), based on Thursby et al., (2009). For Sweden, Ejermo (2011) arrives at a figure of 4-5 per cent but using the same method of Lissoni et al., (2009), he adjusts the figure to 6 per cent (Ejermo, 2012).

Figure 1 Categories of spin-offs founded on Swedish university research

(Source Jacobsson, Lindholm Dahlstrand and Elg 2013)

Entrepreneur affiliated with the university[a]			
	no	external entrepreneur firm c. 100	indirect university spin-off firm c. 400
	yes	side-line firm c. 175	direct university spin-off firm c. 200
		Yes	No

Academic researcher staying at university[b]

[a] at the time of founding the firm, [b] after the founding of the firm

Among the indirect spin-offs, Jacobsson et al (2013) include firms established by previously employed university researchers (alumni) but not until the founder has worked an aditional time in industry. In addition are firms founded by an "external entrepreneur" who is not the university researcher, and therefore in the triple helix model could be classified as 'industry'. In these firms, the university researcher stays with the university and keeps his/her university employment. Taken jointly, they estimated that about 875 new firms were started every year based on university research in Sweden.

Unfortunately, Jacobsson et al. found no available international data that were directly comparable with the Swedish. One reason for this is that in countries with a university

ownership model, it is normally the IP and the disclosures that are measured, for example by university TTOs and associations like AUTM in the US. This means that in available spin-off data, information is not usually given about whether the university researchers have kept their university employment or not. Even so, they presented a rough comparison with UK and US spin-off data. The UK data were drawn from HE-BCI survey[3] and US data by AUTM.[4] Their finding was that the figures for both UK and US were of the same magnitude as the direct university spin-offs in Sweden (only quadrant 4 in Figure 1) (see Table 1). The AUTM reports some 400 to 650 university spin-offs each year, while the British HE-BCI survey reports between 150 and almost 300, i.e. within the range of the figures for Sweden.

[3] Funding of British HEIs (Higher Education Institutes) partly depends on spin-off creation, and, thus, the data reporting is not likely to be an underestimation. See http://www.hefce.ac.uk/econsoc/buscom/hebci/ This data is collected annually from British HEIs since 2003.

[4] The AUTM data only report spin-offs based on disclosures registered at participating universities. It should be noted that the AUTM studies only include data from less than 200 US Universities. These universities are, however, the most research intensive ones. AUTM data for 2004 to 2010 is available at http://www.autm.net/home.htm

Table 1: Swedish, British and US university spin-offs (source: Jacobsson et al. 2013)

	Sweden (SCB)[a]	UK (HE-BCI)[b]	US (AUTM)[c]
2010	Na	268	651
2009	348	206	596
2008	396	191	595
2007	366	221	555
2006	388	226	553
2005	381	187	527
2004	378	148	462
2003	259	167	Na
Average	359	202	563

[a] Data from the MONA database, Statistics Sweden (SCB). The data include direct university spin-offs where the researcher left the university the same year as the new firm was founded.

[b] Data from the HE-BCI survey. It includes Formal spin-offs, with direct application of HEI-owned IP.

[c] Data from the AUTM licensing survey. Spin-offs are dependent on the institutions' IP, and thus equivalent to those in the UK HE-BCI survey.

In the Swedish data, however, the number of spin-offs is underestimated since they only include direct university spin-offs founded by university staff that set up the spin-offs directly after leaving university employment. The national data do not include university researchers creating firms while continuing university employment, nor do they include indirect spin-offs set up after more than one year, or university research being commercialized by someone other than the university researcher (external entrepreneur). Jacobsson et al argue that if these firms were also to be included, the Swedish figures would be at least doubled – the uncertainty is considerable.

Moreover, since the US and the UK data only report spin-offs based on disclosures registered at participating universities, that is, within the IP system, this would suggest that the corresponding figures in Table 1 is seriously underestimated. This problem was discussed by Fini et al. (2010) who found that only 35 percent of new firms started by university researchers in the US were based on patented inventions within the IP system. Correcting for this would mean that the US figure should be increased to about 1 600 spin-offs per year. In an additional US study, Åstebro et al. (2012) instead used SESTAT data to identify university spin-offs in the US. They followed established practice using SESTAT data and defined start-ups as those cases where faculty switched principal employment from university to own business, i.e. similar to those in quadrant 4 above. They found 622 spin-offs in the data (equivalent to 125 firms annually) and by scaling this up to represent a national estimate they arrived at 2 571 university spin-offs per year. Jacobsson et al concluded, however, that even using this higher US figure, the Swedish performance is impressive, and that this has been the case for a long time.

The research on academic entrepreneurship outside the IP system has been undertaken extensively in the U.S., while there, to the best of our knowledge, are no such studies carried out in European context. This, therefore, constitutes the raison d'etre of this study to inform and provide faculties, universities and policy makers with more accurate picture on academic entrepreneurial activities and parameter than the only mechanism of patents disclosure via formal IP channel.

3. Method

This paper uses two case studies – Oxford University in the UK and Chalmers University in Sweden – to analyse and compare technology transfer and university entrepreneurship in two different institutional contexts.

