The purpose of this thesis is to identify patents invented by researchers at Lund University, to describe the university inventors, and to understand the main factors that influence their patenting activities. The analysis focuses on inventors in relation to their environment. A number of factors influence scientists' decisions to patent. Internal factors related to individuals such as solving the research puzzle, demonstrating the quality and novelty of the research, and enhancing professional reputation are the main internal factors that trigger researchers to patent. Although external factors such as TTOs and the Third Task are relatively more important for some inventors, internal factors are still the predominant factors. The thesis has also suggested a typology of inventors to show the differences in the level of patenting and in the way they applied for patent and commercialized. This nuanced heterogeneity among inventors emphasizes the need for caution in generalizations, especially regarding the roles and influences of patent legislation and TTOs in university patenting. Adaptive and flexible institutions and organizations may enable scientists to patent by providing them with the necessary resources and skills they may need for patenting rather than applying standard solutions to different cases. This study has made empirical and theoretical contributions to the literature by developing a focus on individual inventors and by emphasizing the characteristics of these inventors and of their external environments. Hence, this dissertation may provide both theoretical insights and empirical evidence to scholars investigating university patenting and inventors. It may also provide insights to policy makers and university administrators on the appropriate roles of institutions and organizations in promoting and assisting patenting activities of university researchers.

LUND UNIVERSITY

Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE)
and
Department of Design Sciences

Devrim Göktepe Inside the Ivory Tower

Inside the Ivory Tower

Inventors & Patents at Lund University

Devrim Göktepe

Biography

Devrim Göktepe is a researcher at CIRCLE, Lund University, Sweden. This book is her doctoral thesis. She is currently a research fellow at Max Planck Institute for Economics, Germany. Her research interests are university industry technology transfer, intellectual property rights, academic entrepreneurship and the role of technology transfer organizations (TTO) in university industry relations. She studied at the Samuel Neaman Research Institute Israel Institute of Technology (Technion), Israel and at the Faculty of Economics and Administrative Sciences at Middle East Technical University (METU), Turkey.

Inside the Ivory Tower

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Devrim Göktepe

Thesis for the degree of Doctor of Philosophy

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To my family
with all my love

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Glossary

Applicant: The patent applicant is normally one or more individuals, a firm or another organization responsible for the patenting costs, and who/which may assume ownership if the patent is granted. The applicants can be different from the inventors who developed the idea represented in the patent.

Bayh-Dole Act: The Bayh-Dole Act (or University and Small Business Patent Procedures Act) is a piece of United States legislation from 1980. Among other things, it gave US universities, small businesses and non-profit organizations intellectual property control of their inventions that resulted from research funded by the federal government. The act, sponsored by two senators, Birch Bayh of Indiana and Robert Dole of Kansas, was enacted by the United States Congress on December 12, 1980.

Business Angels: Informal investors; private individuals who, in addition to providing capital, may also offer their expertise on business development for start-ups and growing enterprises.

Institutions: Sets of common habits, norms, routines, established practices, rules or laws that regulate the relations and interactions between individuals, groups and organizations. They are the rules of the game. In this thesis, patent legislations and the third task are referred as institutions.

Inventor: The inventor has developed the idea (knowledge) represented in the patent. The inventor of a patent can be collective (co-inventorship) or single. Inventors can be affiliated with universities, research institutes, public organizations and firms, or they can be independent.

Matthew Effect: The Matthew Effect was a term coined by Robert K. Merton to describe how, among other things, an eminent scientist will often get more credit than a comparatively unknown researcher even if their work is similar. It also means that credit will usually be given to researchers who are already famous: for example, a prize will almost always be awarded to the most senior researcher involved in a project, even if most of the work has been done by a graduate student.

Organizations: Formal structures that are consciously created and have an explicit purpose. They are players or actors. In this thesis, technology transfer organizations and /or offices are referred to as organizations.

Spin-off Firm: A new firm that is formed on the basis of university research results or patents and where a university employee is involved in the formation of the firm.

Systems of Innovation: The determinants of innovation processes, i.e. all important economic social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations.

Technology Transfer Organization (TTO): In this thesis the TTOs referred to as all types of organizations and agents that aim to facilitate patenting, licensing and spin-off formation and other commercial activities that are related to e.g. university research. These organizations help researchers to apply for patents, and offer financial assistance with making patent applications and starting new businesses. Among others, examples of such organizations in Southern Sweden are LU Innovation (Lund University TTO), Teknopol, Forskarpatent, Innovationsbron AB, incubators, and so forth. In the US context TTOs mainly refer to university technology transfer offices for patenting, licensing and spin-off company formation.

The Third Task (Tredje uppgiften): The two primary tasks of universities and colleges are to educate and to promote research. There is, however, a third task: to cooperate with organizations and companies, associations and individuals for the purpose of contributing to local and regional development. The universities' task of informing society about their research has been part of the Higher Education Act since 1977. In 1996 the Higher Education Act was changed to state that universities should 'cooperate with the surrounding community and inform it about its operations' (SFS 1996: 1392). Part of the third task is also to promote technology transfer, patenting, entrepreneurship and commercialization.

University Teacher's Exception (Lärarundantaget): This term was introduced in the 1949 act on the right to inventions of university employees. According to the teacher's exception, teachers at universities own the right to commercially exploit the inventions they make in the context of their employment. Inventions, for example, may be results of research. This gives university instructors and researchers the exclusive right to sell, license, exchange or give away their results to anyone they wish.

University-Invented Patent: University-invented patents are defined through the affiliation of their inventors with a university. Such patents have at least one university employee as an inventor. An inventor, a TTO or a firm may apply for the patent.

University-Owned Patent: University-owned patents are patents in which universities or university TTOs are listed as applicants. Such patents are usually applied for and managed by a university TTO.

Venture Capitalist: An investor or organization that invests in businesses with a considerable level of risk. The venture capitalist is willing to invest in a medium- to high-risk business in exchange for a very high level of return for accepting this level of risk.

Abbreviations and Acronyms

AB	Aktiebolag(et) (used with names of companies, English translation Ltd., Inc., Co.)
AUTM:	The Association of University Technology Managers
EPO:	European Patent Office
HSV:	Högskoleverket (Swedish National Agency for Higher Education)
IPR:	Intellectual Property Rights
LTH:	Lunds Tekniska Högskola (Lund Institute of Technology, Faculty of Engineering)
LU:	Lund University
LUR:	Lund University Researchers
LUIS:	Lund University Innovation Systems
LUP:	Lund University Patents
MF:	Medical Faculty (Faculty of Medicine)
NS:	Natural Sciences Faculty (Faculty of Natural Sciences)
NUTEK:	Swedish Agency for Economic and Regional Growth (Verket för näringslivsutvecklung)
PRV:	Swedish Patent and Registration Office (Patent och registreringsverket)
R&D:	Research and Development
SMEs:	Small and Medium Sized Enterprises
SSF:	Swedish Foundation for Strategic Research
TTO:	Technology Transfer Office
UITT:	University-Industry Technology Transfer
USPTO:	United States Patent and Trademark Office
VINNOVA:	Swedish Governmental Agency for Innovation Systems (Verket för innovationssystem)

SA-inventor:	Serial-Active Inventor
SP-inventor:	Serial-Passive Inventor
OA-inventor:	Occasional-Active Inventor
OP-inventor:	Occasional-Passive Inventor

Acknowledgements

I have always wanted to write a children's book. A book that will tell children to dream and be curious and not be afraid of puzzles, a book that wants children not to fear asking questions, a book that will not tell them lies but fascinating stories, that opens new horizons for them to chase after another puzzle… Yet I ended up becoming a researcher who is expected to write a book for adults. I have done my best but never forget writing a book for children.

Like every book, this book too has heroes and heroines. The heroes and heroines in this book are 'university inventors'. To find them, I needed to dig into the depths of an iceberg, since they were barely visible. They were even believed to be non-existent. I was warned that I would not find any, maybe a handful if I was lucky. After a year and half of investigations in the depths of the iceberg, I discovered these invisible heroes and heroines in their so-called Ivory Tower…I therefore looked inside the Ivory Tower. And I asked them to tell me their stories. It took another year and half to learn their stories (and I sometimes found myself in those stories). Like most of us, they are amazed by the puzzles of nature. They are obsessed with unsolved questions, want to solve problems and want to change the world.

Their stories made me question more and more; every story opened another puzzle to be solved. Every story made me believe that the world of research really is fascinating and that one should follow her instincts and not be afraid of 'wild thinking' – even if one's wild thoughts are not welcomed at the time. I now want to share the stories of these inventors with you to inspire you to pursue science, creativity, invention, innovation and entrepreneurship.

In this book you will find theoretical, methodological, empirical and policy insights for adults…but there is a message for children as well: 'Don't be afraid of asking questions, be curiosity-driven, science-driven, get involved in science and do science for science, not only to solve research problems but also to be able to pose further questions. Enjoy science! Make science and curiosity part of your nature. Your curiosity and your science will always be rewarded and nurtured and appreciated.'

I must stop here so that you can enjoy the rest of the book, and I would also like to thank the many people who were with me in my writing of this book.

'As we express our gratitude, we must never forget that the highest appreciation is not to utter words, but to live by them.'
(John F. Kennedy)

Researchers are not islands, even though I felt like one most of the time. After all, playing solitary is the rule of the game while writing a Ph.D. thesis. Yet there are many to be thanked who were with me during my journey.

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I want to thank the inventors at Lund University who participated in this study for their interest and for taking time to respond to my survey and interviews. They have contributed generously by sharing their experiences and views on technology transfer, university patenting, academic entrepreneurship and the joy of science. I am also grateful to the managers of seven technology transfer organizations in Lund who shared their views on university patenting.

I want to thank to my friends in Turkey and all round the globe who have been sharing the pains and joys of writing a Ph.D. thesis. Thanks for your great friendship over the years.

Last but not least – *my own invisible heroes and heroines* – I cannot express the depth of my gratitude to my family in Turkey. Even though we have not been able to see each other as much as we wished, all of you are always in my heart. I am grateful to my parents as role models for many things in my life. Thank you for teaching me all you have taught and letting me learn and be myself. I am also thankful for my ever-growing family in Sweden. Thank you for welcoming me warmly, making me feel at home and relieving my homesickness with your great care, love and support.

For *Carl-Johan Hultén!* Unexpectedly even a Mediterranean sun may lose its light. At times when my own light goes out, you are the one generously bringing your long Scandinavian summer light to me. I cannot think of a better strength, better illumination and more love than this. Thank you for your care, patience, challenges and love, and for reminding me of the 'so-what test'!

Many thanks to my big family, to whom this book is dedicated, for trusting me and assuring me that there is a huge unexplored world with surprises waiting for us beyond the academic puzzles.

Malmö, Ankara, Jena
April, 2008
Devrim Göktepe

Whatever you can do, or dream you can, begin it.
Boldness has genius, power and magic in it.
Goethe

1. Introduction

1.1 University Inventors and Patents

Universities have been and remain crucial generators of new knowledge, although other kinds of organizations such as firms and research institutes are also increasingly engaged in knowledge production. Universities are not only acknowledged as important organizations for teaching and research; they are also expected to contribute to the development of industrially relevant technologies in modern knowledge-based economies. While they have long served as sources of knowledge, it has been argued that universities' relations with industry have intensified in recent years. Such argument has been supported by reference to a number of important developments, some of which can be summarized as follows:

- Closer links between scientific developments (university research) and their outside utilization, e.g. important technological breakthroughs in computing (microprocessors), biotechnology (genetic engineering), molecular biology and nanotechnology (Mowery et al. 2004) made for faster utilization of university research in industry;
- A general growth and relevance in the scientific and technical content of all types of industrial production (Mowery et al. 2001, 2004);
- A need for new sources of funding for academic research, due to budgetary stringency or general declines in research funds at the universities (Geuna 2001; Bercovitz and Feldman 2006);
- The US Congress's passage in 1980 of the Bayh-Dole Act, providing incentives for universities to patent scientific breakthroughs accomplished with federal funding (Henderson et al. 1998; Etzkowitz et al. 2000).
- Increasing emphasis on government policies aimed at raising the economic returns of publicly funded research by stimulating university-industry relations (Geuna 2001; Mowery and Sampat 2004);
- The increase in the number and mobility of scientists and engineers, with higher numbers of scientists and engineers facilitating their movement

between industrial and academic employment (Almeida and Kogut 1999; Bercovitz and Feldman 2006; Crespi et al. 2007);

- The rise of venture capital, providing financing for academic start-up firms dedicated to commercializing the results of university-based research (Rothaermel et al. 2007).

These developments, among others, have attracted the attention of researchers and policy-makers around the world, especially in the US and Europe, for their capacity to pave the way for the third task activities such as the inclusion of an economic development mandate for universities in addition to their traditional missions of education and research (Etzkowitz 1997; Jacob et al. 2003; Rasmussen et al. 2006; Rothaermel et al. 2007). University researchers and universities have been encouraged to embark upon collaborations with private companies in the UK (Geuna 2001). Universities have also been urged to become involved in technology transfer as a way of controlling their own destiny, i.e. in order to continue their other missions and to retain their autonomy (Clark 1998).

University-Industry Technology Transfer (UITT) results from interactions between various actors and organizations such as university administrations, university researchers, research groups, private or public firms, technology transfer offices (TTOs), venture capitalists, other financiers and diverse public sector actors. In the UITT process, these various actors play similar, different and ever-changing roles (Bercovitz and Feldman 2004; Markman et al. 2005a). For instance, the process of university patenting includes initiation of research projects, achievement of research results (inventions), invention disclosures to TTOs for the evaluation of patentability, patent applications and attempts to utilize the patent through licensing or spin-offs.

University researchers carry out the tasks of education, research and commercial activities (third task) at universities. Despite their importance, the roles and the motivations of university inventors have been relatively neglected topics of study. Most studies on university-industry relations are focusing on selected elite universities, TTOs, patent legislation, or technology transfer activities in specific sectors. There are only a few studies focusing on university inventors. For instance, a group of studies underlined the importance of institutions (*patent legislation, rules and regulations, policy mechanisms*) and organizations (*TTOs, university* *administration*) in the patenting activities of scientists. Another group of studies revealed the importance of individual factors such as *entrepreneurial traits, age, experience, scientific background* for scientists to commercialize their research results.

Most of these studies are based on data (number of patents, spin-offs, licensing revenues, etc.) available from TTOs or e.g. the Association of University Technology Managers (AUTM). These registers at the university-TTOs may fail to reflect the actual number of scientists who are involved in commercialization and the actual amount of commercial activities since some scientists may avoid disclosing their inventions to TTOs officially (Audretsch et al. 2005; Markman et al. 2005b; Thursby et al. 2006). As a result, the available data from AUTM or university-TTOs include mainly university-owned patents and may therefore underestimate the actual patenting activity of scientists. Thursby et al. (2006) have also shown that there are patents that are not registered to university TTOs even in the post Bayh-Dole US, although at a relatively lower frequency than in the European cases as shown by Meyer 2003a; Meyer et al. 2003 and Meyer et al. 2005 and other similar subsequent studies.

Broader approaches, e.g. the systems of innovation framework, emerged out of interactive and evolutionary theories of innovation. This framework emphasizes the interconnectivity and relationships of various organizations and institutions at different levels of analysis (i.e. national, regional and sectoral) and has been under development since the late 1980s (Freeman 1987; Perez and Freeman 1988; Lundvall 1992; Nelson 1993; Freeman 1995; Metcalfe 1995; Breschi and Malerba 1997; Edquist 1997, 2004; Freeman and Soete 1997; OECD 1997; Carlsson and Jacobsson 2000).[1] Edquist (2004: 183) defined national systems of innovation as including all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovation. As a framework, innovation systems emphasizes that innovation does not take place in isolation but in continuous interaction between organizations (firms, universities, government agencies as players) and within an institutional structure (in the sense of the rules of the game) (Edquist 1997).

[1] For an in-depth discussion on national systems of innovation, see Edquist (2004).

Closely related to the systems of innovation framework, the triple helix model of Etzkowitz and Leydesdorff (1997), states that increasing linkages and interaction between university, industry and government facilitates technology transfer from university to industry. In addition to increasing linkages and interaction, this model argues that each actor assumes the roles of the others (Etzkowitz and Leydesdorff 1997, 1998, 2000). Thus universities increasingly perform entrepreneurial tasks such as commercializing research results, patenting, licensing or forming spin-offs. Firms take on academic roles such as sharing knowledge with one another and with universities (Etzkowitz et al. 2000). This model assumes that such co-evolutionary transformations in the structures of the university and firms will facilitate technology transfer. Yet in reality universities and firms are still working quite independently of each other. The interactions between universities and firms are therefore in most cases encouraged by governments, through new rules of the game, direct or indirect financial assistance, or legislation such as the Bayh-Dole Act or equivalent legislation adopted in several countries.

The systems of innovation and the triple helix perspectives have both emphasized the increased interaction among university and industry and the diversity in the sources of knowledge. Although these analytical frameworks have shed some light on the changing roles of universities and firms, they have a limited potential for understanding the roles of inventors per se. Instead they provide a larger picture of university-industry relations and interactions for technological development. I therefore take one step further and examine several key themes in the university-industry relations literature with a focus on patenting in order to find different factors that may explain university researchers' patenting activities.

There have also been different views on how the commercial activities at universities may affect university scientists and the nature of university research (see Feller 1990; Martin and Etzkowitz 2000). As discussed by Gulbrandsen and Smeby (2005), authors with a pessimistic view (Slaughter and Rhoades 1996; Geuna 2001; Nelson 2001; Geuna and Nesta 2006) are concerned that over time, this might be detrimental to the academic commons (Hellström 2003) or the academic heartland (Clark 1998). Even when major contributions to industrial growth and restructuring are desired, it is claimed that university researchers should concentrate on teaching and on basic research (Rosenberg and Nelson 1994).

Authors with an optimistic view (Benner and Sandström 2000; Kleinman and Vallas 2001) have argued that the increasing collaboration between academic and corporate research can lead to increased flexibility and autonomy for researchers. Or universities may strengthen their traditional norms and their research and teaching activities as second academic revolution leads them into becoming entrepreneurial entities with closer and more productive relationships with industry and the public sector (Etzkowitz 1983; Etzkowitz 1998, 2001, 2002, 2003; 2004; Clark 1998; Etzkowitz and Leydesdorff 2000; Shane 2003). Instead of being a question of either-or, successful universities and university researchers manage to combine academic excellence with industrial contacts and/or entrepreneurial contributions, according to Godin and Gingras (2000) and Van Looy et al. (2004).

The lack of studies on the role of university inventors is significant given the fact that possible negative consequences of patenting on, e.g. the scientific publications of scientists have received a great deal of attention (Gray 2000). This thesis suggests a shift in the unit of analysis from universities or TTOs per se to researchers and to their environments. This shift may even be considered as another important theoretical and methodological contribution to studies of UITT. A focus on individuals in no way involves underestimating the importance of external factors such as TTOs or patent legislation as well as research environment and groups for the patenting activities of individual scientists. Therefore, I have also investigated the influence of external factors.

In addition to this scholarly debate, there has been an increasing policy interest in UITT, accompanied by concern with increasing this kind of activity – especially in the forms of patenting, licensing and launching academic spin-off firms. At the European Union (EU) level, it has been argued that the level of commercial activity at universities is relatively low compared to the high levels of scientific performance and investment in research. This perception is exacerbated somewhat by the impression that universities in the US have performed much better in commercializing their research results due to the Bayh-Dole Act. While many other factors also came into play in the upsurge of patenting and licensing in the post-

1980 period (Mowery et al. 2004, Mowery and Sampat 2004), e.g. Etzkowitz mentioned that the Bayh-Dole Act improved the ability to move ideas from R&D into the marketplace and into business in the US (Etzkowitz et al. 2000; Etzkowitz 2001, 2002). Despite sceptical views that Bayh-Dole is not the only factor behind the rise of university patenting in the US, (see below), this act has received attention as one of the important factors for the commercialization of university research. It is also considered to be important for the institutionalization of technology transfer (i.e. streamlining the procedures for patenting and licensing of patents developed as a result of federally funded research) in US universities (see Bozeman 2000; Etzkowitz et al. 2000; Thursby and Thursby 2000, 2001, 2002, 2003; Jensen and Thursby 2001; Thursby et al. 2001; Henrekson 2002; Thursby and Kemp 2002; OECD 2003; Mowery et al. 2001; Mowery and Ziedonis 2002; Siegel et al. 2003; Mowery et al. 2004).

Although patenting occurred before 1980 at the US universities it has increased sharply since then. For instance, prior to 1981 fewer than 250 USPTO patents were issued to universities each year. In contrast, slightly over a decade later, almost 1,600 patents were being issued each year (see also Henderson et al. 1998; Shane 2004). Between 1993 and 2000, US universities were granted some 20,000 patents. Over that period, some of these university patents generated millions of dollars in licensing revenues and spurred the creation of over 3,000 new firms, according to AUTM data (OECD 2003).[2] Studies have also shown that the patenting activity at the universities was on the rise in general (see Hall 2005).