The Oxford Case

The University of Oxford is one of the world's top universities. Oxford offers more than 320 different graduate degree programmes and has over 9,800 graduate students from more than 140 countries and territories, over 5,500 graduate research students and nearly 12,000 undergraduates. Oxford's research activity involves more than 70 departments with over 10 000 employees, including 1,600 academic staff and 3,000 research staff. In 2011-12, total University income was £1,016.1m, out of which about half was research. External research grants and contracts is the University's largest source of income. In 2011-12, 40% (£409 million) of income came from external research sponsors.

In a world university rankings published by Times Higher Education in 2012/13, Oxford University is ranked 2nd. Its place in this ranking is owing to unique qualities, i.e., high concentration of "world-class scientists", the world's second best university in medical and the fifth best university in biological science disciplines (QS World University Ranking, 2012), as well as a number of interdisciplinary research centres, which some have links with international academic and industrial partners (Lawton Smith and Ho, 2006).

Oxford University has an elite and very well-established commercialisation system; it also creates three times as many spin-offs as UK universities on average. The key mechanism for creating university spin-offs is through Isis Innovation, the university's

technology transfer company, established in 1988. Commercialisation activities, however, only started to take off and expand in 1997 following the appointment of a successful entrepreneur and business angel as CEO (Lawton Smith and Ho, 2006). Since then, Isis Innovation has been in charge of generating spin-off firms based on academic research produced within and owned by the University. So far it has supported the formation of more than 70 companies. It has created a new spin-off company every two months on average (Isis Innovation, 2013). Since 2000, external investment of over £266 million has been raised by spin-off companies, and 5 Oxford spin-off firms are presently listed on London's AIM market. Besides, in 2012, Isis Innovation filed 100 patent applications on behalf of the University; it also manages over 470 patent application families as well as 700 license agreements (Isis Innovation, 2013). It is claimed that licensees and commercial partners are solicited from both national and international technology and business sectors. In the Oxford case we use a sample of university spin-offs which is drawn from the existing database of 75 companies spun out from the University of Oxford and published on the Isis Innovation website.

In the data collection process, first we use the ICC Directory of UK Companies provided by Lexis Nexis and Companies House, which contains detailed profiles of the companies (<http://www.lexisnexis.com/uk/nexis/search> and Companies House <http://wck2.companieshouse.gov.uk>) which contained detailed profiles of the companies including the company's registered address, date of incorporation, board of directors, any subsidiaries which the company may own, key facts about the companies, and financial data. In this study, we identified and listed names of directors of all 75 Oxford spin-off companies. Second, we cross-checked all director names with the University of Oxford's contact search database to find out who is an academic and in

which departments or colleges he/she is currently working. However, the database does not provide the period(s) of employment with the University of Oxford. Third, to investigate the patents' profile of the Oxford university academics, patent searches were done via the Espacenet of the European Patent Office. ESP@CENET <http://gb.espacenet.com> on the European Patent Office website includes records of the patents filed by companies which can be accessed and searched by a range of criteria such as applicant name, inventor name, and so on. We conducted the search by inputting the name of an academic as an "*inventor*" and put in different applicants beginning with (i) "*name of academic*", (ii) "*Isis Innovation*", and (iii) "*company name*". This patents search process is repeated for all academics in the database.

We recorded the following details of the patents: i) number of patents, ii) publication date (the date when the patent is filed) iii) applicants or assignees iv) European classification number. In addition, we noted down whether the patents were assigned to Isis Innovation or the University of Oxford, or, otherwise, were filed under other names. This is used to determine if the patents filed stay within the University IP system or have bypass potential. We also report on the size of university spin-offs (employees and turnover) within the university system and with a potential bypass.

The Chalmers case

Chalmers University of Technology, in Gothenburg, Sweden, is one of the oldest and largest institutes of technology in Sweden. It offers Master of Science degrees, Bachelor degrees and doctoral degrees. Research is carried out in the main engineering sciences as well as in technology-related mathematical and natural sciences. Some 2 300 employees work at Chalmers' 17 departments. Of these some 1600 are teachers and researchers.

The turnover is around SEK 2.7 billion a year (2011); two-thirds of this sum relates to research. Thus, Chalmers amount of research is around a third of Oxford's (i.e. 30% of research income, 34% of research staff).

Since 2000 Chalmers has a vice-president who is responsible for external relations. A strategic decision is that the processes of knowledge transfer and commercialization should be fully integrated with Chalmers research and education activities. In recent years the 'knowledge triangle' has served as a model for Chalmers, i.e. the integration of the three roles of research, training and utilization. Approximately 60 full-time equivalents work with knowledge transfer and commercialization at Chalmers. In addition several hundreds of persons from business work pro-bone as advisors, board members, industrial faculty, etc., thereby supporting Chalmers' knowledge transfers and commercialization activities. On behalf of the Ministry of Education, Chalmers established the so called Innovation Office West, in 2011. This Office has a role as an innovation advisor to Chalmers as well as seven other regional HEIs. In 2011, the Innovation Office established a support role for research-verification, where 37 validation projects were started which include analysing the commercial potential of research results.

Venture creation is another important process for Chalmers' commercialization of new knowledge. Through the combination of the entrepreneurial school, incubators and seed investments, with an emphasis on active ownership, Chalmers has continued to achieve great success with respect to this value creation process. In 2010, the portfolio companies in the Chalmers venture creation process had a turnover of over 430 million SEK.

By the creation of strong links between education and exploitation of knowledge, Chalmers School of Entrepreneurship has developed a unique venture creation model that has been recognized both nationally and internationally. The idea with this action-based school is to educate people, not about entrepreneurship, but through entrepreneurship. Through this Chalmers contributes with entrepreneurial graduates to the regional / national innovation system. In 2011, Chalmersinvest, Encubator Holding (linked to the School of Entrepreneurship) and Chalmers Innovation Seed Fund invested 20 million SEK in new ventures.

In the Chalmers case the university has provided a list of the names and home addresses of every faculty employee as of spring 2012. Out of the 1191 researchers we excluded visiting professors and others with a temporary employment, ending up with a list of 921 professors, docents, lecturers, and post docs. We used the database Retriever to identify all kinds of private company activities of these researchers. We found 276 persons with some kind of company engagement. After excluding for example sole proprietorship and engagements as director of the board in other kinds of organizations, we finally identified 207 incorporated firms created by Chalmers faculty. We used the Espacenet to do a patent search for all the identified university spin-offs as well as for the individual researcher who had created the spin-off.

To complement the data on spin-offs in the Chalmers case we also used the MONA database of Statistics Sweden to find university spin-offs created by faculty who has left the employment at the university. This data consist of Swedish matched employer-employee panel data where we can find information on all new university spin-offs set up by researchers leaving the university between 1997 and 2009. In doing so we found 62

firms created by former Chalmers employees. Unfortunately the use of this database didn't allow us to identify the firms or the patents held.

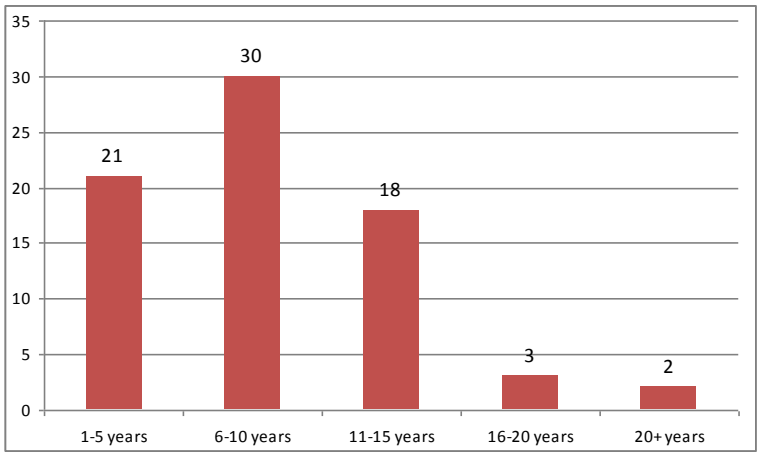
4. Findings

In this section we are presenting facts about the spin-off firms from each of the two universities. This includes data on the firm's patenting and performance, and on the university affiliation of the academic directors.

The university spin-off firms

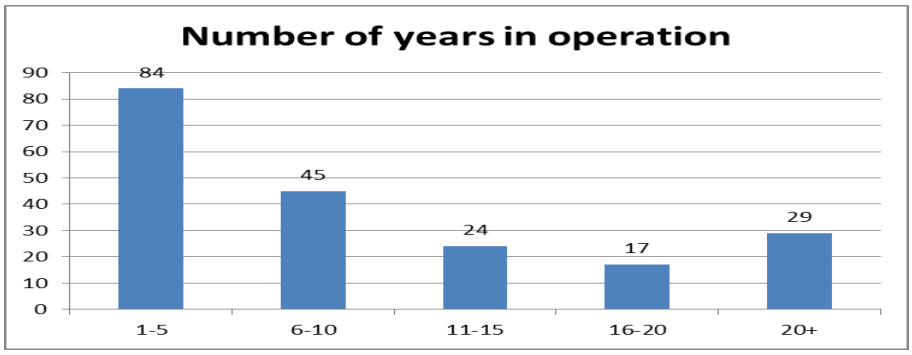
First, for the 75 spin-offs from Oxford University, we found that one company is a non-trading company and 9 companies are dissolved or in liquidation. Also, one company is registered in Belgium, hence there is no information registered in the UK Companies House. More than 50 companies have operated between 1-10 years, 18 companies have been in operation between 11-15 years, while only 5 companies have been in business longer than 16 years (Figure 2).

Figure 2: Number of Years in Operations – Oxford spin-offs



For Chalmers we identified a considerable higher number of university spin-offs, a total of 207 incorporated firms created by researchers still employed at the university in spring 2012. Out of these eight are no longer active, and we lack data of founding year Thus, out of the 921 academic researchers employed at Chalmers in 2012, there were 129 researchers (14%) who had created an incorporated firm. This means that researchers active in company formation on average started 1.67 incorporated firms. The oldest four firms were established in the 1960s, and the average age of all 199 firms (where we know the founding year) was 11,26 years.