Many European countries, however, have or used to have dual intellectual property rights (IPR) systems. While ownership of IPR in the non-university sector (i.e. firms and public research organizations) belongs to the organization, the university researchers have had the right to retain the ownership rights title to patents (e.g. the teacher's exception law in

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[2] The AUTM Licensing Survey 2002 reports that 569 new commercial products were launched that year by the universities in the US. In the same year, US universities also contributed to the establishment of 450 new companies (for a total of 4,320 since 1980, of which 2,741 were still operating at the end of 2002), running royalties on product sales were $1.005 billion, and new licenses and options executed in 2002 increased 15.2% from 2001.

Sweden). Inspired partly by the US legislation, some EU governments have initiated legislative reforms. Such reforms have been initiated in the EU states partly as a result of the converging policies in the EU as well as the impact of OECD. Such policies have been aimed at raising the economic returns of publicly financed research by stimulating interaction between university and industry and focusing specifically on increasing technology transfer to industry from universities (Geuna 2001). Although it has been argued that the Bayh-Dole Act has not been designed to provide new sources of income for universities and only a few elite universities earn income (Mowery et al. 2004; Nelson 2006; Verspagen 2006); a number of countries have passed legislations similar to the Bayh-Dole Act. Several other countries are considering or discussing similar changes with the hope of financial benefits.

Denmark introduced the Act on Inventions at Public Research Organizations (PROs) in July 1999 (effective as of 1 January 2000). This act grants PROs (universities, hospitals) the title to employee inventions (Valentin and Jensen 2006). In Germany, in 2002, a decision was made to change the ownership of intellectual property within the institutes of higher education by removing the exclusive ownership rights of researchers and transferring those rights to the employing organizations, though researchers will retain rights to receive two-thirds of any licensing or other income from their invention (AUTM 2003; OECD 2003; Sellenthin 2006). In Norway, a new bill on the commercial exploitation of inventions went into effect in January 2003 (Iversen et al. 2007). Under certain conditions, it transfers the right to commercialize an invention from researchers to the employing organization. In doing so, it has sought to establish an organizational ownership by universities of intellectual property to the results of research carried out at universities. To date however, the Swedish state has not made any policy change on this issue. A recent government bill on innovation (September 2001) listed a number of the considerations that need to be taken into account if Sweden were to move from the present policy of researcher owned patents. The bill concludes that further discussion and consideration is needed (Prop. 2001/02:2 cited in Jacob et al. 2003).

US universities had experienced an organizational set-up long before the Bayh-Dole Act. The Research Corporation was founded in 1912 by Frederick Gardner Cottrell, with initial funding derived from the profits from his patents on the electrostatic precipitator (see Etzkowitz 2002; Mowery et al. 2004). It was one of the first foundations in the US for handling university patents. The Research Corporation's need for new income sources as well as increasing interest of US universities in licensing income, led to expand its role by handling patenting activities on behalf of US universities.

In 1987, the invention-handing facilities of Research Corporation became Research Corporation Technologies, a wholly-independent company which handles technology transfer. Such a change was spurred in the aftermath of the Bayh-Dole Act and by the decentralization of patent offices across the US universities.[3] Consequently, the importance of Research Corporation Technologies has diminished (Etzkowitz 2002; Mowery et al. 2004). However, it had played some role in the rise of post-1980 patenting activities of individual US universities by setting partially some institutional and administrative routines (Mowery et al. 2004).

Unlike the European universities where the university inventors claim ownership, in US -before the Bayh-Dole Act- the ownership of the intellectual property resulting from federally funded research belonged to the federal government or funding agency. While the US model is a shift from a centralized to a relatively decentralized system by giving rights to universities, in Europe the trend is almost the opposite. Therefore the implications of such an institutional and organizational change may not create the same or similar impacts in the European context compared to the US.

In addition to institutional changes, there have been complementary efforts to establish organizations like TTOs, science parks, and university-industry research centres over the years in different countries – all with a view to accelerating and maximizing the returns from publicly funded research, albeit with mixed success (Mowery 1998).

These policy measures are motivated not only by the arguments that these new institutions and organizations can support and speed up the

[3] The decline of Research Corporation as a major actor in patenting activities was, among others, due to the limited financial returns from patent licensing and growing deficits of the corporation during the 1970s. (See Mowery et al. 2004 for an overview of Research Corporation).

industrial exploitation of academic research and that the financial returns from patenting may help to support research and teaching at universities. In addition, these policies find support in declarations of a *third task* for universities (Rosenberg and Nelson 1994; Lee 1996; Etzkowitz and Leydesdorff 1997, 2000; Branscomb et al. 1999; Etzkowitz et al. 2000), alongside their two traditional tasks of teaching and research. Swedish universities, for instance, were given a third task in the Higher Education Act in 1997. Besides education and research, universities are expected to support economic and social development and play a greater role in explaining academia to the broader public (Jacob et al. 2003; Edquist 2004; Brundenius et al. 2006). However the economic impact of such institutional changes (adoption of organizational ownership of intellectual property rights at universities and organizational attempts, e.g. formation of technology transfer offices), is far from definite especially in the European context.

Some scholars (Mowery et al. 2004; Mowery and Sampat 2004; Geuna and Nesta 2006; Verspagen 2006) have criticized the current policy initiatives towards academic entrepreneurship, pointing out that justifications for these reforms (e.g. emulation of the Bayh-Dole Act) are based largely on anecdotal evidence of successful licensing and spin-off activities at a handful of elite US universities such as Columbia University, Stanford University and Massachusetts Institute of Technology.

They have argued, for example, that even though there has been a rapid increase in patenting activities by universities in the US since the passage of the Bayh-Dole Act in 1980, increased patenting and licensing activities do not indicate that university research results have been commercialized faster or more efficiently (Mowery et al. 2001). Mowery et al. (2004) have also highlighted that the passage of the Bayh-Dole Act coincided with several other developments that facilitated university patenting. The decisions of the US Supreme Court affirming the validity of patent on life forms in 1980 as well as the significant advances in biomedical research which had considerable potential for industrial uses. US universities have also benefited from federal support for research during most of the post-1940 era. The involvement of scientists in patenting or other quasi-commercial activities have also been influenced by the unusual structure of the US university system. Mowery and his colleagues (2004:57) have described how the decentralized system for funding of universities, administrative autonomy and the need for external resources created strong incentives for universities to pursue strong links with firms.

These critics have also pointed to the lack of solid, empirical support for the argument that patenting stimulates the transfer of university technology to industry, and to the ambiguous nature of current empirical evidence for the long-term implications of the role of universities. Though commercial activities are seen as potential sources of revenue for universities, as well as sources of economic growth and job creation for the regions and nations where they are located, only a few universities have generated revenues from licensing patents, and almost none in Europe. Mowery et al. (2004) have also pointed out that even the licensing revenues of such patent experienced universities were dominated by a very small number of block buster inventions, most of which were in biomedical sector. They have concluded that a number of developments in academic research, industry and policy thus have contributed to the US universities' patenting activities, and that Bayh–Dole, while important, was not determinative. It should be also noted that patenting and licensing were only one of many technology transfer mechanisms through which university knowledge can contribute to industry and society.

In sum, the discussion above has shown that the literature on UITT still remains rather fragmented. There has been an increasing debate, concern and uncertainty about the roles that universities will play in teaching, research and entrepreneurial activities. Analyses and perspectives differ not only with respect to the roles of universities, but also regarding which kinds of institutions and organizations can best facilitate university patenting activities – as well as the extent to which they should do so (see Mowery et al. 2004). Forecasts also diverge between those who believe that the roles, values, autonomy and future of universities are under threat from increasing pressure to engage in entrepreneurial activities and long-term effects of patenting (e.g. Slaughter and Leslie 1997; Nelson 2001) and those who believe that the role of universities should be redefined to include entrepreneurial tasks and that such activities will bring new opportunities and autonomy to universities (e.g. Etzkowitz et al. 2000). Despite this fragmented picture, a number of countries have initiated policies to increase university-industry relations with the aim of enhancing the contributions of university research to innovation and economic growth.

1.2 Purpose

In the light of the issues addressed above in the introduction, I have found it particularly interesting to study university inventors and university patenting in Sweden, because of the country's increasingly unique institutional and organizational set-ups for university patenting. Unlike many other EU member states, Sweden has kept the law on the *university teacher's exception*,[4] a law which allows university researchers to retain the intellectual property rights to their research results. At the same time, Sweden has also created many new TTOs, including university holding companies and other regional technology transfer agents (e.g. Innovationsbron AB, incubators etc.). Sweden has also enshrined in legislation the third task of universities to initiate and contribute to commercial activities, although this mandate has been expressed in more general terms that refer to general interaction with, and communication of research results to the broader society (Jacob et al. 2003). Moreover, many large Swedish firms have for long time had strong connections with leading universities in Sweden (Stankiewicz 1986, 1997; Etzkowitz et al. 2005 and Jacob and Orsenigo 2006). Current Swedish policies for the formation of university-industry competence centres or projects with industrial partners have strengthened such relations. Consequently, Sweden's present system provides different routes to university inventors such as: patenting individually, patenting through TTOs, choosing among different TTOs to patent through, or patenting through industrial firms.

The discussion thus far has indicated that there is a scientific need (i.e. lack of studies on university inventors) as well as a policy need (e.g. current debates in Sweden and abroad) that justify further research on university researchers' patenting activities. This study has the ambition to

[4] Hereafter, for the sake of brevity, I use the term *teacher's exception* in referring to the individual ownership of patents at universities (in Swedish, *Lärarundantaget*). It is also common to use professor's privilege, teacher's exemption, etc. in referring to this law.

address these needs, by investigating in depth the extent and patterns of patenting carried out by inventors based at one specific university: Lund University (LU) in Sweden. The study focuses on inventors in relation to their environment, and it aims to understand the university patenting phenomenon. Using the inventors at LU as cases, the study focuses on the causes of this activity, rather than its consequences. Due to its current active involvement in and commitment to the third task in the forms of entrepreneurial activities as well as long-term relations with the surrounding industry, being located close to one of the oldest science-parks (IDEON), LU has been selected from among other universities in Sweden.[5]

In the light of the discussion above the research questions of this PhD thesis are formulated as follows:

What are the extent and patterns of patenting at Lund University?

Why and how do Lund University researchers patent?

In order to be able to address these research questions, I pursue an empirical investigation to identify the patents based on research carried out by scientists employed at LU and describe the researchers who are involved in patenting activities. I also aim to identify the main factors that influence the patenting activities of researchers. As a point of departure, I organize the factors into two groups: (i) internal factors, i.e. factors related to the characteristics of the inventors, such as skills, competence and experiences; and (ii) external factors, i.e. factors related to institutions and organizations surrounding the inventors, such as research mileux, patent laws or TTOs, etc. I finally explored in what ways, and to what degree,

[5] Although other universities in Sweden such as Uppsala University, Chalmers University of Technology, Karolinksa Institutet may also be interesting cases for studying university patenting, I have chosen LU also for practical reasons to facilitate the data collection procedure. See Chapter 3 and 4 for the selection of LU as a case.

these different factors either help or hinder patenting by university inventors.

1.3 Outline of the Monograph

This study is divided into three main parts. The first part consists of three chapters. It addresses theoretical and methodological issues and presents the research context. Chapter 2 presents the theoretical framework. It builds upon the literature on UITT, relevant institutions and organizations and the roles of inventors in university patenting, thereby attempting to identify factors behind university patenting. Chapter 3 presents the methodology that was applied in the empirical research. Chapter 4 gives a brief overview of the research context, i.e. milestones in university-industry relations in Sweden.

The second part reports the empirical research in four chapters. The first of the empirical chapters, Chapter 5, identifies the university inventors and applicants for patents, and thereby maps the patenting patterns. This chapter constitutes the empirical backbone of the thesis. Chapter 6 presents the results of a survey of inventors. It presents the main factors behind university patenting and discusses differences among inventors regarding the propensity for patenting and modes of utilizing patents. On this basis, Chapter 6 suggests a typology of inventors. Chapters 7 and 8 provide more in-depth empirical investigations.

Chapter 7 delineates in detail the unique characteristics, roles and skills of a group of university inventors, i.e. serial inventors. It corroborates the typology of inventors by providing in-depth data from interviews with serial inventors. This chapter also investigates the relations between serial inventors and selected external factors, i.e. research milieux, TTOs and patent legislations. Chapter 8 completes the empirical work by examining the roles of TTOs and another group of inventors, i.e. occasional inventors. It also corroborates the typology of inventors by providing further in-depth data. In sum, while the first empirical chapter constitutes a quantitative and methodological foundation for university patenting studies, the subsequent three chapters provide deeper insights on the roles of inventors and TTOs in different kinds of patenting processes.

The third part presents the analysis, discussions and the conclusions of this dissertation – all of which are addressed in Chapter 9. First, this chapter gives a brief overview of the thesis. Second, the analysis and discussion address the reasons behind university patenting and differences among inventors in light of the theories and empirical findings presented in the preceding chapters. Finally, broader implications of this study for theory and policy are highlighted, and the main conclusions are summarized.

2. Understanding University Inventors and Patenting

2.1 Introduction

This chapter addresses the theoretical standpoints of the dissertation. It describes and discusses the theoretical and conceptual framework used for the empirical research and analysis. The framework described here addresses the study's research questions as formulated in Chapter 1.

The discussion in Chapter 2 proceeds as follows. Section 2.2 provides a brief overview of the key themes in the literature on university-industry relations and different technology transfer mechanisms. Section 2.3 addresses the main theoretical discussion of the thesis by presenting the studies on university inventors and patenting under three groups of studies. In Section 2.4 different factors derived from the existing literature are integrated into an overall framework to guide the empirical investigation and the further analysis. Section 2.5 gives a brief summary of the chapter.

2.2 One Step Back: University-Industry Relations

Several important themes have been studied within the broader area of research on university-industry relations. The literature is quite fragmented and a substantial amount of the work has been done in the last two decades. Literature reviews by Siegel and Phan (2005), Phan and Siegel (2006) and Rothaermel et al. (2007) have provided a detailed overview of the burgeoning literature on university-industry relations. These reviews have shown that most of the current literature has emerged from the US context and mainly discusses the Bayh-Dole Act and university TTOs in the US.

The reviews by Siegel and Phan (2005) and Phan and Siegel (2006) have focused chiefly on synthesizing the current literature on university technology transfer. They examined the objectives and cultures of the three key stakeholders in university technology transfer: scientists, university administrators, and TTOs, firms and entrepreneurs. They found differences among the objectives, motives and cultures of these main actors. They also showed the potential importance of organizational factors and institutional policies in effective university management of intellectual property. They concluded that most of the studies of the relative performance of technology transfer have explored the importance of institutional and managerial practices.

Phan (2005) and Phan and Siegel (2006) classified and reviewed the literature on UITT in three principal areas:[6] (i) research on the effectiveness of patenting and licensing and roles of technology transfer organizations (e.g. papers that focus on TTOs and the Bayh-Dole Act as the main units of analysis); (ii) research on the effectiveness of science parks to stimulate and support entrepreneurial activities at universities; and (iii) research on the formation of start-ups and ventures.

The key message that Phan and Siegel derived from their literature reviews is that university technology transfer should be considered from a strategic perspective. Institutions and organizations need to address skill deficiencies in TTOs and also need to design reward systems that are consistent with enhanced entrepreneurial activity. Institutions and organizations should be designed to provide education and training for researchers relating to interactions with entrepreneurs. Business schools at these universities can play a major role in addressing these skills and educational deficiencies through the delivery of targeted programmes for technology licensing officers and members of the campus community wishing to launch start-up firms.

A more recent study by Rothaermel et al. (2007) highlighted that there have been 173 published articles within the last two decades on the broadly defined topic of university entrepreneurship. University entrepreneurship refers to any published research pertaining to

[6] Within the scope of this thesis, I will not go into the details of the specific themes mentioned in these studies. I use these studies to show that despite the burgeoning literature on university-industry relations on different units and levels of analysis, university inventors are not a major theme and thus require further research. I also carried out an in-depth literature review on technology transfer mechanisms: spin-off formation and patenting and licensing (Goktepe 2004). In that study I also found institutions and organizations to be the main focus for the majority of studies, while individuals were relatively less investigated.

entrepreneurial activities in which a university could be involved, including but not limited to patenting, licensing and the creation of new ventures or the facilitation of technology transfer through incubators and science parks, thereby contributing to regional economic development. Rothaermel et al. have highlighted four major research streams emerging in this area of study: (i) entrepreneurial research university, (ii) productivity of TTOs, (iii) new firm creation and (iv) environmental contexts, including networks of innovation.

The first key message that Rothaermel et al. (2007) derived from their literature review is that for an emerging field, the vast majority of the articles (71 per cent or 122 articles) are more or less atheoretical, focusing mainly on the description of the phenomena and/or testing casually observed relationships without invoking any discernible deductive logic. Most of the articles highlight specific knowledge characteristics (e.g. tacit versus explicit) and how different types of knowledge affect the technology transfer process. Second, the literature review showed that universities are the main units of analysis in more than half of the studies. The second largest segment of studies used the firm level as the unit of analysis, followed by studies on TTOs, science parks and incubators, while research on individuals as units of analysis was quite limited. Studies on individuals focused mainly on academic entrepreneurs and examined the roles of scientists in venture creations. Some studies on individual scientists focused on the possible negative consequences of commercialization and university-industry relations on scientists' research and teaching activities and academic values.

As seen from this discussion of recent extensive literature reviews, research on *university inventors* has not been a major topic, neither in the broader frameworks such as systems of innovation or triple helix nor even in more specific studies on UITT.

On the other hand, another group of studies has investigated academic entrepreneurship. These studies have focused on themes like the: characteristics of the scientists (human capital aspects), the environment surrounding the scientists, the role of scientists (social or human capital) in the new ventures created and the process of new venture creation (see Zucker et al. 1998; Zucker et al. 2002; Murray 2004; Shane 2003). These studies have referred to financial incentives and support provided by institutions and organizations to explain the entrepreneurial activities of researchers.

In the light of the existing studies, in this thesis I aim to explore the patenting activities of researchers with regard to individual characteristics as well as with regard to the roles of institutions and organizations and research milieux.

2.2.1 University-Industry Technology Transfer Mechanisms

In what follows, I present the choice of university patenting among other technology transfer mechanisms. UITT can be achieved in many different ways, but much of the literature on UITT and the industrial impact of university research has focused on the role of patents and licensing (Autio et al. 1989; Adams 1990; Autio and Laamanen 1995; Henderson et al. 1998; Jensen and Thursby 2001; Mowery et al. 2001; Feldman et al. 2002a; Feldman et al. 2002b; Siegel et al. 2003a; Siegel et al. 2003b; Bercovitz and Feldman 2004; Siegel et al. 2004). The formation of university spin-offs has also received a substantial amount of attention from researchers (Autio et al. 1989; Smilor et al. 1990; Radosevich 1995; Mustar 1997; Chiesa and Piccaluga 1998; Ndonzuau et al. 2001; Birley 2002; Di Gregorio and Shane 2003; Perez and Sanchez 2003; Shane 2004; O'Shea et al. 2005). Some of the research has focused on consulting, sponsored research and collaboration (Stahler and Tash 1994; Mansfield 1995, 1998; Mansfield and Lee 1996; Brooks and Randazzese 1998; Cohen et al. 1998; Stuart and Waverly 2003; Vohora et al. 2004). Some studies have focused on labour mobility from academy to industry (Zucker and Darby 1995; Almeida and Kogut 1999; Zucker et al. 1998, 2002; Murray 2004; Crespi et al. 2007). These various kinds of studies have analysed specific areas of interaction and knowledge and have hence focused on specific types of UITT mechanisms.

The focus in this study is on the university researchers' patenting activities. Figure 2.1 shows the classification of technology transfer mechanisms into two main sets: patenting (licensing, spin-off company formation) and other more general types of technology transfer mechanisms. Figure 2.1 is used as a metaphor to present university technology transfer mechanisms. Technology transfer mechanisms at the tip of the iceberg are mostly based on the transfer of particular outcomes of university research. They can be measured quantitatively using such measures as the number of university patents, licenses to industry or the number of spin-offs that are established. It should be noted that in the case of Sweden, it is not easy to measure and identify the amount of university patenting, due partly to the 'teacher's exception' and the lack of central organizations (like AUTM) to collect data on university patents. Further research is therefore needed to identify inventors and the extent of patenting (Chapter 5). Except for a study of Linköping University inventors based on a regional patent database (Schild 1999); there was no database for other Swedish university patents at the time when this study was conducted.

Although a substantial amount of technology transfer may also take place through less visible mechanisms, these mechanisms are beyond the scope of this study. However, the focus on university patenting should not be interpreted as an indication that the second group of mechanisms, e.g. participation in university-industry joint research projects, consortia or joint programmes and labour mobility, are unimportant (Audretsch et al. 2005). While scientists' decisions, for instance to collaborate with industry or not, are not necessarily regulated by legislation, their decisions to patent or not would be subject to various factors such as patent legislation at universities, (local) contexts, national laws and university regulations, agreements with industrial partners, the culture of the research group and their own individual values and beliefs.