Figure 3 Number of years in operation: Chalmers spin-offs



In addition to analyse spinoffs set up by researchers employed at Chalmers University we also used the Swedish MONA database of Statistics Sweden to find out the total number of spin-offs created from Chalmers University The MONA database consist of Swedish matched employer-employee panel data where we can find information on all new university spin-offs set up by *researchers leaving the university*. The database provides information on spin-offs created between 1997 and 2009. In this period, there were a total of 164 new firms created by Chalmers researchers (excluding post-docs, PhDs and visiting researchers). Out of these we found 62 spin-offs where the researcher, in the first year after start-up, had gained a higher income from his/her own firm than from a

university employment. These 62 firms are then – most likely – direct university spin-offs where the researcher has left his/her university employment. Thus, these firms are in general not included among the 207 firms identified among the researchers still employed at Chalmers. We can therefore conclude that Chalmers's academic researcher generates far more spin-offs than is the case in Oxford. Moreover, that this is not a recent phenomenon.

Figures 4 and 5 show the sectors where the university spin-offs are established. Figure 4 shows the diversity of the Oxford companies; the largest group within the sampling firms is in pharmaceutical and biotechnological sector, followed by engineering, software and chemistry sector respectively. The Chalmers spinoffs, Figure 5, are dominated by engineering firms (out of which "research and consulting" is the largest group). Medtech and biotechnology spin-offs are not very frequent, something which is of course related to the fact that Chalmers is a technical university without any medical research. We do not find any "research and consulting" spin-offs in the Oxford case. Probably such firms exist, but are not recorded and owned by Isis Innovatiom. However, if we exclude the "research and consulting" spin-offs from Chalmers, we still find 105 university spin-offs from Chalmers. With respect to Oxford University's research being three times the size of Chalmers, this is a very high figure.

Figure 4: Sector- Oxford spin-offs

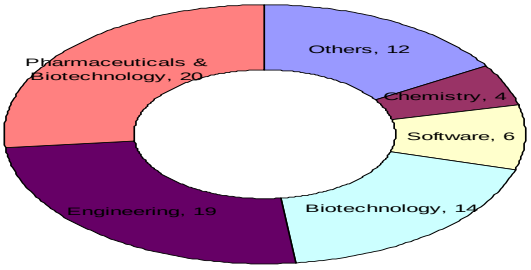
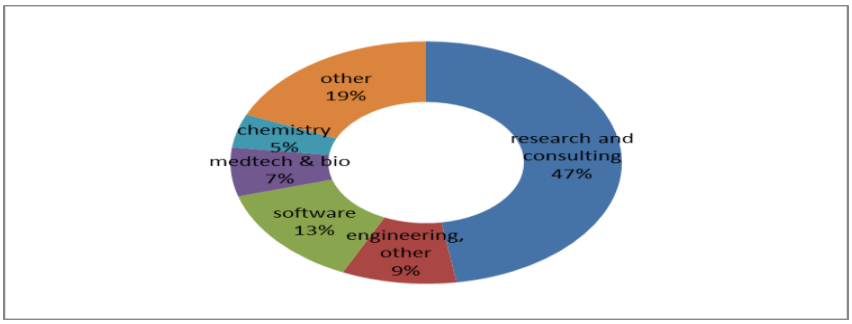


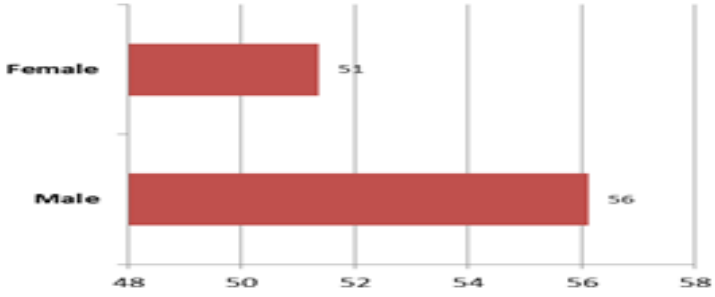
Figure 5: Sector- Chalmers spin-offs



Academic Characteristics and Patents Ownership

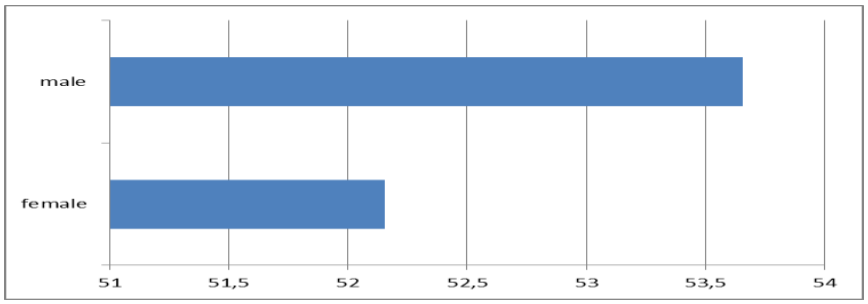
There are 122 academics from the University of Oxford involved in spin-off companies: 114 are male and 8 female. The average age for male academics is 56 years old, while 51 years old for female academics (Figure 6). The average number of patents among male academic is 6.7 and 2.6 for female academics.

Figure 6: Gender and Age - Oxford spin-offs



Despite being a technical university with relatively few female researchers, the share of women directors is higher in the Chalmers case. While only 6.6% of the academic directors in the Oxford spin-offs were women, the corresponding figure in the Chalmers spin-offs is 15%. As can be seen in Figure 7, also in the Chalmers spin-offs the male founders are slightly older than the females; 53.7 years vs 52.2 years. In the Chalmers spin-offs the average age of the founder is 53.42 years.