Moreover, the nature and level of technology, type of scientific and technological knowledge, sectoral field, availability of investors for patenting, and so forth, may influence university researchers' patenting activities. Among other mechanisms, I found university patenting to be more relevant in investigating the influences of institutional and organizational structures, along with individual motivations and skills.

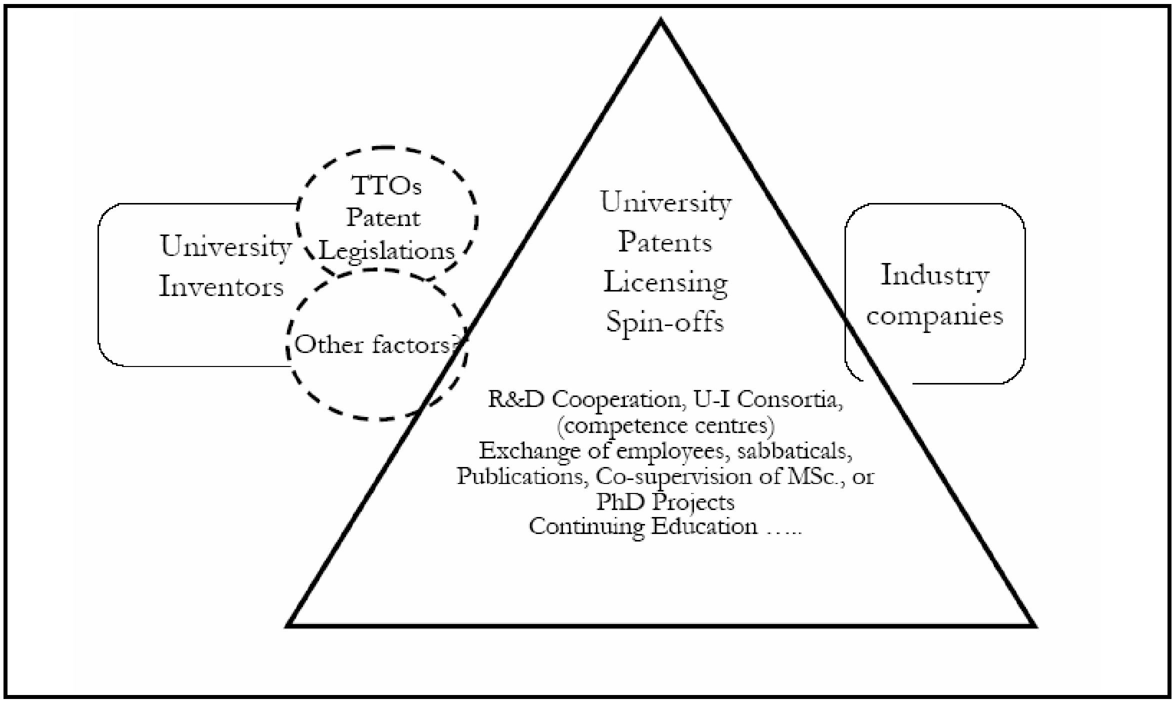

Figure 2. 1 A Basic Illustration of UITT Mechanisms[7]

The second group of mechanisms, on the other hand, may be based on daily transactions, resulting mostly from informal networks and informal relations between scientists and industry. They are therefore not highly informative for investigating the impacts of different factors regarding researchers' patenting activities.

University patents are also informative. They reflect research that the university or academic inventors believe may have a direct commercial application (Henderson et al. 1998). They are also interesting in their own right since they are a unique and highly visible method of technology transfer (Basberg 1987; Boitani and Ciciotti 1990; Trajtenberg 1990; Archibugi 1992).

I acknowledge the limitations of the use of patents. One cannot learn about the full spectrum of university research and knowledge generation from patent data only. They are only a rather partial indicator of inventive activity. Measuring the number of patented inventions is not the

[7] Own illustration.

equivalent of a direct measure of innovative output, since not all innovations are patented (Griliches 1990; Anselin et al. 1997, 2000; Pavitt 1998). My aim is not to measure innovative output or impacts of university knowledge or the consequences of patenting. I aim to investigate factors behind university researchers' patenting activities.

2.3 Studies on University Inventors and Patenting

In what follows, I review the important aspects of the literature on university inventors and patents under three main groups. This review leads to a list of internal and external factors that may explain university researchers' patenting activities. Since patenting activity at universities is sometimes related to licensing or university spin-offs, I also review selected key papers that have addressed these issues.

- Studies on the identification of university inventors and patents under non-Bayh-Dole regimes, where individual researchers own patents based on research conducted at universities;
- Studies on the impact of institutions and organizations on patenting, licensing and spin-off company formation by university inventors;
- Studies on the roles of individuals in patenting, licensing and spin-off company formation.

2.3.1 Identification of University Inventors and Patents under non-Bayh-Dole Regimes

Studies that have mapped *university patenting under non-Bayh-Dole regimes* are the main points of departure for this thesis. Under this heading, I discuss the aims, methods and main findings of the studies on university patenting that have been conducted for some European countries.

A number of scholars have shown that the number of patents applied for by US universities has increased over the last twenty years, coinciding with the introduction of the Bayh-Dole Act in the US in 1980. Over the same years, the number of science-based university spin-offs has also grown (see Henderson et al. 1998; Etzkowitz 2002; Mowery et al. 2004). Although the effects of the Act on the increase of patenting are far from definite and conclusive, universities increased their share of patenting from less than 0.3 per cent in 1963 to nearly 4 per cent by 1999 (Mowery and Sampat 2004). Some observers (e.g. Etzkowitz et al. 2000; Economist 2002[8]; Shane 2004; Stevens 2004) have suggested that there may be a positive relation between the number of university patents and the Bayh-Dole Act. This conclusion has especially misled policy makers and university administrators in Europe and in other OECD countries in general to believe that legislations such as the Bayh-Dole Act and TTOs may not only increase university patenting, but also facilitate technology transfer from universities to industry and even generate revenues for universities.

In Europe, the levels of university patenting, licensing and spin-off company formation have been claimed to be low compared to the relatively high level of investment in higher education institutes or in basic research. This phenomenon has been labelled the 'European Paradox', according to which European countries have a strong science base but are not good at transferring research results into commercially viable new technologies (Dosi et al. 2007; EC 1994; Tijssen and van Wijk 1999). Although there has been no systematic attempt at measurement until recently, it is well known that no European university holds a patent portfolio as large as MIT's or Stanford's. Many European universities have not held any patents at all (OECD 2003; Lissoni et al. 2007). It should be underlined that in a recent study, Dosi et al. (2007) argued that the conjecture that EU countries play a leading global role in terms of top-level scientific output, but lag behind in the ability to convert this strength into wealth-generating innovations is not well-grounded. They showed some descriptive evidence that, contrary to the 'paradox' conjecture, Europe's weaknesses reside both in its system of scientific research and in a relatively weak industry.

Given the impression of higher numbers of university patents and spin-offs, and higher licensing revenues for the US universities, an emulation of the US Bayh-Dole Act has been advised by many European policy-makers.[9] Some concerns have been raised, however, that such policy suggestions are based to a large extent on unrealistic and faulty

[8] Innovation's golden goose. (2002, December 12, p. 3). *The Economist*.
[9] Germany, Denmark, Norway have adopted patent legislation similar to the Bayh-Dole Act.

assumptions which are in turn based on inadequate or erroneous information (Geuna and Nesta 2006; Verspagen 2006). Most information on university patenting, licensing and spin-off company formation comes from surveys submitted to university TTOs or even from newly established TTOs, or on cursory searches for university names or university TTOs as the applicants for patents. Construction of systematic data on patents for European universities and further investigations of the European Paradox have been suggested recently by scholars (Lissoni et al. 2007).

A series of European studies on university patenting has been conducted to gauge the rate of university patenting in Europe and to create patent data sets comparable with those of US universities (Schild 1999; Meyer 2003a; Meyer et al 2003; Balconi et al. 2004; Meyer et al. 2005; Azagra-Caro et al. 2006; Iversen et al. 2007; Lissoni et al. 2007). Due to the different institutional and organizational set-ups at European universities, university patenting should be investigated by finding the names of university scientists who are also registered as inventors in patent databases. For these reasons the distinction between the inventor and the applicant should be highlighted:

Applicant: The patent applicant is normally the individual(s), the firm or another organization responsible for the patent costs, and who/which may assume ownership if the patent is granted. Applicants can be different from the inventor who developed the idea represented in the patent.
Inventor: The inventor developed the idea (knowledge) represented in the patent. The inventor of a patent can be single or collective (co-inventorship). Inventors can be affiliated with universities, research institutes, public organizations or firms, or they can be independent.

Meyer (2003a) distinguished between patents owned by universities and patents that were invented by university researchers but not necessarily owned by a university. These can be defined as follows:

University-Owned Patent: University-owned patents are the patents in which universities or university TTOs are listed as applicants of these patents. Such patents are usually applied for and managed by a TTO.
University-Invented Patent: University-invented patents are defined through the affiliation of their inventors with a university. Such patents have at least one university employee as an inventor. An inventor, a TTO or a firm can be the applicant of the patent.

Some studies (Schild 1999; Meyer 2003a, Balconi et al. 2004; Meyer et al. 2005; Iversen et al. 2007; Lissoni et al. 2007) have taken the distinction between the inventor of a patent and the applicant for a patent as their point of departure. They argued that, depending on the ownership of IPR at universities (i.e. individual ownership or organizational ownership); university researchers can apply for patents by themselves (individually), or they may assign their rights to another firms to apply for a patent with. Or they may patent with the aid of TTOs or through other actors, e.g. colleagues, patent consultants. These scholars thereby argued that the different patenting regimes at European universities require another methodology. They suggested the approach of finding how many university researchers are actually listed as inventors of patents, instead of searching for university names or newly established university TTOs as applicants of patents.[10] Before these studies, university patents were often understood as patents assigned to universities, and the patenting activities of university researchers were more or less invisible in European studies (see Cesaroni and Piccaluga 2002; Saragossi and van Pottelsberghe de la Potterie 2003).

In order to identify the university-invented patents, these aforementioned scholars matched two different databases. Databases of patent applications (e.g. national patent offices, European Patent Office (EPO), United States Patents and Trademark Organization (USPTO)) were matched with the so-called university researchers' registers which

[10] In Chapter 5, I revisit the methodologies used in these studies. However, the name-matching techniques for these studies have not been described in depth. In some cases, therefore, I communicated personally with other researchers. I had very limited information on the specific methodologies used in these previous works. I want to thank Eric Iversen, Magnus Gulbrandsen, Manuel Trajtenberg, Stefano Breschi and Martin Meyer for commenting on my work.

contain information on employees at the universities, university colleges, state colleges and research institutes. In these studies, the results of name-matching between scientists and inventors have had to be validated for each patent by direct contacts with the inventors to confirm the name-matching between inventors and university employees. The common finding of these studies is that there are many more university-invented patents than university-owned patents across European countries. Hence, the inventive output of European universities or university researchers is more common and higher than previously thought. In the following part, I present the findings of each individual study.

Meyer and his collaborators in a number of studies used a matching procedure between first and family names of inventors in patent databases and university researcher registers. They matched all USPTO patents that had at least one Finnish inventor for the period 1986 to 2000 with the names of university researchers that were employed at Finnish universities in the years 1997 and 2000. First, Meyer et al. (2003) reported that Finnish universities owned 36 USPTO patents that had at least one Finnish inventor, while university-invented patents amounted to 530. Second, in their comparative study of Flemish and Finnish universities, Meyer et al. (2005) found that there were 379 university-invented patents compared to 100 university-owned patents at Flemish universities.

A number of subsequent studies adopted Meyer's method and came to similar conclusions. Balconi et al. (2003) found that out of 1,475 university-invented patents in Italy between 1978 and 1999, only 40 EPO patents had universities as applicants, whereas Italian university-inventor patents account for 3.8 per cent of EPO patents by Italian inventors.

Azagra-Caro et al. (2006) pointed out that although French universities are legally entitled to own patents based on scientists' research results, the university-invented, but not university-owned, patent has been and remains in practice the most common form of patenting at the University Louis Pasteur (ULP) in France. ULP had 463 patents (from the French Patent Office, the EPO and other patent offices) from 1993 to 2000. Of these, only 62 patents were owned by the ULP.

Lissoni et al. (2007) found that the university professors, who were active in Sweden and Italy during 2004 and in France during 2005, were responsible for a substantial number of patent applications during the period between 1978 and 2002. During that period there were 2,800 patent applications in France, 2,200 in Italy and 1,400 in Sweden. Lissoni et al. (2007) compared the level of patenting in these three countries (between 1994 and 2001) with US university patent data (between 1993 and 2000) in order to make a comparison possible between the US and Europe. They found that French, Italian and Swedish university-owned patents constituted less than 1 per cent of the total number of domestic patents. The proportions of university-invented patents are around 3 per cent in France, 4 per cent in Italy and more than 6 per cent in Sweden. US estimates for university-invented patents are about 6 per cent (Thursby et al. 2006). Lissoni et al. (2007) have also shown that the alleged gap between the US and Europe in terms of university patenting turns out to be a very limited gap between the US and France and Italy, and no gap at all between the US and Sweden.

Iversen et al. (2007: 405) found that a total of 569 researchers from Norwegian public research organizations were involved in at least one patent application in the years between 1998 and 2003. These researchers were involved in 10 to 11 per cent of domestic patent applications during those years. The contribution of university and college researchers was high in chemical and pharmaceutical patenting, accounting for nearly 18 per cent.

In Germany, university-owned patents are found to be relatively rare, but university-invented patents have been increasing continuously from less than 200 in the early 1970s to around 1,800 in 2000 (Meyer-Krahmer and Schmoch 1998).

Schild (1999) examined inventors from Linköping University who have Swedish patents applied for by firms from the East Gothia region. Schild identified 82 inventors affiliated with Linköping University out of 656 inventors in the East Gothia region She found that a total of 88 (approximately 14 per cent) of the East Gothia patents had at least one inventor from Linköping University.

Giuri et al. (2006) showed that the total number of university patents in the PatVal survey of inventors for six European countries (Italy, United

Kingdom, the Netherlands, France, Germany and Spain) was 433.[11] Based on the PatVal survey, Crespi et al. (2007) further investigated these 433 university patents and found that much of the university research that leads to patents in Europe does not show up in the statistics, because it is private firms rather than the universities themselves that apply for the patent. About 80 per cent of the EPO patents with at least one academic inventor are not owned by the university. Hence, there is no statistical record of the university involvement in the patent office records. Thus, the lack of university patents in Europe is really a lack of university-owned patents, not necessarily a lack of university-invented patents. Once the data are corrected to take into account the different ownership structure in Europe and the US, simple calculations suggest that the European academic system seems to perform much better than had been believed until now. In relative terms, European universities' patenting output lags only marginally behind that of US universities (Crespi et al. 2007).

University-invented patents can also be analysed by looking at the distribution across science and technology fields. The studies presented above show that patenting is most frequent in biotechnology and pharmaceuticals (Geuna and Nesta 2006). The strongest technological sectors in each country also tend to be those in which university patents are heavily concentrated. For instance, patents in telecommunication in Finland account for 12 per cent of university-invented patents while pharmaceuticals and biotechnology account for about 9 per cent each (Meyer et al. 2003). The broadly defined research area of biotechnology and pharmaceuticals tends to be an area of extremely high university patenting activity in many countries.[12]

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[11] The PatVal survey was addressed to inventors listed on (granted) European patents with a priority date in the period of 1993–1997, in six European countries: Germany, France, Italy, The Netherlands, Spain and the UK. These six countries accounted for about 88% of granted EPO patents whose first inventor has an address in of the EU-15 countries (about 42% of the total EPO). The survey obtained responses relating to 9,017 patents representing 18% of all granted EPO patents with a priority date in the considered period. Out of 9,017 patents, 433 patents, which were identified as university patents, have at least one inventor who was employed by a university.

[12] These studies have found almost the same tendencies as in the US. In 1998, 41% of US academic USPTO patents were in three areas of biomedicine, indicating a strong focus on

These empirical investigations support the view that *university patenting is not a new phenomenon for European universities*. They show that the more inclusive approach of tracing patents made with university inventors allows the analysts to identify a much broader range of university patents. They provide clear empirical evidence that the *number of university-invented patents is much higher than the number of patents owned by universities*. While university-owned patents do not capture the contributions of university researchers to patenting for universities, in countries where scientists own IPR based on university research, university-invented patents can be used as a better indicator of the role of universities (Meyer 2003a; Meyer et al. 2003; Meyer et al. 2005; Lissoni et al. 2007; Iversen et al. 2007).

A final conclusion of these studies can be summarized as follows: although the number of university-owned patents is limited, these universities or countries do not necessarily lag behind US universities. The difference in numbers can be explained by different institutions and organizations. However, these studies have not investigated why researchers patent and what are the main factors behind patenting activities in European universities in a systematic way, except for a few recent studies by Gulbrandsen (2005), Giuri et al. (2006)[13] and Baldini et al. (2007) to date.

2.3.2 Institutions & Organizations and University Patenting

A burgeoning literature has investigated the effects of organizations such as TTOs, universities, firms, science parks and so forth, and/or institutions such as the Bayh-Dole Act, the third task, academic culture, university policy and strategies and government policies on university patenting. Most scholars have referred mainly to the AUTM databases, or to results and data from their surveys or interviews at American

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developments in the life sciences and biotechnology. In terms of revenues, about half of the total royalties were related to life sciences, including biotechnology. Whether a corresponding degree of concentration in this area exists for university patents in Europe is less clear-cut, but the available evidence is not at odds with this assumption (Geuna and Nesta 2006).

[13] The PatVal survey was conducted among all inventors without necessarily distinguishing between university inventors and inventors employed at firms, public research organizations or other organizations (Giuri et al. 2006).

universities (among others see Bozeman 2000; Etzkowitz 2000; Bercovitz et al. 2001; Thursby et al. 2001; Carlsson and Fridh 2002; Friedman and Silberman 2003; Thursby and Thursby 2002; Jensen et al. 2003; Siegel et al. 2003a; Siegel et al. 2003b; Lach and Schankerman 2003). They have aimed to investigate university patenting and licensing phenomena by assessing patent legislation, university structures and TTOs, industrial trends, and so on.

Thursby et al. (2001) modelled the process of faculty disclosures and TTO licensing in a series of articles. They considered the TTO to be a dual agent for both scientists and university administration. The TTO engages in a balancing act to influence the rate of invention disclosures, while the university administration adjusts the incentives of TTOs and scientists towards patenting by establishing university-wide policies to share royalty incomes. In subsequent studies, these scholars found that the merits and willingness of scientists to be involved in technology transfer activities are positively related to the rate of patenting at the universities.

Thursby and Thursby (2002) have also found a link between motivations and use of support structures. The most active and proficient entrepreneurial scientists have their own network linkages to venture capital, business angels, patent consultants and so on. They therefore do not need to use the services provided by TTOs. TTOs are left, then, with mediocre ideas and scientists who are not very much interested in commercialization (Jensen et al. 2003).

Rogers et al. (2000) found a positive correlation between the qualities of scientists, the age of the TTO, the number of TTO staff and the rate of patenting and licensing activities. Bercovitz et al. (2001) examined the role of the organizational structure of the TTO and its relationships to the overall university administration. Siegel et al. (2003) found that the variation in relative performance of TTOs' rate of patenting and licensing could be explained by environmental, institutional and organizational factors. They also found that while IPR policies at the universities are important for the growth of patenting, cultural and informational barriers between universities and firms as well as insufficient rewards (both pecuniary and non-pecuniary) for scientists are impediments to effective patenting. In addition to the findings by Thursby and Thursby (2002) and (Jensen et al. 2003), Friedman and Silberman (2003), Thursby et al. (2001)

and Siegel et al. (2003a) found that external factors namely university strategy and culture towards entrepreneurship as well as pecuniary rewards, e.g. higher royalty shares for scientists provided by the university or the TTOs, are positively related to patenting activities and licensing income of TTOs.

Shifting attention to the university spin-offs, Di Gregorio and Shane (2003) assessed the determinants of spin-off formation using AUTM data from 101 universities and 530 start-ups. They looked at the importance of internal factors, specifically the quality of university researchers (measured in terms of scientific performance), and the ability of scientists and TTOs to undertake equity in a spin-off as possible influences on the patenting activities of scientists. They also found that external factors such as the availability of venture capital in the region of the university and the commercial orientation of the university (measured in terms of percentage of the university research budget funded by industry) had not had statistically significant impacts on the rate of spin-off formation.