Figure 7: Gender and Age- Chalmers spin-offs



There are very large differences between the two cases when we compare the frequency of patenting in the spin-offs (Figures 8 and 10). Figure 8 shows that more than half of the academic directors from Oxford own 1-10 patents, while as many as 27 of them possess more than 11 patents. In addition, we discovered that 47% of the Oxford spin-offs' patents were filed within the University IP system, whereas 53% of patents have filed outside the University IP system (Figure 9).

Figure 8: Number of Patents Owned by Academics in Oxford spin-offs

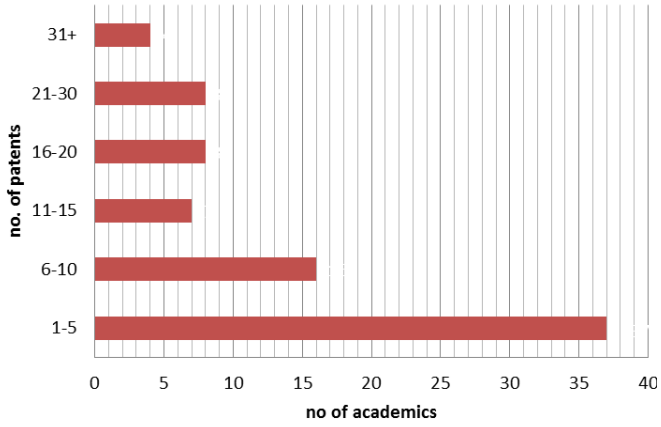
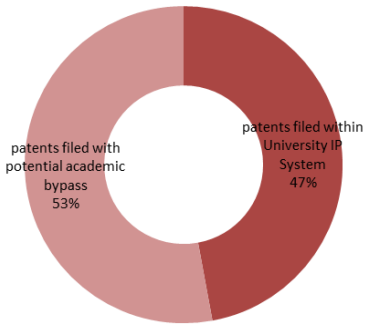
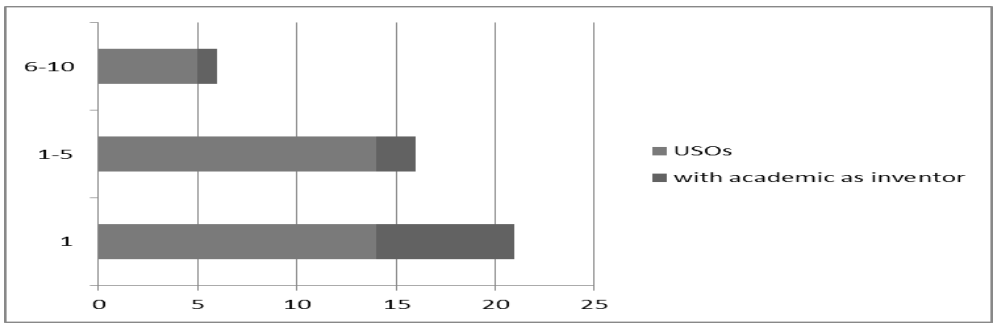


Figure 9: Number of Patents filed within Oxford University IP System and Number of Patents with Potential Academic Bypass



Most of the academics in the Chalmers spin-offs do not own any patents (Figure 10). Together all the 199 spin-offs own 94 patents. Only 33 of the spin-offs have any patents at all. No firm holds ten patents or more. Moreover, it is not always the academic him/herself who is registered as the inventor. In fact, only 17 of the 129 academic directors have invented patents owned by their own firms. Together these individuals have 39 patents.

Figure 10: Number of Patents in Chalmers spin-offs



Since the Swedish law gives the IP rights to the individual academic researcher, there cannot be any bypassing within the Swedish system. But, as was found by Lissoni et al (2009) and Geuna and Rossi (2011), in the Swedish case academic patents are most often

applied by existing firms. Elaborating a bit with the KEINS data[5] for Chalmers we find that between 1980 and 2001 the database includes 102 Chalmers-invented patents and 39 academic inventors. However, the assignees of the Chalmers patents are mainly (68.6%) large existing firms, over 50% of the patents are assigned to five large companies (Ericsson 22.6%, Kvaerner 8.8%, Pharmacia&UpJohn 7.8%, EKA 5.9%, Berol 5.9%). Only 21.6% are assigned to university spin-offs (15 start-up firms). Using the Espacenet to do a patent search for these 15 university spin-offs we found that they own 104 patents, (out of which 22 included in KEINS data). 36 of these were granted between 1980 and 2001 and 68 between 2001 and 2011. This means that the average spin-off firm held 6.93 patents. Thus, in the Chalmers case, where the IP rests with the academic inventor, this leads to a high share of patents being assigned to large existing firms. Few of the university-spin-offs are patent-based, but there is a fraction of spin-offs that are assigned a relatively high number of patents.