Franklin et al. (2001) found, in the UK, that at old universities with well-established reputations the high-quality scientists were more involved in spin-offs. New universities tended to have weaker academic reputations and were less interested in the start-up of entrepreneurial firms. The lack of entrepreneurial policies was found to be related to cultural and informational problems of the university administration. In subsequent studies, Locket et al. (2003) suggested that universities generating higher numbers of ventures had clear and well-defined strategies for entrepreneurship. Such universities had greater expertise and more extensive social networks conducive to creating more spin-offs. These universities also used surrogate entrepreneurs rather than academics to manage their spin-offs. The roles of academic inventors were found to be similar in both less and more productive universities. Locket and Wright (2005) assessed the relationship between resources and capabilities of TTOs and the level of spin-off formation. These studies implied the importance of external factors. They concluded that there was a positive relationship between the rate of spin-off formation and universities' expenditures on IPR, the business development and marketing capabilities of the TTOs and the extent to which the royalty distribution formula favoured scientists.

Based on interviews with 128 university TTOs managers in the US, Markman et al. (2005b) found three key determinants for the success of TTOs: TTO resources, competency in identifying licensees and participation of the inventors in the licensing process. They also found a positive relation between compensation to TTO staff and venture formation. Royalty payments (financial rewards) to scientists and their departments were uncorrelated or negatively correlated with entrepreneurial activity. In their later studies, Markman et al. (2005c) stated that universities prefer not to invest in inventions that are in the early stages and combined with spin-off formation, since both factors make it the most risky route. Universities and TTOs prefer short-term cash maximization and are risk averse. TTOs may face conflicts with scientists who may want to form a spin-off with an early stage technology. This finding implies that TTOs may need to change their strategies if they want to promote more entrepreneurship.

Most of the studies on patenting, licensing and spin-off company formation are dominated by the cases from the US with a specific focus on elite research universities such as MIT, Stanford and the University of California.[14] The findings are not generalizable to other institutes and organizations that do not have similar legislative or other conditions, since the unique experiences and structures of these universities may explain university patenting. The differences in patent legislation for European universities and US universities, and differences in the university structures (Mowery et al. 2004) and culture (Henrekson and Rosenberg 2000) make it especially interesting and important to explore the extent of patenting and the factors behind scientists' patenting activities at a European university. The fact that few studies have been made on European universities compared to studies on US universities in addition to the lack of systematic data on university patents and inventors for the European universities is an important motivation for carrying out this research at a Swedish university.

[14] Rothaermel et al. (2007) showed that 103 of the 173 articles included in their literature review are about university entrepreneurship in the US, or to some extent from the UK. There are about 14 studies from Sweden (among others, by Merle Jacob, Magnus Henrekson, Magnus Klofsten).

2.3.3 Individuals and University Patenting

Science and technology policy analysts have paid relatively little attention to independent or lone inventors (Meyer 2005: 113). Jewkes et al. (1966) and Schmookler (1957) even claimed that studying individual inventors might seem somewhat obsolete in the twenty-first century (both cited in Amesse et al. 1991). They hypothesized that individual inventors were more often associated with the era of industrialization than with the age of innovation. Industrial firms, R&D labs, universities and research centres are now considered to be the sources of invention.[15]

Nevertheless, individual inventors are still important, even if their activities may not increase to the same extent as corporate patenting (Meyer 2005). Lee (1996) mentioned that studying the role of individuals would be an important contribution to research on university-industry relations. Several scholars have also underlined the importance of the scientists for the commercialization of university research, since the decisions to patent and/or be involved in commercial activities are a matters of personal choice, and the decision to patent may depend on the scientists' perceptions of the effects of academic patenting and the costs and benefits of patenting (Sirilli 1987; Macdonald 1984, 1986; Amesse et al. 1991; Lee 2000; Owen-Smith and Powell 2001; Thursby et al. 2001; Shane 2003; Bercovitz and Feldman 2004; Libecap 2005).[16]

The main issues that have been examined from the studies of individuals are: the basic characteristics and socio-demographic traits of inventors; differences among inventors; motivations or incentives to invent; the productivity of inventors; and patenting versus publishing.

[15] These authors showed that in many countries (US, UK, Federal Republic of Germany, France) the individual inventor's share of patents had declined from about 80% at the beginning of the 20th century to 20 or 25% in the 1970s (Amesse et al. 1991; Meyer 2005).

[16] At Swedish universities, the teacher's exception makes the decisions of scientists to patent very important.

Characteristics of Inventors

The first group of studies of individuals is inspired partly by psychology and behavioural sciences. These studies have asked *who the inventors are and what their characteristics are.*[17] Macdonald (1984, 1986), Sirilli (1987), Amesse et al. (1990), Klofsten and Jones-Evans (2000)[18] and Giuri et al. (2006) have investigated the characteristics, background and socio-demographic features of inventors. The socio-demographic findings of different studies are fairly consistent. Inventors were most often men, their average age being between 45 and 48. They were highly educated and had technical and commercial knowledge and had experience above the average.

Stephan and Levin (2005) investigated whether personal characteristics, age (life-cycle), citizenship status, gender and receipt of federal funding were related to patenting activities. They found little evidence of age effects, yet they found that tenured scientists are more likely to patent than non-tenured ones (Levin and Stephan 1991; Stephan 1996). Women patent less than men.

Studies on the identification of the socio-demographic traits of inventors have not distinguished between different kinds of employment for inventors (e.g. at universities, firms, self-employment, etc). They also have not considered whether there are differences among inventors' motivations to patent, their level of patenting, and different modes of application and commercialization of patents.

Factors behind Patenting or Commercializing Academic Research

The second group of studies on the roles of individuals has taken one step further and has asked *why university researchers commercialize their research results, or why they became involved in patenting, licensing, spin-off company*

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[17] The socio-demographic traits of inventors that the previous studies have suggested so far are compared with the findings of this study in Chapters 6 and 7.

[18] A note should be made here. Klofsten and Jones-Evans (2000) investigated all university scientists; they did not make any distinction between a university inventor and scientists without a patent. The socio-demographic results from Klofsten and Jones-Evans (2000) are therefore not included.

formation.[19] Bercovitz and Feldman (2004) studied the individual scientists. They looked at invention disclosure activities across two medical schools at Johns Hopkins and Duke Universities. They found that certain high-opportunity departments, such as genetics and pharmacology, showed high levels of disclosure events per researcher. They found a wide variation across these two medical schools in other departments. While technological opportunity, scientific fields and university incentives (e.g. royalty shares, rewards, etc.) play a role, it is clear that these are not the only factors at work. Norms associated with training influence subsequent behaviour and drive the adoption and diffusion of new practices. Professional training does more than simply transfer technical knowledge; it actively socializes people to value certain things more than others. Bercovitz and Feldman (2004) hypothesized that the decision of the scientists to participate in invention disclosures is strongly influenced by three factors:

- Training effects: The norms of the institute where the researchers are trained;
- Leadership effects: The actions of the chairperson of the department appear to influence the behaviours of the others;
- Peer effects: Scientists are more likely to be involved in technology transfer if their peers are also doing the same. These three factors were summarized as social imprinting.

Bercovitz and Feldman (2004) pointed to the importance of external factors other than university-TTOs and administrations. It is expected that due to close relations within the research group, researchers would be influenced by their colleagues or they would be under the pressure to follow the activities of seniors or peers. Louis et al. (1989) analysed the commercialization activities of life-science researchers from fifty research universities. Similar to Bercovitz and Feldman (2004), Louis et al. (1989) found that the most important factor behind the involvement of scientists in commercialization was local group norms and culture. They argued that a culture that encourages and advocates entrepreneurship is critical.

[19] Motivations and characteristics of inventors and differences among them are addressed in Chapters 6 and 7.

University strategies, policies and structures have a relatively small effect on commercialization activities.

Regarding another external factor, Roberts (1991) found that social norms and the university's tradition and encouragement of entrepreneurship were important determinants of successful and widespread entrepreneurship at MIT.

Lee (2000) found that the most significant benefit of commercialization realized by scientists is complementing their own academic research by securing funds for graduate students, gaining access to lab equipment and seeking insights into their own research. Reflecting on their collaborative experience, an overwhelming majority of these participants say that in the future they would expand or at least maintain their present level of collaboration. These three factors may therefore motivate scientists to patent. While Etzkowitz (1998) perceived the financial rewards as a positive factor behind the increasing commercial activities at universities, Slaughter and Leslie (1997) underlined the risks of financial rewards and profit motives in the emergence of academic entrepreneurship.

Owen-Smith and Powell (2001) used qualitative data derived from field work on two universities in the US in order to develop an explanation for widely different rates of invention disclosure. They argued that faculty decisions to disclose are shaped by their perceptions of the benefits of patent protection. These incentives to disclose are influenced by the perceived costs of interacting with technology transfer offices and licensing professionals. Finally, faculty considerations of the costs and benefits of disclosure are shaped by institutional environments that are supportive or oppositional to the simultaneous pursuit of academic and commercial endeavours (see above discussion on the roles of institutions and organizations).

Stephan et al. (2007) discussed incentives behind patenting as follows: an interest in solving research problems, gaining recognition and reputation, gaining economic rewards (from the university or external organizations) and interacting with industry (industry has a patent focus and patent know-how and industry may steer towards patentable research).[20] They further assumed that the culture of the university, the effectiveness of the TTO, the field of specialization and duality (patentable research is also publishable) most likely affect the patenting activities of scientists.

Scientific fields may also influence the patenting activities of scientists. Stephan et al. (2007) found that individuals working at medical schools had a higher tendency to patent, as did individuals working at research institutes. This finding is consistent with Owen-Smith and Powell (2001, 2003), who also found that scientists in the life sciences are more active in the commercialization of research results than those in physics and engineering.

Gulbrandsen (2005) found that personal satisfaction and doing something professionally enjoyable were important reasons for scientists to be involved in commercialization. Giuri et al. (2006) investigated the motives of all types of inventors to invent. They asked whether monetary rewards or non-monetary rewards were important motivations for patenting. They found that social and personal rewards (i.e. the fact that the innovation might increase the performance of the organization where the inventor works), personal satisfaction in showing that something is technically possible, and prestige/reputation were considered by the inventors to be more important than other types of compensation like monetary rewards and career advancement.

On a similar note, Baldini et al. (2007: 333) showed that university inventors get involved in patenting activities to enhance their prestige and reputation, and to look for new stimuli for their research; personal earnings do not represent a main incentive. University-level patent regulations reduce the obstacles perceived by inventors, as far as they signal universities' commitment to support patenting activities. In addition to the studies that underlined the importance of external factors such as, social imprinting (research group effect), university culture, TTOs and scientific field; recent studies by Gulbrandsen (2005), Guiri (2006) and Baldini underlined internal factors like personal satisfaction and the joy of

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[20] Although Stephan et al. (2007) mentioned these three incentives as factors behind university patenting, their paper does not report results indicating why scientists patent and what impacts these three factors have on the patenting behaviour of scientists.

solving research puzzles as important factors behind scientists patenting activities.

Differences among Inventors

Researchers have hitherto focused on differentiating inventors and entrepreneurs from the rest of the population, while implicitly assuming that almost all inventors and entrepreneurs constitute a very homogenous group. Even though the aforementioned studies on socio-demographic characteristics of inventors have revealed consistent results, inventors do not necessarily have the same levels of patenting and do not necessarily apply for a patent or commercialize in the same way. An analysis that considers university inventors as homogenous actors would have some limitations. I therefore try to distinguish differences and commonalities among inventors instead of simply distinguishing inventors from non-inventors. To do so, I have investigated a third group of studies which have posed the question of *what the main differences among inventors are and what may explain these differences*. This literature has identified two important differences among inventors: differences in productivity levels and differences in the modes of commercialization.

The first group of scholars, inspired by the work of Lotka (1926), looked at the differences in the productivity of inventors over the researchers' life cycle (Narin and Breitzman 1995; Ernst et al. 2000). These recent studies of the patenting behaviour of scientists and engineers show that patenting activity is highly skewed. They suggest that the skewed distribution of productivity may be related to scientists' image and experience. Merton (1968: 58) used the term *Matthew effect* to describe how, among other things, eminent scientists will often get more credit than comparatively unknown researchers even if their work is similar; the term also indicates that credit will usually be given to researchers who are already famous. Thus, the reputation and the image of scientists may contribute to their productivity.

Stephan et al. (2007), based on Alison and Stewart (1974) and Cole and Cole (1973), stated that a variety of factors may help skilled and motivated scientists to leverage their early successes and that some form of feedback mechanism is at work. They have referred briefly to factors such as intelligence, scientists' image, knowledge accumulation (multiplication) and experience, behind the skewed distribution of performance. These unobservable characteristics, if properly leveraged, lead scientists to be highly productive.[21] Stephan (1996) and Levin and Stephan (1991) suggested that the probability of applying for a patent rises with increasing age and experience. They found that once scientists in the US receive tenured positions, their attitudes towards patenting will increase positively.

Zucker et al. (1998) found that a large number of scientists who patent are either *star scientists* themselves or are affiliated with the most highly ranked research universities. Zucker et al. (2002) argued that a scientist who is involved in industry is not necessarily a loss to the progress of science at her or his university. They found that ties between star scientists and firm scientists have positive effects on research productivity. Star scientists are identified by the number of granted patents, the number of products in development and the number of products on the market.

In addition to different levels of productivity, existing studies have shown that inventors may also differ in the way they commercialize their research results. The literature has emphasized two paths for the commercialization of patents (Amesse et al. 1991; Jaffe et al. 1993; Audretsch and Stephan 1996, 1999; Jaffe and Trajtenberg 1996; Henderson et al. 1998; Zucker et al. 1998; Jaffe and Lerner 2001; Jensen and Thursby 2001; Thursby et al. 2001; Lockett et al. 2003; Shane 2003, 2004; Lockett et al. 2005; Lockett and Wright 2005).

Inventors may either form a spin-off firm based on the patent, or the patent may be commercialized by a third party to whom inventors sell (license or transfer) the rights to the patents. In line with this, many scholars have systematically referred to academic entrepreneurship as activities like patenting, licensing and spin-off company formation rather than regular contract research work or consultancy for established industrial firms (see Zucker et al. 1998; Meyer 2003b; 2005; Gulbrandsen 2005), although they acknowledge the importance of other channels of technology transfer.

Some scholars have tried to identify why and how scientists choose a particular mode for technology transfer and have aimed to categorize the

[21] I deal with the possible factors behind why some researchers patented more in Chapter 7.

scientists into different groups on the basis of such differences. Etzkowitz (1998: 830, 2002: 134) characterized four ways that scientists can be involved in technology transfer:

- National Institute of Health (NIH) persons: These scientists have persistent resistance to industrial involvement. They are often tied to the federal agencies (e.g. National Institute of Health in the US) as their primary sources of support and can hence be referred to as NIH-persons.
- Hands-off: They are indifferent to the technology transfer and opt to leave such matters entirely to the TTOs.
- Knowledgeable partners: They are willing to play a significant role in arranging transfer of their research to industry since they have business insight and are aware of the potential commercial value of their research results.
- Seamless web: This group has full commitment to industrial development through the integration of an academic research group with industrial research programme.

Etzkowitz's classification is based on the *scientists' technology transfer types*, *not on the type of inventors or entrepreneurs*. Rather than stylizing different types of inventors and describing their motivations and the specific traits of different types of inventors, Etzkowitz has suggested four kinds of interaction with industry. His classification has provided some insights about different types of scientists or the way scientists may get involved in commercial activities. He has not investigated the motivations of scientists to commercialize their research results, or why scientists choose different modes of commercialization.

Meyer (2003b) distinguished between *academic entrepreneurs* and *entrepreneurial academics*. The former type tries to implement their research results in the form of university spin-offs by starting their own business. The latter type refers to scientists who adapt their basic research agendas according to the new funding sources (industry) but without a financial growth motive or any perspective of leaving academia.[22] Meyer (2003b) has focused mainly on the impacts of public support measures on the

[22] For other types of categorization of university scientists' commercial behaviours, see Louis et al. (1989), Amesse et al. (1991) and Klofsten and Jones-Evans (2000).

activities of inventors and whether or not researchers' needs are met by the existing mechanisms. In his later study Meyer (2006: 509) has suggested that a further exploration of inventors' and other stakeholders' perception of support measures, local policies, the entrepreneurial orientation of the university and the motivation for entrepreneurial activity on the part of academics is necessary to learn to what extent these factors influence the commercialization paths of scientists.

Gulbrandsen (2005: 55-56) suggested two types of university scientists. He also took some steps beyond his predecessors in terms of investigating motivations. The first type he has described is *basic (academic) researchers* who have a clear academic orientation. Researchers of this type have moderate interests in commercialization activities and consider their patents mainly as an extension of their academic efforts. They use consultants (e.g. TTOs or other actors) to handle their entrepreneurial activities. Although they have shown and expressed an interest in the commercialization of their research results, they prefer to spend little time on it, and they do not want to be involved too much in commercialization. The second type Gulbrandsen has described is *liminal scientists*. Researchers of this type have expressed a certain detachment from the academic world as well as from the commercial world. They have carried out a lot of the entrepreneurial work themselves and have spent more time on commercialization than the basic researchers.

Gulbrandsen (2005) argued that many entrepreneurial scientists should be considered liminal, i.e. on the boundary between these two worlds rather than inside either one of them. In statements about research orientations, motivations for entering commercialization, experiences, cooperation and more, many Norwegian entrepreneurial scientists establish a certain distance from other faculty members and private entrepreneurs. The status of liminality or in-between-ness allows a flexible networking and commercialization process.

Gulbrandsen (2005) compared personal backgrounds, motivations to patent and personal views on the legislative changes for commercialization in Norway. He found that most liminal scientists have professional experience from applied research institutes and/or industry, which is unusual for basic researchers. He found that while doing something professionally stimulating and enjoyable are the main motivations for both types of scientists, liminal researchers are more motivated by financial gains compared to basic researchers, for whom getting extra research funding for their research group is the main monetary motivation. Another central driving force for both groups is the interest and demand of students for entrepreneurial activities. Creating job opportunities for graduate students is another reason for being involved in commercial activities. To a limited degree, some scientists are influenced by earlier role models who have combined basic research with patenting.

Gulbrandsen (2005) further compared the views of 'liminal and basic researchers' on the patent legislation at universities.[23] While basic researchers did not dispute the new law, some liminal scientists were more critical about the recent changes and more sceptical about the ability of universities to handle patenting and company formation in a better way. Liminal scientists seem to be excluded from the planning processes for initiatives like TTOs following the legislative change regarding ownership of research results in Norway. Although there were some differences between these two types, the distinction is sometimes blurred and in most cases it is not significant due to the limited number of observations. Gulbrandsen (2005) suggested that further evidence is required from countries with a different legislative history and status with regard to university patenting.

Gulbrandsen (2005: 71) concluded that the classification of academic entrepreneurs into *basic* and *liminal scientists* with an interest in commercialization fits well with earlier categorizations. In Meyer's (2003b) terms, the basic scientist is similar to the *entrepreneurial academic* who extends fundamental research interests into new settings. Liminal is similar to the *academic entrepreneur* who actually initiates firms. In terms of Etzkowitz's (1998) classification, the liminal scientists correspond slightly to the *knowledgeable partner* who believes that all ideas belong to the originator, while the basic scientist is similar to the *hands-off* category who leaves commercialization to a third party.

Different categorizations that have thus far been developed suggest that there may be differences even among the entrepreneurially oriented scientists. Although the implications of these studies (i.e. identification

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[23] Norway abolished the 'teacher's exception' in 2003 (Chapter 2).

and exploration of different types of scientists and their activities) cannot be generalized, they are interesting themes and merit further investigations. In this study, therefore, I further explore researchers' patenting activities and aim to integrate both dimensions, i.e. different paths of commercializing patents and level of patenting, in order to categorize inventors.

Patenting and Publishing

A fourth theme in the studies of individual inventors, albeit one which is somewhat less relevant for this study, has raised the question *of whether the recent increase in university patenting has challenged the open nature of university research and shifted academic research towards more commercialization*. A number of scholars have investigated the relationship between patenting and open dissemination of research results by scientists in the forms of publications (see Agrawal and Henderson 2002; Stephan et al. 2002; Breschi el al. 2005, 2007; Fabrizio and DiMinin 2005; Azoulay et al. 2006; Meyer 2006; Van Looy et al. 2006). These studies have found that publication and patenting are complementary and *not* competing activities of university researchers. Most of these studies have found a positive relationship between scientific publication and patenting activities.[24] These studies and the relationship between patenting and publishing activities of researchers merit more attention than can be covered in this review. However, it is important to mention that although possible potential influences of patenting on scientific production have received considerable attention, why and how researchers patent has not until recently received the same amount of attention (Gray 2000).

2.3.4 What we have learned about university patenting…and what we still need to know…

In the preceding sections of this chapter, I have discussed the existing literature on university patenting under three main headings. I now

[24] I address this debate by investigating how and to what extent university inventors balance their university tasks alongside patenting activities in Chapter 7.

summarize the key findings of these studies and reflect on the further steps taken by this study.