Size of the University spin-offs

The size distribution of spin-off companies in the Oxford sample by employees and turnover is shown to be very similar for those within the Isis Innovation system and those which were formed outside (Table 2). Taken together the 75 Oxford spin-offs employ almost 4 000 persons, and have a turnover of 430 million pounds. Thus, in the Oxford case the 4600 academic and research staff has generated an additional 4000 new jobs in the spin-offs (a ratio of 3959/4600=0.86).

5 The KEINS database on academic inventors contains detailed information on university professors from France, Italy, and Sweden, who appear as designated inventors on one or more patent application registered at the European Patent Office (EPO), 1978-2004. It was produced for the EU-sponsored project on Knowledge-based Entrepreneurship: Innovation, Networks and Systems, and is made available to all interested researchers through the CESPRI website. http://www.cespri.unibocconi.it

The majority of firms are however small (nearly three quarters). The exception being that there was one large company that did not go through Isis Innovation (1834 employees and a turnover of 337 million pounds). On this basis, the route taken to commercialisation and therefore the impact of the institutionalisation process has no significant effect.

Table 2 Number of employees and turnover in Oxford spin-offs inside and outside the Isis Innovation system

No. of employees of companies	with bypass potential (n=41)	within Isis system (n=34)	Turnover of companies	with bypass potential (£, n=41)	within Isis system (£, n=34))
N/A	6	0	N/A	9	3
0 (dissolved)	4	3	- 0	3	4
			1-25k	6	4
			25k-50k	0	1
1-10 (micro)	11	13	50k-100k	3	1
			100k-250k	1	5
11-50 (small)	9	9	250k-500k	4	3
			500k-1m	3	4
50-250 (medium)	10	9	1m-10m	10	8
250+ (large)	1[a]	0	10 m+	2[a]	1
Total employment	**3079**	**880**	**Total turnover (k£)**	**401 865**	**28 758**
Mean employment	**75.1**	**26.0**	**Mean turnover (k£)**	**9 802**	**846**

a) One Oxford spin-off with bypass potential is a large outlier (1834 employees and a turnover of 337 300 k£). Excluding this firm reduces the total employment into 1614 employees (average 31.1 employees) and the turnover into 64 565 k£ (average 1 614 k£)

The pattern for turnover is rather more varied. On the whole, more of those which have bypassed the system have a higher turnover, which might suggest an association between the ownership regime and performance i.e. that for the larger firms, not being owned by the university has some impact on turnover. However, in both groups there is an indication of higher performance as measured by turnover (29% of bypass, and 26% of those within the system) which is probably a more realistic measure of performance than

employees as entrepreneurs are less likely to be interested in employment growth than in turnover and by implication profitability (see Storey and Greene 2010).

As already mentioned, with the Professors Privilege, bypassing is not an option. But, as shown above, only very few of the Chalmers spin-offs are patent-based firms. To see if this affects the performance of the Chalmers spin-offs we choose to separate spin-offs with and without patents. Table 3 presents the number of employees and the turnover (in pounds) of the Chalmers spin-offs.

Table 3 Number of employees and turnover in Chalmers spin-offs (with and without patents)

No. of employees of companies	with patents (n=33)	without patents (n=166)	Turnover of companies	with patents (£, n=33)	without patents (£, n=166)
N/A	3	26	N/A	3	26
0	7	59	- 0	5	31
			1-25k	8	23
			25k-50k	2	18
1-10 (micro)	20	68	50k-100k	1	17
			100k-250k	5	16
11-50 (small)	3	10	250k-500k	2	12
			500k-1m	2	9
50-250 (medium)	0	3	1m-10m	5	12
250+ (large)	0	0	10 m+	0	2
Total employment	**126**	**683**	**Total turnover (k£)**	**17 016**	**80 596**
Mean employment	**4.2**	**4.9**	**Mean turnover (k£)**	**583**	**633**

Taken together the Chalmers spin-offs employ approximately 800 persons, and have a turnover of 106 million pounds. On the average each firm had 4.8 employees and a turnover of 623 k£, figures considerably lower than for the Oxford spin-offs. Also, the ratio between generated spin-off employment and academic and research staff is lower in

the Chalmers case (809/1600= 0,506). However, if the Oxford outlier is excluded(a ratio of (3959-1834)/4600=0,27) the Chalmers ratio is in fact higher.

Also noteworthy in Table 3 is that the spin-offs without patents outperforms the 33 Chalmers spin-offs with patents. Moreover, checking figures of profitability among the Chalmers spin-offs show that the patent-based ones in fact generates a loss (on average a loss of 100 k£ in 2011) while the non-patent-based spin-offs instead are more profitable (on average 27 k£ in 2011). Thus, the majority of the Chalmers spin-offs are small non-patent-based firms with a small profitability.