The common insight that can be derived from the studies on the identification of the extent of university patenting in Europe (e.g. Meyer 2003a, Meyer et al. 2003; Meyer et al. 2005; Lissoni 2007) is that European university researchers are patenting as extensively as the American researchers, even without the Bayh-Dole Act. This is based on the fact that different technology transfer infrastructures and patent legislations at European universities require different methodological approaches. The names of university inventors need to be matched with the names of inventors in patent databases, rather than searching for the names of universities or TTOs as applicants for patents. For instance the studies by Meyer (2003a) and Lissoni et al. (2007) have provided a better picture of the extent of university-based patenting. In countries where universities do not own the patents based on university research, researchers still make substantial contributions to patenting. European universities do not necessarily need to emulate the Bayh-Dole Act in order to increase university patenting. European university scientists already are just as inventive and/or entrepreneurial as their US counterparts (Lissoni et al 2007). However, our understanding of university patenting in Europe is still incomplete for reasons that I now address.

First, while this thesis builds on methodologies and insights provided in previous studies on the identification of university patents and inventors, it goes some steps further than these studies. This study also aims to investigate the factors that explain university scientists' patenting activities by utilizing another group of studies addressing the roles of institutions and organizations as well as individuals in university patenting.

Secondly, even after reviewing studies that have proposed different factors that explain university patenting, our current knowledge about the impact of different factors on university patenting is limited mostly to US or UK studies. Most of the external and internal factors discussed have therefore originated from a US context. The focus in this study is therefore on a European university (Lund University). The lack of theoretical and empirical data for European universities is an important reason to carry out the research in Sweden. There have been a few parallel studies for European countries within the timeframe of this study (Gulbrandsen 2005; Meyer 2005; Giuri et al. 2006; Baldini et al. 2007).

Their evidence and conclusions are mostly indicative, but they are interesting and hence merit further investigations in different contexts.

Third, most of the research to date has focused on universities, firms, science parks and TTOs as the most common units of analysis. There are only a few studies that have focused on individual university inventors. Such studies have mainly pointed to financial, institutional and organizational factors to explain the perceptions and behaviours of scientists towards commercializing their research results. We also need to know further different types of academic inventors, and to what extent different inventors have the same skills or different needs. We do not know the extent to which their needs are met by the existing technology transfer support system and/or patent legislations.

Finally, incentives, support and assistance provided by TTOs, university policies, patent legislation, changes in the scientific disciplines and colleagues are certainly part of the explanations for patenting. But they are only one facet of the story. Another facet is related to the scientists' motives, expectations and perceptions about the importance and necessity of patenting. There are no comprehensive studies to date that cover both internal and external factors. This is an important, complex and relatively under-researched theme. Instead of making a case for or against one view, I try to address both sets of factors to investigate how and to what extent they influence the patenting activities of scientists.

2.4 Factors Behind University Researchers' Patenting Activities

Having presented the studies on university patenting and inventors as reported in Section 2.3, I will now proceed to compile a list of factors affecting university researchers' patenting activities, based on the existing literature. As a point of departure I first group the main factors that previous studies have suggested into two main categories.

The first category focuses on *internal factors* such as individual skills, characteristics, motivations and values, scientists' age and career, scientific human capital, an interest in solving the research question, job satisfaction, industrial experience and diversity of career, social and personal rewards, reputation, promotion, image and confidence, personal income, benefits, social capital and networks, job security and alternative career options. Factors such as scientists' age and academic position, scientific human capital, industrial experience and diversity of career, image and confidence, social capital and networks may enable scientists to patent by providing the skills and resources needed to do so. On the other hand, some of these internal factors such as values and expectations regarding academic entrepreneurship, solving a research question, job satisfaction, social and personal rewards, reputation and promotion may trigger scientists' patenting activities.

The second category is *external factors*, which focuses primarily on institutions and organizations such as patent legislation (e.g. the teacher's exception in Sweden), the third task mandate, TTOs, university structure and culture, as well as increasing relations with industry, new academic culture (e.g. social imprinting). Factors such as patent legislation, TTOs, the third task or strategies and policies of university administration enable scientists to patent. These factors may facilitate scientists' patenting activities by providing scientists with the necessary resources, skills and infrastructure. Factors such as the new academic culture, role models, influences of colleagues and peers, research areas, scientific fields, industrial funding and getting access to external resources may, on the other hand, trigger scientists towards patenting. External and internal factors that have been discussed above are classified in Table 2.1 in order to show how these factors are grouped.

Table 2. 1 Classification of Factors behind University Patenting

Internal Factors		External Factors	
Solving the research question	Characteristics	Scientific discipline & industrial relevance	University strategy & policy
Social & personal rewards	Scientists' career life cycle	Research funds & getting access to external funds	Patent legislation
Financial Benefits/Rewards:	Scientific human capital	Social imprinting & role models	TTOs
Job security & alternative career paths	Social capital & networks	Location, society, & culture	Policy interest (Third task)

2.4.1 Internal Factors

Internal factors that are listed above in Table 2.1 to explain why university researchers patent are summarized as follows in different categories.

1. **Solving the Research Question:** Scientists take pleasure and interest in solving research questions and problems (Levin and Stephan 1991; Hull 1988: 306 in Stephan et al. 2007). The innate curiosity of scientists and the fascination of the research process itself (Stephan et al. 2007) motivate scientists to do research. Solving research problems is believed to give job satisfaction to scientists (see Arvey et al. 1989, Thursby and Thursby 2007). In addition to Mertonian norms (see Merton 1979); there is considerable evidence that scientists have a taste for inventing (Stern 2004). Scientists at universities are intrinsically motivated to do research. Much of the incentive to invent comes from the joy of solving research questions (Levin and Stephan 1991; Stephan 1996). Thus they may be intrinsically motivated to conduct research which may be apart from the ability to earn financial rents from their effort (Hellmann 2007). Recent empirical studies have also confirmed that the innate curiosity of scientists make them do research that can bring reputation and visibility (Gulbrandsen 2005; Giuri et al. 2006). (*This factor is investigated in the survey by asking about solving the research problems.*)

2. **Social and Personal Rewards:** In addition to curiosity-driven research, researchers are motivated to achieve reputation and recognition among their peers (Merton 1957). Scientists are motivated by rewards of recognition and prestige among peers and they have a strong interest in gaining visibility in the academic world. Patenting can enhance the prestige and increase the scientific productivity of the scientists by reaffirming the novelty and usefulness of their research (Owen-Smith and Powell 2001, 2003). Although there is no explicit evidence that patents are used as a criterion to evaluate the academic merits of the researchers (e.g. in academic promotion), some researchers may consider patenting in order to increase their visibility and reputation. On the other hand, scientists who are concerned with more traditional academic values like *publish or perish* might be less motivated to patent for the sake of academic promotion. (*This factor is*

investigated in the survey and the interviews by asking whether scientists patent for promotion, reputation, publication possibilities.)

3. **Financial Benefits/Rewards:** Etzkowitz (1998) and Slaughter and Leslie (1997) underlined financial rewards, monetary compensation and profit motives in their analyses of the new entrepreneurial scientist. Universities that provide greater rewards for researchers' involvement in patenting (e.g. in the forms of equity shares, royalty distribution) are found to motivate scientists to commercialize (patent) more. Greater rewards are measured by the amount of royalty income received by the inventor. Siegel et al. (2003) concluded that organizational factors, in particular researchers' reward systems and technology transfer office compensation, influence the productivity of the technology transfer activities and thus the motivations of scientists to disclose their inventions.

   Owen-Smith and Powell (2001) argued that researchers' decisions to disclose are shaped by their perceptions of the benefits of patenting, licensing and start-up company formation. The incentives to be involved in technology transfer are influenced by the perceived costs and gains of interacting with industry and TTOs. Bercovitz and Feldman (2004: 4) assumed that faculty members would be responsive to financial incentives and that there would be a direct relationship between licensing royalty distribution rates and the amount of technology transfer across universities. Thursby et al. (2001) and Lach and Schankerman (2003) provided empirical evidence that milestone payments and share of license revenues from their inventions are positively related to the motivations of researchers to patent. (*This factor is investigated in the survey and the interviews by asking whether scientists patent to increase their personal income and make financial gains.*)

4. **Job Security and Alternative Career Paths**: In order to develop job opportunities in industry, some researchers who do not have permanent positions yet (e.g. Ph.D. students, post-doctoral fellows) might be motivated to patent in order to have job options in industry, even if they want to pursue an academic career. Moreover, reasons for junior researchers (post-docs, Ph.D.s) to patent could be expectations (plans) to change their career paths from academy to industry. Such

expectations could arise due to tight job opportunities in the existing academic labour market. Dreams of having their own businesses could also lead junior researchers to get involved in more commercial activities. (*This factor is investigated in the survey by asking whether the inventor has wanted to change career from academy to industry*.)

5. **Characteristics:** Socio-demographic studies have highlighted that inventors are mostly men whose average age is between 45 and 48. They are highly educated and have above-average technical and commercial knowledge and experience. These specific traits are discussed below. People who are making entrepreneurial decisions show higher levels of initiative, need for achievement, need for affiliation, need for authority, self-efficacy and creativity (Shane 1994). Moreover, entrepreneurs are described as more risk tolerant, more profit driven, and having stronger personal motivations (Autio and Kauranen 1994) relative to non-entrepreneurs. (*This factor is investigated in the interviews by asking whether inventors' image, popularity and self-confidence influence their patenting activities. It is further investigated through interviews with inventors*.)

6. **Scientists' Career Life Cycle:** Levin and Stephan (1991), similar to Arrow's (1962) argument for firms, suggested that scientists who invest in the creation of knowledge can best appropriate the economic returns from that knowledge depending on their career trajectory as well as the career stage. The university career trajectory expects and rewards the production of new knowledge in good time. Thus the goal of the university researchers is to establish their scientific credibility and reputation. The scientists' career life-cycle factor suggests that early in their careers scientists invest heavily in scientific human capital in order to be promoted (tenured). In the later stages of their career scientists may prefer to exchange their scientific knowledge and reputation for economic returns (Levin and Stephan 1991). On the other hand, due to gradual changes in university culture towards academic entrepreneurship and patenting, younger researchers are now expected to be more entrepreneurial since they may have been less exposed to traditional academic values. (*This factor is investigated in the survey by asking about the age and rank of the inventor*.)

7. **Scientific Human Capital (Image)**: This factor refers to the scientific reputation and status as well as the individual skills and talents of scientists. Commercialization of scientific research results is risky and uncertain (Audretsch and Stephan 2000). The scientific reputation and skills of scientists provide credibility and capability to any anticipated commercial project (Audretsch et al. 2005: 25). Due to low risks of losing their image and credibility, scientists with strong scientific reputations have higher incentives to patent. The propensity of a scientist to engage in patenting is positively related to the amount of the expected rewards. If scientists believe they will receive a greater award amount, or will not damage their image and credibility, they will be more likely to patent (ibid.). A similar argument concerns the academic quality of the scientists and their ability to allocate time for commercial activities. Senior scientists (e.g. with tenure in the US) are also found to be involved in patenting activities more often than juniors (Thursby and Thursby 2003).

   The literature shows that so-called star scientists are the ones who are most interested in commercializing their research results, in contrast to those who claim that academic capitalism lowers the academic quality, novelty and scientific relevance of the research agenda (Fabrizio and DiMinin 2005; Azuloay et al. 2006; Meyer 2006; Van Looy et al. 2006; Breschi el al. 2007). These studies underline that a specific sub-set of researchers, the so-called 'star scientists', appear to be better researchers with more publications and citations as compared to their peers (Lowe 1993; Zucker et al. 1998; Agrawal and Henderson 2002; Stephan et al. 2002; Thursby and Thursby 2003; Van Looy et al. 2004; Lowe and Gonzales-Brambila 2007). However, it should be noted that not every scientist involved in entrepreneurial activities would be able to strike a balance between academic tasks and entrepreneurial engagements. (*This factor is investigated in the interviews by inquiring whether inventors' scientific background, reputation, networks influence them to patent.*)

8. **Social Capital (Networks):** The concept of social capital (Putnam 1993 in Audretsch et al. 2005: 22) refers to connections among individuals or social networks. In analogy with notions of physical capital and human capital, which enhance individual productivity by adding tools and training, social capital facilitates individual

productivity by facilitating coordination and cooperation for mutual benefits. Social capital refers to meaningful relations and linkages that scientists have with others. Similar to the effects of the image (scientific quality) or age of scientists, scientists who have stronger social networks may have easier access to complementary skills, financial support and resources that may be necessary for patenting. They may leverage their social capital in a way that helps them to patent more than scientists who do not enjoy the similar social networks. For instance, researchers who change jobs between academia, industry and government, sometimes changing sectors, or working in multiple settings simultaneously, should have developed more diverse skills and networks that may motivate them to patent (Dietz and Bozeman 2005: 351). Such people should be able to mobilize the social capital present in their networks to facilitate their patenting activities and productivity by facilitating coordination and cooperation for mutual benefits. (*This factor is investigated in the interviews by asking whether inventors' networks with firms, investors, TTOs, research groups, international networks influence their patenting activities and whether this is an important factor for patenting.*)

2.4.2 External Factors

External factors that may explain why university researchers patent are summarized below.

1. **Scientific Discipline and Industrial Relevance:** Working at medical schools (based on the assumption that medical research results can be more easily patentable) has been found to increase the possibilities for university scientists to patent their research results (Friedman and Silberman 2003: 20; Mowery et al. 2004). On the other hand, computer science or natural sciences are not found to be the most patent-oriented research disciplines. Thus university scientists in these fields are found to be less motivated to patent (Thursby et al. 2001), although almost all bio-tech patents result from basic science. Faculty who are involved in multidisciplinary fields or who collaborate with industrial partners are more likely to patent. In emerging fields, scientists are more open and motivated to patent in order to establish their emerging fields or ideas. They may find it necessary to patent in order to attract industrial and/or public resources, and they may want to demonstrate

their achievement and the usefulness of their new research area. (*This factor is investigated by the field and industrial relevance of the research field of the inventor*.)

2. **Research Funds and Getting Access to External Funds:** The literature points out that patents can be used as a tool to trade with industry for access to funding, equipment, materials and other opportunities from industry (Stephan and Levin 1991; Owen-Smith and Powell 2001; Bercovitz and Feldman 2004; Mallon and Korn 2004). Scientists can use patents as a signal to show the industrial relevance and applicability of their research results in order to attract more industrial support. In this case, the research results would be likely to be patented together with the industrial financier of the project. (*This factor is investigated in the survey by inquiring whether researchers patented to attract industrial funds, materials, equipment, resources*.)

3. **Social Imprinting and Role Models:** University research is often done in teams. Due to social imprinting, scientists are easily influenced by the decisions and traditions of their research teams. University scientists who are working with patent-active chairpersons, supervisors or colleagues are more likely to yield more patents compared to faculty who may not have experienced or worked in patent-conducive environments (Bercovitz and Feldman 2004). Junior researchers are motivated or discouraged to patent depending on their supervisors' or chairpersons' attitudes. Roberts (1991) underlines the importance of the existence of role models as an incentive for academics to become entrepreneurs. Bercovitz and Feldman (2004) show that the likelihood of scientists' engaging in commercialization activity (i.e. invention disclosure) is shaped by the commercialization behaviour of the doctoral supervisors in the organization where the scientist has received his or her Ph.D. degree. (*This factor is investigated in the survey and the interviews by asking about the roles of research group, supervisors, chairs, colleagues and peers in the decisions of inventors to patent*.)

4. **Location, Society and Culture:** Scientists' national or regional location is also claimed to be an important factor behind their commercial activities. Knowledge tends to spill over within geographically bounded regions (Jaffe 1989; Jaffe et al. 1993;

Audretsch and Feldman 1996; Jaffe and Trajtenberg 1996). This implies that scientists working in regions with high levels of investments in new knowledge can more easily access and generate new knowledge. Louis et al. (1989) and Audretsch et al. (2005: 29) also found that the local norms of behaviours and attitudes towards commercialization are important factors in shaping the propensity of scientists to engage in commercialization activities, i.e. starting a new firm. In parallel to the opinion of Bercovitz and Feldman (2004) mentioned above, societies, scientific departments or research groups which are relatively open social structures that accept and reward enterprising behaviour seem to produce more inventive and creative people. (*This factor is investigated in the interviews by asking about the impacts of Swedish society and academic culture on the patenting activities of the inventors*.)

5. **University Strategy and Policy:** Universities that have more experience in technology transfer, that have a more entrepreneurial culture and encourage commercialization, are claimed to be more successful in motivating inventors towards patenting (e.g. Etkowitz 2000; Di Gregorio and Shane 2003). Researchers in such institutes are believed to generate more invention disclosures, patents, spin-offs and license income. On the other hand, incompatible strategies regarding patenting from different groups (e.g. university administration, research group, etc.) may confound scientists' attitudes towards patenting. (*This factor is investigated in the survey and interviews by asking about the role played by university administration and the role of the research group in encouraging scientists to patent*.)

6. **Patent Legislation:** Laws and regulations not only provide incentives to patent, but also constrain university researchers' patenting activities in certain ways. Under systems with organizational ownership of patents, university scientists are required to disclose their inventions to the university TTO. On the other hand, individual ownership of patents creates incentives for researchers to engage in commercialization. There are two main types of patent legislation at universities: the so-called Bayh-Dole and the teacher's exception. Patent legislation stimulates institutionalized behaviours, and these, whether they are based on organizational ownership or individual ownership, thereby affect the researchers patenting activities. Since

institutionalized behaviours are customary and expected, and also because they tend to be meshed with complementary patterns of behaviours, they will lower the transaction costs of commercialization (see Sampat and Nelson 1999; Nelson 2008). Second, since they are customary and widely employed, they tend to be sharpened and honed by cumulative social learning (Sampat and Nelson 1999). Therefore the main motivating or compelling aspects of patent legislation depend on how much the given legislation has become customary, habitual, widely accepted and used by the scientists. (*This factor is investigated in the survey and the interviews by asking about the roles of individual versus organizational application for a patent*.)

7. **Technology Transfer Organizations (TTOs):** The size, competence, age and experience of a technology transfer offices or licensing offices are claimed to be the most important aspects for increasing patenting or commercialization activities in general (Bercovitz et al. 2001; Meseri and Maital 2001; Owen-Smith and Powell 2001; Siegel et al. 2001; Carlsson and Fridh 2002; Siegel et al. 2003; Kruecken 2004; Debackere and Veuglers 2005). These studies provide qualitative findings on different types TTOs and their activities. Existing studies show that incentives to become involved in patenting and other entrepreneurial activities are increased or decreased by the perceived costs of interacting with TTOs or dealing with patenting and licensing and firm formation individually. The services and competences of TTOs are claimed to be important factors behind the rise of university patenting. In terms of organizational structure, creating specialized and decentralized TTOs within the university is often viewed as instrumental in securing a sufficient level of autonomy for developing relations with industry (Macho-Stadler et al. 2004). (*This factor is investigated in the survey and interviews by asking how inventors perceive the roles of TTOs.*)

8. **Policy Interest (Third Task)**: The notion of a 'third stream' of activities or 'third mission' developed from research activities. The starting point is the assimilation of fundamental research into codified knowledge and thus into information (Laredo 2007). Alongside a university's core missions of teaching and research, there is a third task of using its knowledge to support economic development, social well-

being and policy-making. This covers a number of industrial, commercial, entrepreneurial or other societal or policy-related activities (Martin 2003). In Sweden, the third task states explicitly that universities now have an obligation to inform the public about their research and to actively cooperate with other actors in the society to decide research goals and problems. Although the third task is not further specified and it is solely up to universities to interpret how they will implement it. Since the amendment was made in 1997 there seems to be a definite trend towards a reading that interprets the third task as being mainly about the commercialisation of academic research (Jacob et al. 2003: 1557). In line with this trend, within the scope of this thesis the third task is referred to as commercial and patenting activities. (*This factor is investigated in the survey and interviews by asking about the importance of the third task in encouraging scientists to patent.*)

2.5 Summary

Chapter 2 has discussed the previous literature on university patenting in order to derive a list of factors to guide the empirical investigation. I have utilized the factors listed in Table 2.1 in the design of the survey and interview guides. All the aforementioned factors are investigated in the empirical analysis, as indicated by the italicized comments in parentheses. The categorization enabled me to formulate the inventors' survey and interview guide as well as to address the address the dissertation's second research question: *Why and how do Lund University researchers patent?* I expect that scientists may have a variety of reasons, motivations and incentives to patent.

3. Methodology[25]

3.1 Introduction

This chapter addresses the methodology of the dissertation. It describes and explains the methods chosen to address the study's research questions as defined in Chapter 1. The empirical chapters contain more detailed and concrete accounts of these techniques and how they were actually employed. Here, the focus is on the overall methodology rather than specific methods, and the discussion is accordingly conducted at a more general level.

This chapter is organised as follows. Section 3.2 presents the choice of case study as an approach to analysing university inventors and patenting at Lund University (LU). Section 3.3 discusses the choice of LU and Sweden as the research context. Section 3.4 presents the specific data collection methods. Section 3.5 reflects upon how the data are analysed.

3.2 A Case Study Approach

This dissertation utilizes the case study as a general research strategy. One of the most widely cited accounts of case study research methods is found in Yin (1994: 6). He identifies the case study as the preferred method in research situations where 'how' or 'why' questions are being posed, where the investigator has little control over events and where the focus is on a contemporary phenomenon within a real-life context. The choice of this research strategy aligns well with the purposes of this dissertation as formulated in Chapter 1. The study examines university researchers' patenting activities within a specific institutional and organizational context (that of LU in Sweden) and in addition to investigating the extent of this phenomenon, the study also inquires into 'how' and 'why' it occurs.

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[25] This chapter is based on Goktepe 2005b. An earlier version of this chapter was presented at the DRUID Winter Conference 2005. I am indebted to the late Dr. Leif Hommen for his in-depth discussion on methodology.

University researchers' patenting activities can be influenced by different factors. As underlined both in the framework of different factors behind university researchers' patenting activities (Chapter 2) and in the following discussion of data collection techniques (see also the empirical chapters), this study aims to investigate not only the internal factors related to characteristics of university inventors but also the external factors. This aspect is also relevant to the choice of a case study approach. Leedy (1997) describes the case study method as an in-depth study which situates the phenomenon central to each case within its natural context and also includes the viewpoint(s) of the participants.

Goode and Hatt (1952: 331 in de Vaus 2001: 234) have described the case study as 'a way of organizing social data … to preserve the unitary character of the social object being studied' and thus 'an approach which views any social unit as a whole'. Yin (1993: 31) also stresses holism in his account of the rationale for using a case study approach. He argues that this research strategy is especially well suited to research situations where the investigation covers both a particular phenomenon (i.e. patenting activities of university inventors) and the context (i.e. the university system, institutions, organizations and research milieux) within which the phenomenon occurs – either because (a) the context is hypothesized to contain important explanatory information about the phenomenon or (b) the boundaries between the phenomenon and the context are not clearly evident.

The holistic aspect of the case study approach is highly appropriate to this study. The underlying theoretical and empirical purpose is to investigate the role and the activities of university inventors within their social context – i.e. with regard to a particular university environment, the associated institutional and organizational set-ups for patenting and other relevant social factors. Taking a case study approach to this subject matter is justified, above all, by the consideration that inventors cannot be isolated from the environments in which they are living and working. First, they are subject to the limitations as well as the opportunities offered by their surroundings. Second, inventors may have different or similar backgrounds, skills and motivations enabling them to utilize what their surroundings offer them. Third, and most importantly, the patenting behaviour of these researchers is influenced by both external and internal factors. The case study method has been selected to inquire into this dynamic process and, more generally, to investigate the research topic of patenting by university researchers within the real-life context of Lund University, based on multiple sources of evidence.

3.3 The Choice of Sweden and Lund University

As explained previously, *university inventors* at LU in Sweden have been chosen as the main units of analysis. As noted in Chapter 1, LU is not only a large, 'first tier' research university situated within the EU context; it is also located in an EU and OECD member state that has continued to afford university researchers exclusive intellectual property rights to the results of any publicly funded research they have carried out within the university (the teacher's exception).

LU was founded in 1666 and is based primarily in Lund, a small town in the south of Sweden. It is one of the largest entities for research and higher education in Sweden (and in Scandinavia), with eight faculties and a multitude of research centres and specialized institutes. It has campuses in three neighbouring cities: Lund, Helsingborg and Malmö. The university has 42,500 students and 6,000 employees. More than 3,000 post-graduate students work there, whereof 45 per cent are women. Most doctoral degrees are awarded in medical sciences, followed closely by engineering and natural sciences. In 2004, the university had 554 professors, of whom 14 per cent were women, and 435 new research students were accepted, half of whom were women. In the same year, 458 doctorates were awarded.[26]

Although this study is limited to one university, it covers a broad range of scientific disciplines and a large number of individual inventors. It investigates a wide variety of factors that may influence the patenting activities of inventors. There has also been considerable attention and need to understand how entrepreneurial activities, e.g. patenting can be encouraged within the university context. At the same time, it has restricted its empirical focus to the most important centres for patenting activity at LU, in order to make data collection and analysis more manageable. The Medical Faculty (MF), the Lund Institute of Technology

[26] Public information on Lund University <http://www.lu.se> retrieved 15/07/2007

(LTH) and the Natural Sciences Faculty (NS) were chosen as sites for this study because of their important roles in university patenting processes at LU.

As mentioned briefly above, and also discussed in Chapter 1, it is interesting to study university inventors in Sweden because of the country's particular institutional and organizational set-ups for university patenting. Sweden has kept the law on the teacher's exception, while creating a wide range of technology transfer organizations (TTOs), including university holding companies and other regional technology transfer agents, alongside the initiation of the third task for universities. Moreover, many large Swedish firms have long had strong connections with leading universities in Sweden. Current policies towards for the formation of university-industry competence centres or projects with industrial partners have strengthened such relations. Consequently, Sweden's present UITT system provides university inventors with different commercial routes such as: (i) patenting individually, (ii) patenting through TTOs, (iii) choosing among different TTOs to patent through, or (iv) patenting through industrial firms.

As discussed further in Chapter 4, LU has taken several steps towards the establishment of a technology transfer infrastructure. For instance, LU Innovation (formerly the university's industrial liaison office) and LUAB (LU Development Company) were formed in 1995 to provide business advice and assistance to university researchers. In 2007 these agents were gathered under an umbrella organization called Lund University Innovation System (LUIS). Several regional actors, e.g. the Technology Bridge Foundation, Forskarpatent, Teknopol, and so forth, were also established in the 1990s to facilitate technology transfer and to guide and help university researchers in their commercial endeavours.

Additionally, there have been practical reasons for the choice of Sweden and in particular LU. This research has been conducted during my doctoral education at LU, Sweden. By basing this study at LU, I have therefore had the possibility of gaining relatively easy access to information about the university, as well as having favourable conditions for arranging interviews with inventors and representatives from TTOs.

3.4 Combination of Quantitative and Qualitative Methods

Yin (1994: 14) has argued that case studies should not be equated with qualitative research. The case study approach is rather a general strategy for research, in connection with which there is considerable latitude regarding the choice of evidence, which may include either qualitative data or quantitative data – or both. Further, there is also a wide range of choice with respect to specific techniques for data collection and analysis. The case study approach is therefore not limited to qualitative data collection but, on the contrary, allows the researcher to employ both quantitative and qualitative data collection techniques. Eisenhardt (1989: 537) has also stated with regard to inductive or exploratory case study research that multiple data collection methods provide a stronger validation for building theories. Moreover, a combination of different data sets generated by using qualitative and quantitative techniques can be stimulating, rewarding and highly useful.

This study therefore combines qualitative and quantitative methods. Qualitative evidence is used to describe and analyse the processes of university patenting in a rich and detailed way, while quantitative evidence is used to describe and analyse the extent and structure of patenting activity by university researchers at LU. Through the combination of different data collection techniques, including surveys and interviews, patenting activities are mapped in general and more than 120 inventors' patenting activities are observed. Detailed accounts of the specific methods used can be found in the empirical chapters, for which different data collection methods have been used.

Quantitative Data Collection

The quantitative part of this study has two main components. The first is the construction of the Lund University Patent (LUP) Database. The aim of constructing this database was to address the first of this dissertation's two research questions: *What are the extent and patterns of patenting at Lund University?* Using techniques similar to those employed in previous studies seeking to describe and analyse university patenting in Europe (see

Chapter 2), I identified inventors at LU by matching the names and home addresses of LU researchers with the names and addresses of inventors listed in the EPO database. Further description of how the LUP database was constructed and how patenting patterns at LU were mapped can be found in Chapter 5. Without constructing the LUP database, the rest of the research for this study would not have been possible.

The second component of the quantitative work carried out for this study is a survey of the inventors who were identified in the LUP. With this survey, I aimed to address the dissertation's second research question: *Why and how do Lund University researchers patent?* Surveys are one of the most commonly used descriptive methods in the social sciences. Data from the inventor survey provided insights about the patenting process and implications of patenting from the perspectives of the inventors. The survey was carried out as a standardised questionnaire distributed by e-mail. When requested by the inventors, surveys were sent by regular post, and in ten cases the questionnaire was administered face to face. Although the survey was not conducted anonymously, the names of the participants were kept confidential. The results of the survey are reported and analysed mainly in Chapter 6. An essential aspect of the analysis of survey data is to identify factors that influence university researchers' patenting activities. One important outcome of this analysis is the typology of inventors.

Together, the LUP database and the inventor survey provide an extensive body of quantitative evidence on university patenting and university inventors at one of Sweden's most important research universities.

Qualitative Data Collection

The qualitative part of this dissertation also has two main components. The first consists of interviews with sub-sets of inventors (selected serial inventors and occasional inventors) who have been identified in the LUP database. The aim of the interviews with inventors was also to address the second research question; here I seek to provide an in-depth understanding of the internal and external factors affecting researchers' patenting activities and to substantiate the typology of inventors based on the inventor survey. In total, sixty inventors were interviewed (forty serial inventors and twenty occasional inventors).[27] As with the inventor survey, the names of the interviewees were not revealed.

The second component of the qualitative work carried out for this study is an investigation of the roles of TTOs (or similar third agents) in the patenting activities of inventors. In total, seven interviews were carried out with representatives of relevant TTOs associated with LU. These interviews are analysed and reported in Chapters 7 and 8.

In addition to the primary data discussed above, some secondary data were such as reports of National Agency for Higher Education (HSV), the Swedish Governmental Agency for Innovation Systems (Vinnova), the OECD, TTO and websites of departments and faculties were used to complement the LUP database and the results of the survey and interviews.

3.5 Analysis

As explained previously, the dissertation's purposes were addressed by means of a case study approach that facilitated the incorporation of contextual (institutional and organizational) factors into the analysis and, at the same time, developed a strong focus on individual inventors as the main unit of analysis. Case studies involve much more than explaining variation in one variable in terms of variation in another variable. I have therefore tried to take into account alternative explanations for any causal relationships between different factors and inventors' patenting activities.

The data collected on this basis, by the techniques described above, supported an analysis indicating that there are many different factors that have an impact on how and why inventors patent. The quantitative empirical data have been analysed and presented in the form of descriptive statistics. One way of reporting and organizing the analysis is to use typologies. The results from the inventor survey and interviews were organised in a way that led to the development of the typology of inventors. The typology is derived inductively from the empirical findings (de Vaus 2001: 225).

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[27] Some of the interviewed inventors had also responded to the survey.

The data obtained from interviews were analysed in two stages. First, each interview was summarized – although these long summaries are excluded from the final version of the study. On the basis of the interview summaries, cross-case comparisons were developed, and their results are presented in Chapters 7 and 8.

Following Eisenhardt's (1991) insights, I studied university patenting by observing more than 120 inventors' patenting activities. Different cases permit replication and extension among individual cases. This corroboration helped me to perceive patterns more easily and to eliminate chance associations, even though I faced difficulties of statistical generalizations. For instance, different interviews often raised different aspects of the university patenting phenomenon.

In order to achieve second-level generalization (Eisenhardt 1989) university patenting, the empirical findings and theoretical conclusions are compared to those of other UITT studies (see Etzkowitz 2003; Bercovitz and Feldman 2004; Mowery et al. 2004; Gulbrandsen 2005; Meyer 2003b) with which empirical and theoretical parallels can be drawn.

In this study, a reasonably long historical period of university patenting is covered. Additionally, the interviews with the inventors aim to capture the changes in the current and past patenting activities of inventors. Rather than eliminating historical, or evolutionary, contextual factors, I include them in order to enhance the understanding of university patenting.

In this thesis, the aim is therefore to understand how the patterns of university patenting at LU can contribute to a more general account of the factors behind university patenting, rather than asking what the study can tell us about the wider population of university inventors based at universities other than LU. Because of this, I acknowledge that one cannot be sure that the conclusions drawn about cause-effect relationships do actually apply to inventors or universities in other geographic locations or with different features. By the same token, this typology is aimed not at explaining a wider population, but rather at stimulating new thinking and theoretical approaches to investigating the activities of university inventors. It is therefore interesting to utilize the analytical framework and the typology of inventors in further studies.

4. An Overview of University-Industry Relations in Sweden

4.1 Introduction

The question of how to improve the contributions of universities to economic development and growth has become an issue in Sweden in recent years. Chapter 4 first gives a brief introduction to the general picture of university-industry relations and important historical and political milestones in the Swedish system of higher education. It then presents the institutions and organizations, e.g. the teacher's exception, the third task, technology transfer infrastructure (e.g. TTOs) and the Competence Centre Programme, concerned with university-industry relations. Chapter 4 is a bridge between the discussion of theory in Chapter 2 and the empirical chapters to follow.

4.2 An Overview of the University System

Sweden is believed to have strong knowledge foundations in both the public and the private sectors. It can even be argued that Sweden has been an 'ideal-typical' knowledge-based country throughout the period since the Second World War (Benner 2003: 140-141). Sweden has put substantial resources into R&D, and its R&D spending relative to GDP has been one of the highest in the world for more than a decade (Vinnova 2002). Sweden also hosts several world-leading firms with high R&D intensity, e.g. in high-technology sectors, large firms such as Ericsson in telecommunications and AstraZeneca in pharmaceuticals (ibid.). Sweden also holds a world-class scientific position in terms of publication rates in leading academic journals. In some key fields, such as immunology, clinical medicine, neuroscience, ecology and biochemistry, Sweden is producing large absolute numbers of scientific publications (Persson 2002 in Benner 2003: 141). 'Sweden has been able to retain its scientific strengths and has the largest international impact of all the Scandinavian research systems' (Benner 2003: 141).

Until the mid 1940s, higher education was offered in Sweden at the universities in Uppsala and Lund, at the university colleges in Stockholm and Gothenburg and at a number of institutes specialized in medicine, economics, technology, agriculture and silviculture (forestry). Most higher education institutes were state run except for the university colleges in Stockholm and Gothenburg which were operated by local authorities. The schools of economics in Stockholm and Gothenburg were run by private foundations.

Swedish universities have a significant role in performing publicly funded R&D. Along with the private sector, therefore, academia is an important source of inventions that may be commercialized (Karlsson 2004: 86). A basic difference from e.g. the US universities is that universities in Sweden are public authorities and receive a majority of their funding from the national budget (ibid.). This has implications for openness and secrecy regulations. University departments typically decide whether to take on contract research or to participate in publicly funded R&D. Swedish researchers may carry out sideline activities (such as contract research and consulting work) within certain limits (Karlsson 2004: 86).[28] Additionally, the research institute sector is very limited in Sweden compared to e.g. Germany, the US, France and Italy (Edquist 2004). Universities in Sweden are therefore generally expected to do both basic and applied research.

Expenditure on total R&D as a percentage of gross domestic product (GDP) increased from 2.2 per cent in 1981 to 4.3 per cent in 2001, and was slightly less than 4 per cent in 2003 (Vinnova 2006: 11).[29] According

[28] University researchers are allowed to take 20% of their employment time to engage in industrial activities.

[29] In 2004 the total investment in research and development in Sweden amounted to SEK 95.1 billion, which in current terms is a reduction of SEK 2 billion compared to 2003. The expenditure on R&D expressed as a proportion of the GDP therefore fell from 4% to 3.7%. Despite this decline, Sweden still comes out well in any international comparison and attains the target set by the EU that 3% of the GDP should be invested in R&D. The government's goal is that government appropriations for research should amount to 1% of the GDP. In 2005 the GDP was SEK 2,674 billion, which means that the target level is SEK 26.7 billion (HSV 2006).

to 2004 data, R&D conducted by the private sector accounts for 74 per cent of the total R&D expenditure, and almost all of it is conducted by the country's twenty largest firms (e.g. Ericsson, ABB, Volvo, AstraZeneca). R&D conducted by universities accounts for 21 per cent of total the R&D expenditure, which is the highest percentage in the world.[30] On the other hand, R&D conducted by research institutes is only 3.5 per cent of the total R&D expenditure (ibid.). Government funding is the most important source of funding for universities in Sweden as in most other OECD countries (OECD 2002). The funding of academic research has changed considerably. The importance of external funding increased from 42.6 per cent of the total budget in 1993/94 to 53.1 per cent in 2000 (Hällsten and Sandström 2002). In 2002, external funding accounted for about 55 per cent of the total research funding (HSV 2003).

Even though there is no conclusive evidence that Swedish technology transfer programmes are a failure, many scholars have claimed that it is unlikely that Sweden is harvesting the as much of the commercial potential of its academic research output as successfully as the US. This phenomenon is sometimes dubbed the Swedish Academic Paradox, and it refers back to four different notions which have been summarized by Ejermo and Kander (2006) as follows. The first formulation of the Swedish Paradox was made by Edquist and McKelvey (1996), who found that the production of high-tech products in Sweden was low in relation to the country's high R&D expenditures. The second version of the paradox was formed by Braunerhjelm (1998), who stated that Sweden's high-tech exports were low given the large R&D investments. The third version was more general and stated that Sweden was inefficient in transforming its high R&D expenditures into productivity and growth (Andersson et al. 2002), or more generally that the country's economic performance was poor (Klofsten 2002).

The fourth formulation, which is the most relevant for this study, is based on a narrower analysis of the commercialization of university

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[30] This share is largest for Sweden, with about 0.88% of GDP in 2003. For Germany, the share of R&D performed by the higher education sector is about half that of the Swedish efforts, namely 0.43% of GDP in 2003. The US invests about the same share as Germany, with 0.44% of GDP in 2003. This illustrates the important role that the universities have as performer of R&D (Sellenthin 2006: 47).

research. This account of the Swedish Academic Paradox claims that despite relatively high investments in universities, technology transfer from universities in the form of commercial outcomes such as patents, spin-offs or licensing revenues are low (Vinnova 2003).[31] Andersson and Henrekson (2003) discussed the role of university structures in Sweden in the entrepreneurial activities of researchers. They argued that due to weak incentive structures for getting researchers involved in entrepreneurial activities, commercial outputs from universities were lower in Sweden compared to, for instance, to US universities. Henrekson and Rosenberg (2000: 23) argued that the Swedish system has, at least until very recently, constricted the entrepreneurial avenue of commercialization, and Henrekson (2002) argued that due to the lack of institutional and organizational support, it is unlikely that Swedish university researchers have strong incentives to produce commercially valuable knowledge. These studies refer to several key differences between Sweden and the US in patent legislation, availability of TTOs, and university policies and structures (Henrekson and Rosenberg 2001; Goldfarb and Henrekson 2002).

Stankiewicz (1986, 1997), Etzkowitz et al. (2005) and Jacob and Orsenigo (2006) claimed that most of the university technology transfer activities have been informal and outcomes are not systematically organized. Especially in line with policies of the 1970s,[32] universities have established traditional relations with large Swedish firms such as Astra, Pharmacia, Volvo and Ericsson. These informal relations were created by individual scientists and were designed to solve the problems of a relatively small group of large firms. For many years systematic data about these 'informal' relations were lacking (Jacob and Orsenigo 2006). Such

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[31] Jacobsson (2002), Jacobsson and Rickne (2004) and Granberg and Jacobsson (2006) have suggested that official figures on higher education R&D in Sweden may be overstated compared to other countries. Jacobsson and Rickne (2004) focused on the investments in higher education and the extent of scientific publications in order to review the Swedish Academic Paradox. However, the main concern of this study is not the extent of academic publication but the extent of academic patenting.

[32] In the 1970s the sector research concept (sektorsforskning) was introduced by the Social Democratic government. The main point of this sectorally oriented research policy was that the state should determine, formulate and initiate the research needs of different economic sectors as well as meet the costs. The researcher should develop the knowledge and methods needed to achieve specific goals (Helmström and Jacob 2005).

linkages were casual and formed between university researchers and industrial partners without the intervention of university administration. These relations have some critical aspects. First, research groups may turn into subcontractors of the aforementioned large firms, nearly all of which are multinational corporations. Second, university research may be tapped by these firms, with limited possibilities of firm formation. Third, informal networks may disappear, since most of the former partner firms have been internationalized and the individual contacts have become unstable.

In addition to these fairly informal relations between existing large industrial firms and universities, a considerable number of new policy programmes and policies such as industrial research institutes, sectoral research and the establishment of science parks and incubators have been introduced over the last fifty years to promote university-industry collaboration.

4.3 Institutional and Organizational Set-up

During the 1990s, several major changes were made in Swedish research policies that would lead to increased collaboration between Swedish universities and industry. In the next section I present the patent legislation (the teacher's exception) as well as the inclusion of the third task in the Higher Education Act, and the formation of new organizations to facilitate technology transfer. The Competence Centre Programme is presented due to its relevance for the ownership of patents at universities.