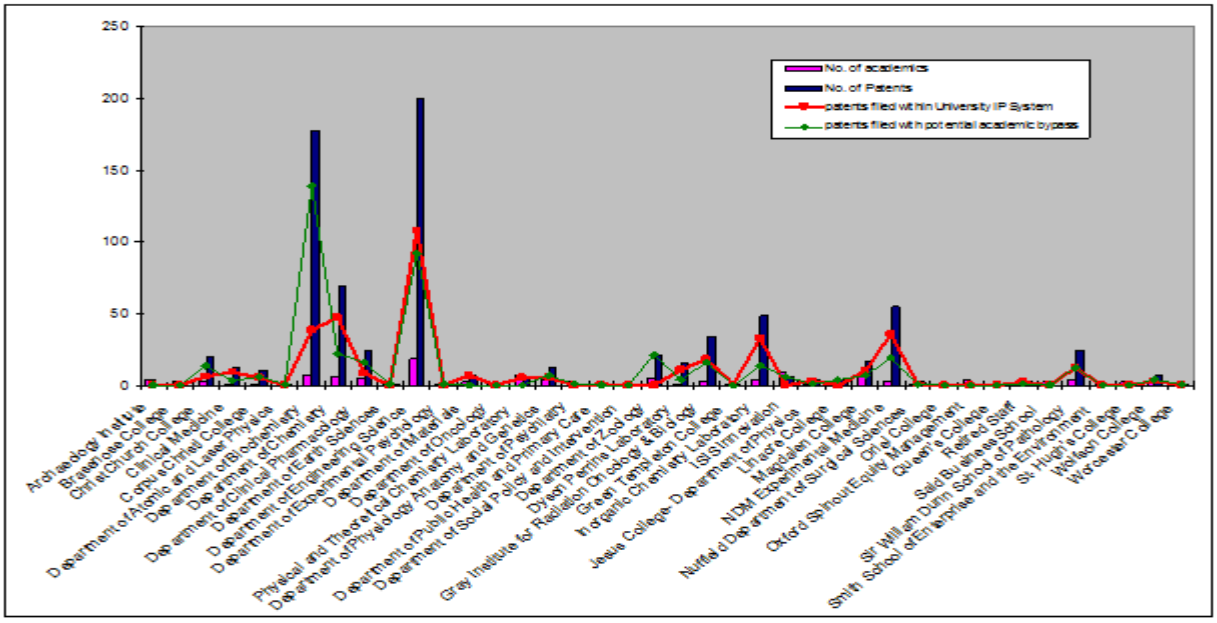
University affiliation of academic directors

Academics, who are involved in Oxford spin-off activities, are from 40 (out of Oxford's 70) departments and Colleges. More than half of the departments and Colleges in the sampling only produced 1-2 spin-off companies. However, 16 spin-off companies are created from the Department of Engineering Science, followed by 7 companies spun out from the Physical and Theoretical Chemistry Laboratory, and 6 companies from Department of Chemistry, Department of Biochemistry and Magdalen College respectively.

The consolidated picture of data (e.g., number of patents, number of academics, number of patents filed within the University IP system, and number of patents with potential academic bypass) illustrates that academics from the department of Engineering Science owned a high number of patents, in which the number of patents disclosed within the University IP system is slightly more than the number of patents filed outside the formal IP system. Conversely, the different pattern has been observed for academics from the

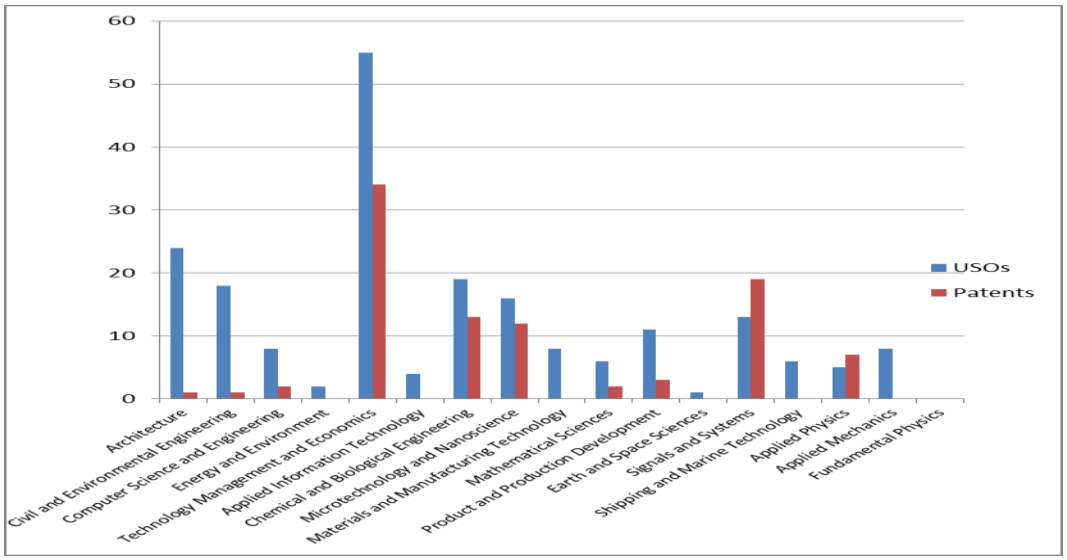
department of Biochemistry. They are more prone to filing patents outside the IP system. This can possibly be explained by the potentially higher commercial value of the patents (Figure 11).

Figure 11: Number of Patents by Departments/College and Number of Patents Disclosed Within and Outside Oxford University IP System



In the Chalmers case the university does not own the IP, and thus, bypassing is not possible. Instead Figure 12 is used to illustrate the frequencies of both spin-offs and patenting from the 17 Chalmers departments.

Figure 12: Number of Patents and spin-offs by Chalmers Departments



As can be seen in the figure the highest number of spin-offs and patents has originated from the department of Technology Management and Economics. At first this might seem odd, but is easily explained by the fact that researchers at this department are active in the Chalmers School of Entrepreneurship with its unique venture creation model. In addition, the departments of Chemical and Biological Engineering, Microtechnology and Nanoscience, and Signals and Systems, also generates a relatively high share of spin-offs and patents. The departments of Architecture and Civil and Environmental Engineering also generate many spin-offs, even though these in general do not hold any patents.

5. Discussion and Conclusions

In this paper we asked how different institutional settings affect the commercialization/exploitation of university research in Europe? What does this tell us about commercialisation processes within the triple helix model? We found that institutional settings matter in the rate and type of entrepreneurial activities (spin-off companies and patents). However, performance indicators of employment size and

turnover were less conclusive in the Oxford case. There was some association between not being formed through Isis Innovation and higher turnover. This is consistent with Markman et al (2004) who found that university incentives to academics and departments did not contribute to higher rates of formation or to the performance of university spin-offs.

The most important finding is that universities can contribute to entrepreneurship and act entrepreneurial even when the IP rests with the university inventor, a function of decisions made within the prevailing system of government. Moreover, as illustrated in the Oxford University case, a considerable amount of university entrepreneurship does take place outside the formal IP system by industry. This potential bypassing is not necessarily a problem that universities should try to stop - not one that implies an unravelling of the triple helix system. To encourage university entrepreneurship an entrepreneurial university could also try to encourage the kind of entrepreneurship that is not necessarily based on university IP. Thus a triple helix model which assumed linearity associated with ownership and control of university IP would not be optimum.

By way of illustration, we found 75 spin-off companies where 122 academics from the University of Oxford are involved as company directors. In Chalmers, with only a third of the research activities performed at Oxford, we found as many as 129 academics with 207 university spin-offs (199 still active) among the academics still employed at the university. Analysing Chalmers University spin-offs created by researchers who left the university to set up a new firm, we found 62 more spin-offs between 1997 and 2009. Thus, we could conclude that Chalmers researchers generate a high number of university

spin-offs. This is true even if we exclude a large group of firms doing "research and consulting", a category that was not recorded among the Oxford spin-offs.

Instead we found a considerable amount of patents among the Oxford spin-offs. The average number of patents among these is 6.7 for male academics and 2.6 for female academics. In addition, we discovered that 47% of the patents were filed within the University IP system, whereas 53% of patents were filed outside the University IP system. In the Chalmers case we found that 33 of 199 spin-offs together held 94 patents. This is a figure significantly below that in the Oxford case. Instead it was argued that in the Chalmers case, where the IP rests with the academic inventor, this leads to a high share of patents being assigned to large existing firms. Few of the university-spin-offs are patent-based, but there is a fraction of spin-offs that are assigned a relatively high number of patents.

Our findings are consistent with previous studies, which show that a significant percentage of academics do not engage in the entrepreneurial activities through formal IP channels. The idea of an entrepreneurial university rests on the idea that universities can and may act entrepreneurial themselves, for example by exploiting and commercializing academic research. This is often done through the formation of technology transfer offices with a specific task to commercialize university IP, both through licensing knowledge and set up of university spin-offs. In this way, entrepreneurial universities are often assumed to contribute and encourage university entrepreneurship. In other institutional settings where universities themselves do not own the research results and IP, one of the basic conditions for an entrepreneurial university simply does not exist. Even so, as demonstrated in this paper, this does not hinder university entrepreneurship. In fact,

as found in the Chalmers case, university entrepreneurship can be very frequent even in cases where the rights to commercialize research results rest with the academic researcher.

Furthermore, our results indicate that even though there is a high frequency of university spin-offs in the Chalmers case, these are small and usually not based on patents. Compared to the Oxford case, the Chalmers spin-offs are considerably smaller, often acting as consultants. Interesting, the patent-based Chalmers spin-offs are not performing as well as the non-patent-based ones; they are both smaller and less profitable. Having spin-offs acting as consultants can of course be important when the spin-offs functions as research boutiques and transfer research results to other companies and organizations which use the IP to create growth and renewal. To further analyse the effects of technology transfer from university spin-offs it is an important task for further research.

One limitation in this study is that due to the lack of data on period(s) of employment with the University of Oxford, this study cannot conclude authoritatively on the academic bypassing of Isis Innovation/University of Oxford for the disclosure or exploitation of their inventions. Even though the case provided in this study is drawn from a single institution and the data is rather descriptive, our findings appear to be consistent with previous studies, which showed that a significant percentage of academics do not engage in the entrepreneurial activities through formal IP channels.

Our findings thus have some suggestions to the modus operandi of academic entrepreneurship. An attempt from policy makers or university administrators to highlight the importance of intellectual property rights towards academic

entrepreneurships seems to be focusing only on a fraction of academic entrepreneurial activities, whereas omitting some vital portions of them. In addition, the existing Oxford system that the entrepreneurial activities are expedited through Technology Transfer Office falls short in supporting a substantial segment of academic entrepreneurial activities, which take place outside of the formal university IP system. Otherwise, the aim and attempt of universities to employ academic entrepreneurship for the creation and contribution to regional economic development might be undermined versus its prospect.

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