4.3.1 The Teacher's Exception (*Lärarundantaget*)

Employment laws play an important role in determining the extent to which individual researchers can or cannot own and commercialize the intellectual property generated in the context of their employment. Employment law may differ, however, for researchers who are public or civil servants and those who are privately employed.

The scope or applicability of the laws for universities depends on a variety of factors and differs across OECD countries. In some countries, provisions for ownership of intellectual property by researchers at universities are found in the patent legislation, and in others they are the result of employment law governing inventions by employees. Regulations on research funding may contain explicit provisions regarding the ownership and transfer of intellectual property, but again, there are important differences between countries. In some countries, provisions take the form of recommendations or are institutionalized in procedures and practices, leaving room for interpretation and exceptions (OECD 2003).

In general, either the employer (organizations) or the employee has the ownership of intellectual property. In Sweden, the teacher's exception has been in force since 1949. This law implies that lecturers, researchers and students own all of the results of the research they have conducted at the universities where they are employed (Goldfarm and Henrekson 2002). Therefore in Sweden, while non-university public organizations retain the ownership of intellectual property, college and university employees have the right of ownership of their patents. This exception allows the employees to sell, exchange, or give away their research results to anyone they wish, or keep them for themselves. The teacher's exception guarantees and provides the individual ownership of the intellectual property. This law gives university researchers full entitlement to their research results.

A leading argument for keeping the teacher's exception is that it creates incentives for researchers to engage in commercialization. According to the teacher's exception, the Swedish system can be considered to be a relatively direct approach which expects researchers to be the main initiators of patenting. On the other hand, many argue that this exemption should be abandoned in order to facilitate the commercialization of research. According to the critics, few researchers favour applying for a patent before carrying out research and researchers often also lack the financial means to pay the heavy patent fees and to defray the costs of disputing encroachment on patents in court. For these reasons potential research results may never be patented. It is argued that if the teacher's exception is taken away and holding companies and patent and license agencies are set up, scientists will patent with the help of technology transfer agencies and patenting will increase (Brulin et al. 2000).

By the same token, critics expect that a continued existence of the teacher's exception would lead to smaller incentives for universities to support technology transfer. Since universities have no direct benefits, some universities might therefore discourage contacts between faculty members and industry due to the fear of losing researchers who may prefer higher wages in industry or who may want to have their own companies without sharing revenues with universities (Etzkowitz et al. 2000: 35).

Another argument against individual ownership of patents is that, as most university research involves multiple researchers, there is some risk that firms might hesitate to license the technology when several individuals have claims on the same invention. It might also be difficult to reach a consensus among several researchers to patent. Moreover, a researcher who owns intellectual property can commercialize it abroad and thus reduce the national benefits from public funding for research (OECD 2003: 25). Finally, the financial burden and risks of a patenting process may lead inventors to prefer publishing as a more secure and less costly way of gaining academic promotion. Consequently, some university inventors decline to get involved in patenting activities themselves.

4.3.2 The Third Task (Den Tredje Uppgiften)

In the 1990s, university collaboration with industry and society in general came into sharper focus. This has been explicitly formulated as the third task in the Higher Education Act (1997). Universities and other higher education institutes are expected to collaborate with their local communities, the business communities and the public sector, and universities are expected to provide information about their activities (HSV 2005). The convention of the third task was made into a law although it had already existed in Swedish university governance since the mid 1970s. This law holds that in addition to the two main tasks of research and teaching, universities have a responsibility to communicate their research results to the surrounding society and industry (Jacob et al. 2003; Edquist 2004). As discussed by Jacob and her colleagues (2003: 1557-1558), due to a lack of clear understanding of the third task, besides interaction with the surrounding society, it has often been interpreted as 'entrepreneurial and commercial activities of universities'. On the other hand, the absence of any clear notion of what is properly interpreted as the third task and what is not seems in some cases to be read by the state as an open invitation to pile more and more new functions on universities (ibid). Thus, for instance, no additional funding is provided for the demands for the various forms of collaboration that are invoked in the name of the third task, and the result is that many universities are facing a situation of functional overload.

Nevertheless, some efforts have been made to facilitate the spill over of knowledge produced in universities to industry and society. University researchers have considerable freedom to engage in societal (third task) activities, which are rather broadly defined. This means that they are normally allowed a certain percentage (often 20 per cent) of their normal working time to engage in consultancy, starting up firms, patenting in separate firms, writing debate articles, etc. (Andersson and Ejermo 2005). However, the law about the third task of universities is not very specific as to what universities should do to fulfil this mission. In a narrow sense, the third task can be interpreted as aiming to streamline (institutionalize) the policy effort towards more entrepreneurial activities and interaction between universities and firms and society.

4.3.3 The Technology Bridge Foundations

A major initiative with regard to facilitating technology transfer from universities was the introduction of a number of foundations with funding that was not tied to annual budget allocations from government agents, but to stock market earnings from an initial capital stock. The capital invested was created in the 1990s when the liberal-conservative government transformed the so-called wage-earner funds into research funds.[33] The research funds created by this measure was aimed to provide Swedish research with additional capital, were all oriented towards funding research and development. The funds were intended to be independent of any government or research policy doctrine. They were also supposed to work directly to promote collaboration between

[33] Wage-earner funds were created by the Social Democratic government in 1983 for the purpose of giving workers more power in the companies they worked for.

universities and firms and the commercialization of academic research results (Sellenthin 2006).

Among various research foundations, a number of Technology Bridge Foundations (TBF hereafter) were founded in 1993. They were reorganized in 2005 under the name Innovationsbron AB (Innovationsbron AB in Lund is presented in Section 4.3.5.) Seven TBFs located in seven major university cities became operational. Together they received capital of about one billion SEK, the return on which they could use to increase commercial benefits from university research and to encourage cooperation between industry and academia. The mode of operation in the TBFs varies between the different units. They have developed differently depending, among other things, on the conditions and needs in each region.[34] TBFs have a broad mandate. Their major aim is to act to increase contacts between universities and industry in the whole country with the purpose of increasing the exploitation of universities' knowledge and competence in order to increase growth in Swedish industry (RRV 2001: 32 in Sellenthin 2006). However, the absence of a clear notion of the third task has implications on the understanding of the roles of such technology transfer organizations. Generally, however, it may be said that they provide universities with assistance to make the linkages with the rest of society (Jacob et al. 2003). They are basically active in three areas. First, they support patenting and licensing of research results, including assessment of the commercial impact of the product and financial support, e.g. seed capital. Second, they increase contacts between universities and industry, including collaborative research projects. Third, they increase collaboration between small and large enterprises in projects in which they are involved.

4.3.4 University Holding Companies

In addition to the seven TBFs, five holding companies were founded in 1994 and six in 1995 at major universities. The Swedish university sector is largely public with most universities being essentially state authorities. Since the third task was interpreted specifically as commercialisation and entrepreneurial activities, university holding companies were founded to

[34] < www.oecd.org/dataoecd/59/54/2762717.pdf > retrieved in 15/07/2007

provide some legal solution, e.g. to the financing of patenting and other commercial activities. The holding companies are however for the most part under-resourced, in terms of both funding and competence and many are either dependent on the TBFs or generally ineffective (Jacob et al. 2003). In general their aim is to own, sell and administer shares of wholly or partly-owned companies whose purpose should be to pursue research and development aiming at commercial exploitation. The university holding companies are owned by the universities and can be seen as important instruments of the universities for facilitating technology transfer. The holding organization separates this activity from the rest of the university. The university holding companies provide information and guidance to researchers regarding patenting and commercialization. Some holding companies are actively involved in commercialization through the establishment of new enterprises (Sellenthin 2006).

4.3.5 An Overview of TTOs in Lund

Two types of technology transfer organizations (TTOs) have been formed in Lund. The first group, which includes the LU Development Company (LUAB) and LU Innovation, is part of the university administration. The second group is external to the university, e.g. the Innovationsbron AB (formerly the Technology Bridge Foundation), Forskarpatent, Teknopol, TeknoSeed and Lumitec, but they have close relations and ownership arrangements. While the main objectives of these external TTOs are to commercialize LU research results and to guide LU researchers, they have close connections with other universities (or university colleges and public research institutes) in the Skåne Region.

In addition to the political initiatives coming from the central government for the formation of external TTOs, there are also local factors behind the formation of technology transfer agents. Some of these regional organizations have been created because of changing relations between LU researchers and firms at Ideon Science Park in Lund since the mid 1990s. For instance, when Ideon was established in 1983, relations between Lund Institute of Technology (LTH) and Ericsson were very intense and were based on networks and relations between scientists and researchers at Ericsson. Those relations seemed to weaken during the 1990s when Ericsson moved from Ideon to its own premises, though it was still in the same area. Ideon management focused on filling the vacated space by attracting new and smaller firms.

Lund University Development Company (LUAB): The LU Development Company (Lund University Utveklingsbolag, LUAB hereafter) was founded in 1995 as part of the Swedish government's new focus on the importance of university-industry relations in Sweden and its recognition of the potential benefits that commercializing university research could bring to Swedish society. Owned by LU and financed largely by Innovationsbron AB, the holding company has the role of building an efficient technology transfer infrastructure and giving grants and investing, at a very early stage, in projects or spin-offs emanating from the academy. It also has a subsidiary that functions as a legal platform for projects which for some reason are not suitable for conversion into independent subsidiary companies. The primary objective of LUAB is to commercialize knowledge from LU in a business setting.

LU Innovation: LU Innovation is the former Industry Liaison Office of Lund University. It has been reorganized to become the TTO of Lund University. The mission of LU Innovation is to stimulate, seek and support innovations coming out of LU by making personal visits to research groups.

Innovationsbron AB: The Innovationsbron AB was formerly known as the Technology Bridge Foundation (TBF) in 2005. A new holding unit, called the Innovationsbron AB, was formed by the former seven regional TBFs as well as Vinnova and the Swedish Industrial Development Fund (Industrifonden). The Innovationsbron AB, which has been and remains a non-profit organization, aims to act as a kind of umbrella organization for other agents which have a specific focus on technology transfer (as described below).

Lund University Technology Group (Forskarpatent i Syd AB): Forskarpatent AB is a company established to exploit the commercial value of the results of scientific and technical research from universities in southern Sweden through patenting and licensing. Forskarpatent is co-owned by the Innovationsbron AB, LUAB, the Development Company of Halmstad University, the Holding Company of the Swedish University of Agricultural Sciences, and the Blekinge County Research Foundation.

Through agreements with individual scientists or groups of scientists, Forskarpatent offers professional help in matters associated with patenting and licensing. But Forskarpatent is not a patent agency as such. Its primary task is to patent the university researcher's invention before passing it on to a company that can develop it into a successful product or service. Forskarpatent is prepared to assume the sole responsibility for the patenting and commercialization of a product, offering the researcher a share in future profits in exchange.

Teknopol: Teknopol AB has been helping innovators and entrepreneurs since 1994. It is owned by the Innovationsbron AB, the Region of Skåne, and ALMI. Teknopol is located at Ideon Science Park in Lund, but its partners are universities and science parks in the south of Sweden and can be found in Kalmar, Karlskrona/Ronneby, Växjö, Halmstad, Kristianstad, Helsingborg and Malmö. Based on the entrepreneurs' needs, it aims to provide entrepreneurs with the appropriate expertise from its network and to help entrepreneurs sort out their thoughts and test the potency of their ideas. Teknopol also participates in the development of the Swedish-Danish Öresund region.

TeknoSeed: TeknoSeed is a venture capital company, financing university spin-offs and other start-ups related to the R&D community in the south of Sweden. It is located in Ideon Science Park and is owned by Innovationsbron AB. Since its inception in 1997, it has been providing early-stage venture capital as well as consulting to young research-based firms. TeknoSeed has been developing an extensive network, through which it aims to provide a high-quality deal flow as well as contacts for later-stage financing.

Lumitec: Lumitec is a venture capital company founded in November 2002 by LUAB (Lund University Development Company), the regional venture capital company Malmöhus Invest, and the Swedish Industrial Development Fund (Industrifonden). Lumitec's role is to identify projects associated with the universities and technology research institutes in the Öresund region and to create profitable growth through an active ownership.

4.3.6 The Competence Centre Programme

The Swedish Competence Centre Programme is an important attempt to connect university researchers and firms. University researchers and industrial researchers participate for the purpose of achieving long-term research results (Vinnova 2004). The basic motivation is the active participation of industry in academic research that brings about mutual benefits. The twenty-eight competence centres are specialized in specific research fields within the following areas:

- Energy, Transport, and Environmental Technology (eight centres),
- Production and Process Technology (seven centres),
- Biotechnology and Biomedical Technology (five centres),
- Information Technology (eight centres).

According to Vinnova (2003: 1), 'during a 10-year period (1995-2004) Swedish industry and the Swedish government make a joint investment of 550 million Euros on research collaboration in 28 competence centres at 8 universities.' Industry pays about 22 million Euros per year, universities pay 19 million Euros per year, and Vinnova and the Swedish Energy Agency pay 19 million Euros per year. On average, eleven firms participate in each centre. Seventeen centres have applied for 115 patents and eleven centres have contributed to the establishment of 22 spin-off firms.

In these competence centres, university researchers and researchers from the financing enterprises conduct collaborative research. The ownership issues of IPR have been resolved by letting the universities represent their employees in dealing with the participating firms (Vinnova 2006: 18). Agreements that regulate IPR issues have been signed between universities and public and private participants. In such cases, firms have option rights (first right to refusal) to an invention produced in a competence centre project. This means that researchers who collaborate in these national competence centres do not own the patenting of research results without the agreement of the participant firms. The teacher's exception is valid only if there are no other contractual agreements.

The possible influences of patent legislation, technology transfer infrastructure (e.g. TTOs), programs for university industry cooperation and the third task will be examined as external factors in the empirical analysis.

To sum up, this chapter has presented an overview of university-industry relations in Sweden, with a specific focus on the main institutions and organizations relevant to university patenting.

5. Identification of University Inventors and Patents[35]

5.1 Introduction

One of the arguments put forward in Chapters 1 and 2 is the lack of systematic data on university patenting in Sweden. This chapter aims to address the first research question: *What are the extent and patterns of patenting at Lund University?* I aim to identify the patents based on research carried out by scientists employed at LU and describe the scientists who are involved in patenting activities. In order to be specific and detailed enough for a meaningful analysis, patenting activities at three faculties, Lund Institute of Technology (LTH), the Medical Faculty (MF), and the Faculty of Natural Sciences (NS), are complied into a database called the Lund University Patent (LUP) database. This database provides the basic information and profiles on the university inventors. The conceptual background for the construction of the LUP database is discussed in Chapter 2, in section 2.3.1 on the identification of university patents and inventors under *non-Bayh-Dole* regimes.

Chapter 5 is organized as follows. Section 5.2 describes the data collection method and the construction of the LUP database. Section 5.3 presents the empirical findings. First, I describe the basic characteristics of patenting patterns at LU. Second, I present the characteristics of inventors affiliated with LU. Third, I present the patent applicants. Section 5.4 summarizes the main empirical findings regarding the LUP.

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[35] This chapter is based on Goktepe 2006a, Goktepe 2008. Earlier versions of this chapter were presented at the Technology Transfer Society Conference 2005; Division of Innovation Seminar 2005, the DRUID Winter Conference 2006; and the 2nd EPIP Conference 2007. Many thanks to Jonas Gabrielsson, Jesper Christensen, Maryann Feldman, and Elad Harison, Ed Steinmueller and Bruno von Pottelsberghe de la Potterie. I thank Johan Deger, Olof Ejermo and Martin Meyer for their initial comments and suggestions.

5.2 Construction of Lund University Patent Database

Definition of a Lund University Patent (LUP): Based on the distinction between university-owned versus university-invented patents (Meyer 2003a), LU-patents are defined here as patents for which at least one of the inventors is affiliated with LU. In order to be counted as a university person, the inventor has to be included in the official university personnel registers and has to be employed by LU at the time of the invention.[36]

In this chapter I have applied a methodological approach which has become a standard method for identifying university inventors where individual ownership is the common practice, as discussed in Chapter 2 (see Meyer 2003a; Meyer et al. 2003; Balconi et al. 2004; Meyer et al. 2005; Iversen et al. 2007). The methodology is based on a procedure which matches names and addresses between two databases, i.e. university personnel registers and the patent database. The methodology can be divided into two main steps and several sub-steps as follows:

Selection of the databases:

- Use of European Patent Office (EPO) database
- Retrieving Swedish patent applications from EPO
- Lund University Researchers (LUR) registers

Construction of the LUP database:

- Name matching between EPO-Swedish (EPO-SE) Patents and LUR
- Name, address and zip-code matching between EPO-SE Patents and LUR
- Address and zip-code matching between EPO-SE Patents and LUR
- Further manual checking
- Validation of names in the grey zone

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[36] Adjunct professors and lecturers have about 20% of their employment at a university. They are involved in teaching, research and supervision. In Sweden, Ph.D. students have the working conditions similar to those of any other faculty members. Both of these groups are considered to be employees of Lund University. I further investigated whether or not the patent was applied for during their employment at LU (see Chapter 6).

5.2.1 Selection of the Databases

The two databases that were used for identifying the university inventors are EPO and LUR.

Use of the European Patent Office (EPO) Database

On the basis of my previous comparative study between the EPO, the Swedish Patent and Registration Office (PRV) and the USPTO (Goktepe 2005a), I chose the EPO database because it provides more information about inventors, such as the full names and addresses of inventors alongside applicants. The databases of the other patent offices provide only the names of inventors' cities but not the addresses of the inventors.

The EPO database is preferable to the PRV database for practical reasons. The PRV database does not include the addresses of the inventors, and without controlling for the addresses of the inventors and university employees, there would have been many wrong matches. The EPO database is also chosen over the USPTO database for practical reasons. Because the USPTO database does not include the full addresses of inventors, it would have been very difficult and complicated to find out whether the inventor and university researcher is the same person.

EPO patent applications from Sweden have also been on the rise in general. Sweden submitted the highest number of patent applications per capita to the EPO, according to EPO statistics, for the year 2000. Swedes submitted 3,070 patent applications in 2000 to the EPO, or 346.4 applications per million inhabitants. This was a 73 per cent increase over 1999. Swedish companies are increasingly submitting more applications for patents to the EPO than to the PRV.[37] This trend has been found to be a significant change not only for large Swedish companies; but also important for small technological companies which want to have international expansion.[38]

However the use of the EPO database limits the scope of the analysis. In using it, I might have excluded inventors who have patents registered

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[37] <http://www.isa.se/templates/News____2599.aspx> retrieved 04/04/2008

[38] < http://www.awapatent.com/?id=13758&tid=print> retrieved 04/04/2008

only in other offices (e.g. the USPTO, the Japan Patent Office, and the Swedish Patent and Registration Office–PRV).

This study has counted patent applications rather than granted patents. All patent applications are published 18 months after their filing date, unless they have been withdrawn. The publication of a patent application is not an indication of the patentability of the invention in any way. From the date of publication, a European patent application confers 'provisional protection' on the invention in the states designated in the application. Although it would have been interesting to use granted patents, there are several reasons to use patent applications instead. For instance, due to examination times the number of granted patents would have been much more limited, and I would not have been able to capture the views of the inventors who had applied for a patent but whose patents had not been granted yet. In addition, different examination times across technological sectors mean that the coverage would have been more comprehensive for some areas than for others. In certain areas, such as biotechnology, examination times can last about five years. This is mainly due to a lack of qualified personnel and an overload of applications to be examined in the patent offices (Meyer 2002 in Meyer et al. 2003). Although patent applications and patents are not the same thing, for the sake of brevity, the word patent is used instead of patent applications. This has been a standard practice among the studies using the EPO database (see Schild 1999; Balconi et al. 2004; Breschi et al. 2005).

Retrieving Swedish Patent Applications from the EPO

The EPO-Swedish patent is defined as a patent where at least one of the inventors has a residing address in Sweden (SE), i.e. I made the search query to find all patents that have SE in the inventors' address field. This query gives 35,073 patents from 1978 until February 2005 that have at least one inventor from Sweden. All the bibliographic information is provided and then converted into an MS Excel file.

Patents that have application dates earlier than 1990 have been excluded. This is because if I had sampled very old patents, it would have been difficult to track their inventors. I would not have been sure whether or not the patent had been applied for during the inventor's employment at LU. As a result I had 22,824 patents from September 1990 to September 2004 (fourteen academic years) that have at least one inventor with a Swedish residence regardless of the nationality of the inventor.

The EPO database for Swedish inventors was cleaned manually and standardized so that the data became suitable for matching. In the EPO database some special letters (letters with diacritics, *å, ä, ö, é, á, ü*) were sometimes not used or were spelled with combinations of extra letters (e.g. *å* as *ao* or *a*, *ä* as *ae* or *a*, *ö* as *o* or *oe, ü* as *u* or *ue*). These possible characters and letters were checked manually.

The empty values in each column and cell in the MS Excel sheet were re-checked to make sure that all information was placed correctly. For instance, if the information was placed in the wrong column or cell, it was corrected manually. Empty spaces before the information in each cell were trimmed and cleaned to make the database ready for matching with the LUR database.

Lund University Researchers (LUR) Database

The second database used in this research was LUR for three faculties: LTH, MF and NS. Employment records of researchers at these faculties from September 1999 to September 2004 (five academic years) were obtained from the Personnel Office of LU.[39] Before starting the name- and address-matching process, the university researchers' registers were checked and any mistakes were cleaned manually. The data for each of these five years from September 1999 to September 2004 were merged from separate files into a single file, named LUR–all; this file has 17,280 names (university researchers). The doubles (researchers who were employed over those five years and who appeared more than once in the LUR with same address) were eliminated. This cleaned file contains the names of 4,214 university researchers employed from September 1999 to September 2004. However, I kept the original LUR–all database so as to

[39] I had to limit my use of the Lund University researchers' registers to September 1999 to September 2004 since the personnel registers for earlier years become less reliable due to misspellings and lack of postal and e-mail addresses.

be able to check if there were any changes in the positions and departments of the inventors over time.

Inventors' and researchers' names were matched across the periods. One must keep in mind that this is a conservative measure since only five years of Lund University researchers were available for analysis (matching) compared to fifteen years of EPO patent data. Although it is considered to be a legitimate choice and is common in other studies as well, (see Meyer et al. 2003) it has some implications which I need to point out. What seems to be an implicit assumption that university researchers are typically inventors of university-originated patents, it is non-trivial since only registry data is chosen for the end of the observational period.

It was difficult to asses whether the inventor was employed at the university at the time of invention. It was especially important for pre-1999 patent applications in this study. Since I could not match on a year-by-year basis, there is a possibility that a set of patents were applied for when inventors might have been employed elsewhere (at the time of the invention). While one can well argue that these patents are not related to LU and thus may not reflect the actual extent and trends in university patenting, this problem has been subsequently addressed by further controls and especially in the inventors' survey by asking them to 'choose one of their patents during their employment at LU', 'about their employment status during the patent application' as well as by asking the 'about the nature of research that led to the patent'. Thirteen researchers stated that they were inventors but had made their inventions at another organization, and they were eventually not included in the final LUP database (see step 8 and Chapter 6).

5.2.2 Construction of the LU-Patent Database

In order to construct the LU-patent (LUP) database, I matched the names and addresses of researchers in LUR with the names and addresses of inventors in the EPO-SE database. The database matching followed a logical step-by-step procedure, often involving the repetition of the same basic steps. (Figure A1 in Appendix A1 visualizes the basic steps taken for the construction of the LUP database).

Step 1a: Name matching between EPO-SE patents and LUF

The procedure was based on matching the first two letters in the first name and the full surnames of inventors in the EPO-SE patent and LUR databases. This type of matching gave preliminary coupling for different name-surname combinations (e.g. Anders Andersson – Anders Andersson but also Andrea Andersson, Andreas Andersson, etc.).[40] All these matches were checked manually and only exact matches were accepted. I repeated the same matching procedure for every inventor of the same patent if a patent had more than one inventor. As a result of this matching procedure, I had the exact name matches for LUR and EPO-SE inventors.

The matching procedure described above was repeated for different possible combinations of the first and middle names of the inventors and LUR. For instance, for a name like Sven-Erik Svensson I matched, first, Sven-Erik Svensson; later, I matched Sven Erik Svensson, Sven E. Svensson, S. Erik Svensson, Erik Svensson. Moreover, some names were abbreviated (e.g. Daniel → Dan, Danny). All these different name combinations were checked. Further, I thoroughly went through every match and checked each name one by one for possible spelling mistakes such as use of double *ss* or single *s* (e.g. Andersson might be spelled as Anderson). Homonyms were controlled for by matching their addresses.[41] I checked addresses, zip codes and cities, and then concluded that the university scientist and the inventor was the same person.

Step 1b: Name, address and zip-code matching between EPO-SE patents and LUR[42]

To supplement the first part of step one, I matched the addresses and zip codes between the two databases. This matching provided perfect

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[40] All names used for methodological explanations are arbitrary and created by the author. They do not reflect the names of the actual university inventors.

[41] Homonyms: They have the same names but they are not the same person. I do not know if they are the correct match of the inventor and university employee.

[42] This kind of methodology has not been used in previous studies. This method is especially important for finding misspelled names.

matches since it confirmed both the names and the addresses of the inventors.

Step 2: Only address and zip-code matching between EPO-SE patents and LUR

In the third step, only the addresses and zip codes were matched. All possible abbreviations of addresses (e.g. Gatan – G, Vägen – V, Södra, Östra, Västra, Norra) and different spellings of *ä–å–ö* were checked manually. If a patent had more than one inventor I repeated the address and zip-code matching procedure for every inventor of the same patent.

As a result of the address matching, some of the names that were missed in the previous matching exercises were found. Some names were misspelled, changed (due to divorce or marriage), abbreviated (sometimes middle names were not used). I also found some missed names due to different transliterations of foreign names, (e.g. Chinese or Russian) or due to different spellings of *ä–å–ö*. After the name and address matching and subsequent manual checks, I constructed two sets of name matches as follows:

Perfect matches: The first name, middle name and surname, and address, zip code and city of the inventors in the EPO-Sweden (EPO-SE-inv) database and researchers in the LUR were matching.

Name-only matches: The first name, middle name and surname of the inventors in the EPO-SE-inv database matched the researchers in the LUR registers but their addresses could not be checked due to lack of information. Inventors without addresses were checked further on the Internet and the university personnel catalogue.

Step 3: Checking the scientific field of the inventor-researcher pairs and patent area

For further confirmation I also checked the scientific discipline of the researchers with the technological classification of the patents. All these checks were performed manually.

Step 4: Co-inventors and colleagues

I manually checked the co-inventors to find out if they too were affiliated with Lund University. For example, I checked the lists of LU publications and research projects, the homepages of faculty and researchers and the CVs of inventors to find out if any of the co-inventors were also from LU. Through this process, ten more LU-inventors were identified. Their names or addresses were spelled differently (e.g. inventors who have different name orders, such as Arabic and Chinese names, and who did not have the same addresses in the databases) and could not be identified in the previous steps.

Step 5: Identification of academic title and age at the time of the patent application

In order to identify the academic title of the inventor, I considered the academic title and age closest to the date of the patent application.

Step 6: Identification of academic affiliation at the time of the patent application

The identification of academic affiliation was complicated due to ongoing re-organization at different departments and faculties. Another problem was the miscoding of academic affiliations in the LUR database. Moreover, some researchers have been affiliated with more than one department or division. Some departments and divisions have been also merged or have changed their names. All these issues made it difficult to determine which of an inventor's divisions might be pertinent when the patenting activity took place. I have chosen the academic affiliation which was closest to the date of the patent application.

Step 7: Identification of patent applicants

In order to get the most accurate information about applicants' size, sector, location and type, and their links to the inventors, the applicants for each patent were identified in the EPO-Sweden (EPO-SE) patent database. These features were investigated for all applicants by using search engines, homepages and business websites. Changes in the names of applicant firms, e.g. Astra or AstraZeneca, Ericsson or Telekombolaget Ericsson, were checked manually.

To sum up, the name and address matching was more accurate than the methods used in previous studies, which generally relied on name matching and surveying the name matches. This study has decreased the risks of including non-patent holders with identical names. As a result of the matching and the manual checks I found around 273 inventor-researcher pairs. Of these, 23 inventor-researcher pairs had name matches but did not have address information for further confirmation. These 23 inventor-researcher pairs were checked further in step 8.

Step 8: Validation of the names in the grey zone

This thorough methodology decreased the number of researcher-inventor pairs that needed to be further checked manually by phone and e-mail to twenty-three. Ten inventors confirmed that they were the inventors and employed at LU. Three inventors stated that they were inventors but had patented at another organization and eventually asked not to be included in the LUP database. Ten inventors could not be reached due to missing addresses. I checked their EPO-SE addresses in online telephone and address catalogues in order to contact them,[43] but this effort did not lead to any positive outcomes and these inventors were not included in the final database. This step-by-step, quite tedious, manual procedure provided methodological usefulness by eliminating the risks of erroneously excluding or including inventor-researcher pairs to a certain extent. Through this process, 260 inventor-researcher pairs from LU were identified. However, ten inventors later responded to the survey (Chapter 6) and stated that they were not employed at LU at the time of the patenting. They were accordingly excluded from the LUP database and the surveyed sample.

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[43] E.g. <www.eniro.se> for unknown telephone numbers and addresses.

5.3 Mapping of Patenting Patterns at Lund University

As a result of these matching and validation processes with the survey and telephone calls, a total of 458 patents were identified as LU-patents, and 250 university researchers from LU were identified as inventors in the EPO patent database. Finding the names of LU-inventors through these processes, instead of hasty searches for LU or university TTOs, has illustrated a more inclusive notion of university-related patents and has captured the contributions of academic science to patenting in a more comprehensive fashion (see Meyer 2003a).

In what follows, I describe and analyse the empirical findings in the light of three aspects. First, I present the extent and the patterns of LU-patents between September 1990 and September 2004. Second, I present basic characteristics about the LU-inventors and set the background for Chapter 6. Third, I present the LU-patent applicants and propose exploratory insights about the various characteristics (e.g. type, size, sector and location of applicants.

5.3.1 Basic Aspects of Patenting Activities at LU

Distribution of the patents at LU by year over selected periods

The extent of patenting at LU is displayed in Table 5.1 from September 1990 to September 2004. As shown in Table 5.1, there has been a relative increase in the patenting activities, despite slight decreases in the number of patents over the years from September 1990 to September 2004. Although university patenting may not have been shown before the 1990s, it has become much more common within the last two decades. A slight drop in the year 2004 can be explained by the fact that the patent database used for the matching at the time only covers the applications made up until September that year.

In total, from September 1990 to September 2004, 458 patent applications were made at the EPO. Patent applications can be analysed in five year periods. During the years 1990 and 1994 the total number of patent applications was 65. Between 1995 and 1999 the number of patent applications was 159. This is more than double of the patents applied in total during the years 1990-1994. Finally, the number of patent applications reached to 234 between 2000 till 2004.

Although it is difficult at this point to draw any conclusions about the reasons behind this relative increase in the patenting activities, in Chapter 2 I presented several potential factors such as the development of new, high-opportunity technology platforms (e.g. computer science, molecular biology and material science); the more general growing scientific and technical content of all types of industrial production; the need for new sources of academic research funding; and the so-called third task activities. The relative increase in LU patents may also be affected by the general increase in Swedish patent applications to EPO (see Section 5.2.1).

Table 5. 1 Number of Patent Applications by Year (9/1990-9/2004)

Year of Patent Applications	*Number of Patent Applications*
1990	9
1991	7
1992	18
1993	13
1994	18
1995	15
1996	28
1997	27
1998	54
1999	35
2000	54
2001	60
2002	70
2003	34
2004	16
Sum	458

Further possible explanations for patenting activities among the Lund University researchers will be addressed in Chapters 6, 7 and 8.

Distribution of patents by three faculties at Lund University

Patenting activities can also be related to the field of scientific specialization. Figure 5.1 shows the more patent-intensive research environments at LU. Of the total number of patents from the three LU faculties under consideration, 63 per cent emerged from Lund Institute of Technology (LTH) related fields, 32 per cent are related to disciplines at the Medical Faculty (MF). 5 per cent originated from departments from the natural sciences (NS). However since some patents are co-invented by researchers affiliated with different departments and/or different faculties, the distribution of patenting among three faculties led to a substantial amount of double-counting.

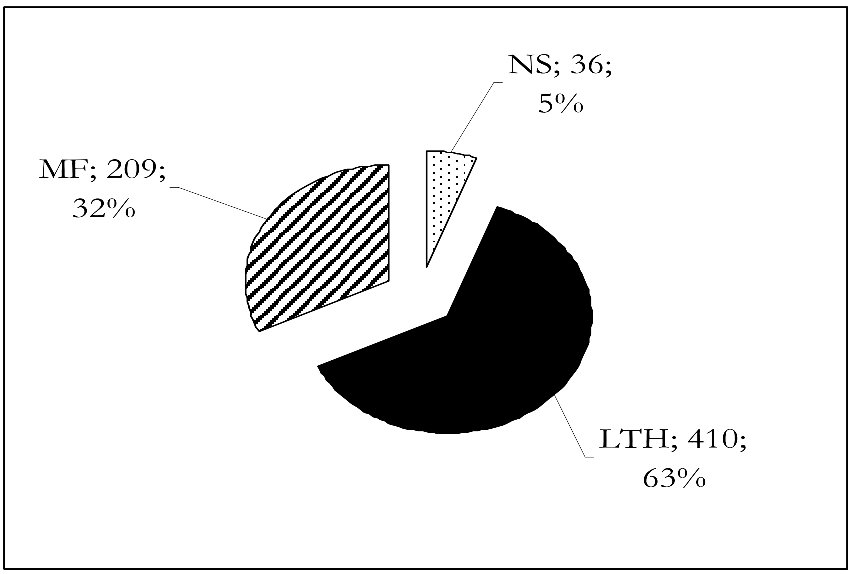

Figure 5. 1 Distribution of Patents by Three Faculties at LU (9/1990-9/2004)

The relatively higher concentration of patenting activities in the MF and the LTH can be explained by the nature of research conducted in these faculties. Previous research has shown that it has become more common to patent in fields like biotechnology, chemistry or engineering. The broadly defined research areas of biotechnology, pharmaceuticals, information and communication technologies and new materials tend to display a higher level of university patenting activity across countries (see Mowery et al. 2001; Geuna and Nesta 2006). University patenting among the LU researchers at the MF and the LTH could also be stimulated by the growing technological opportunities in these fields. Moreover, traditionally strong industrial links and collaboration between researchers with the firms in areas like mechanical engineering, chemistry and pharmaceuticals may also lead to more patenting activities in these two faculties. Such sector-specific developments and the existence informal relations prompt a questioning of the impact of other factors like deliberate policy changes towards entrepreneurship and/or the activities of TTOs.

The NS has 36 patents. The relatively lower amount of patenting at the NS can be explained in part by the more basic research conducted there compared to the applied and industrially relevant nature of research at the LTH and at the MF. An underlying explanation for the distribution among scientific fields could be that in certain fields (basic theoretical physics, geology), patenting is not the preferred route for the protection and utilization of research results (Stephan and Levin 2005). It has also been pointed out empirically by Jacob et al. (2003) that within traditional research areas, researchers tend to look only at such a small and well-defined area that it is unlikely that new knowledge in that area alone would give rise to a new product. The newer research fields such as biotechnology, ICT, etc. can therefore be a larger source for new companies.

Differences in the size and resources of departments, the roles and motivations of the scientists and the chairperson, the inherent culture of respective departments towards technology transfer, the availability of industrial funding, collaboration of researchers with industrial partners or participation in Vinnova Competence Centres may explain the differences among departments within the same faculty. However, in comparing departments and faculties in terms of patenting, it should also be noted that departments and faculties vary in size (number of scientists, research expenditure, types of research). For instance, in the period from September 1990 to September 2004 the average number of scientists at the LTH was 1,802; at the MF 1,610; and at the NS 802. The number of researchers and size of research group may affect the level of patenting activities at different faculties. However, it should be noted that some of the departments were merged with other departments and some were subdivided. It was therefore problematic to find exact the number of researchers at the time of patenting.

Distribution of patents among the departments within the same faculty

In this sub-section, I take one step further and present the distribution of patenting activities among the departments within the same faculty. The data shows that the number of patents differs not only among the three faculties, but that the departments within the same faculty differ in the level of patenting activities as well. Each university patent in the LUP database was allocated to a university department by the identification of the inventor's departmental affiliation. In cases where a single patent is invented by several inventors from LU, the patent was allocated to the department of each of the relevant inventors. This resulted in a substantial amount of double counting. The following three tables show the distribution of patents at the departments within the same faculty.

It would have been interesting to relate the number of researchers and the resources available per department or division to the levels of patenting activities. However, it was rather complicated to find this kind of information. For instance, almost all chemistry divisions at NS and LTH are closely related, and they also work in collaboration at the Chemical Centre. Similarly, Department of Physics at NS is closely related to the Engineering Physics at LTH.

It should therefore be noted that the size of the departments may vary depending on the double affiliation or actual work place of researchers. I therefore address further possible explanations for this pattern in Chapters 6 and 7.

In what follows, I briefly describe the patenting activities at the departments of the three faculties.

Faculty of Natural Sciences (NS): Natural Table 5.2 shows that the most patent-intensive field at the NS is analytical chemistry. It is followed by biochemistry, physics and organic chemistry. During the years 1999 to 2004, the number of patents at different departments at NS was as follows: Analytical Chemistry had 10 patents, Biochemistry had 8 patents, Physics has 7 patents, Organic Chemistry had 6 patents, Physical Chemistry had 3 patents and Biology as 2 patents.

Table 5. 2 Patents at Natural Sciences Faculty (NS) (9/1990-9/2004)

Departments at NS	*Patents*
Analytical Chemistry	10
Biochemistry	8
Physics	7
Organic Chemistry	6
Physical Chemistry	3
Biology	2
Total	36

Lund Institute of Technology (LTH): Distribution of patenting activity at the different departments at the LTH is shown in Table 5.3.

According to Table 5.3, the Chemical Centre had 130 patents. The Chemical Centre which includes all chemistry areas at LU is the largest department. It has almost 700 employees, including the researchers who are employed at different chemistry divisions at the NS. Most researchers at the Chemical Centre collaborate with industry through individual networks or through Vinnova Competence Centres, e.g. the Bioseparation Centre, the Functional Food Centre and so on.

Table 5. 3 Patents at Engineering Faculty (LTH) (9/1990-9/2004)

Departments at LTH	*Patents*
Chemical Centre (Biotech & Food Engineering)	130
Electrical and Information Technology	83
Electrical Measurements Industrial Elec. & Automation	77
Engineering Physics	44
Mathematics	41
Building and Environmental Technology	20
Mechanical Engineering	10
Computer Science	5
Total	410

The Department of Electrical and Information Technology is a merger of the departments for Electro-Science and Information Technology together with the networking group from Communications Systems.

According to Table 5.3, in total there were 83 patents at the department of Electrical and Information Technology. There were approximately 150 employees during 1999-2004. Researchers from the department participate in various types of research centres and research programs supported by Vinnova, regional actors, and industrial partners, e.g. Vinnova Industrial Excellence Centre - System Design on Silicon, Competence Centre for High Speed Wireless Communication and the Competence Centre for Circuit Design.

As shown in Table 5.3 above, there are 77 patents at the Department of Electrical Measurements and Industrial Electrical Engineering and Automation. There are approximately 70 researchers were employed during 1999-2004 on average. The research at this department is also industrially relevant and several researchers participate in industrial networks.

The Department of Engineering Physics have 44 patents. The Department of Physics has divisions belonging to both the NS and the LTH, where about 170 researchers were employed during the 1999-2004 on average. Researchers at Physics are also engaged in centres such as the Nanometer Structure Consortium, the Centre for Combustion Science and Technology, or researchers interact with industry through individual networks which may influence the patenting activities at the department.

The Centre for Mathematical Sciences is a joint department covering all areas of mathematical sciences at LTH. There are about 100 employees and 41 patents at Mathematical Sciences. Most of the research is carried out within applied mathematics, especially image analysis and computer vision. Researchers also participate in a Vinnova funded project on automatic generation of metadata from images, a Swedish Foundation for Strategic Research (SSF) funded project on computer and biological vision and so on. Such projects may also increase the possibility of patenting at the Centre for Mathematical Sciences.

Building and Environmental Technology had 20 patents, and there were about 100 employees during 1999-2004. The research at the department covers a broad spectrum of fundamental and applied issues in building technology. Research activities are strongly supported by the Forest Industry Sector.

The Department of Mechanical Engineering includes the theoretically oriented subjects of mechanics and solid mechanics, and the more applied subjects of materials engineering, machine elements and production & materials engineering. About 50 employees worked during 1999-2004 at the Department of Mechanical Engineering, and there were 10 patents.

The Department of Computer Science is part of both the NS and the LTH. About 70 researchers were employed by the department during 1999-2004. The subject of computer science covers, in principle, all aspects of computer programs and software. Computer Science has 5 patents. In general it is less common to patent computer sciences.

Medical Faculty (MF): Table 5.4 below shows the distribution of patenting at the three departments and the divisions at the MF.[44] The Medical Faculty comprises six departments situated in the cities of Lund and Malmö and collaborating on clinical education and research with the two major university hospitals there. The MF is one of the largest faculties at the Lund University. The Faculty encompasses 2,500 full-time students, 950 graduate students and 1,200 employees. There are 139 professors and about 450 researchers and teachers. Among them, 101 are senior lecturers, 63 are instructors and 30 research assistants. Research spans across a broad area from basic experimental research to applied research in order to answer questions related to clinical practice, the health sciences and society.[45]

The patenting activities in the MF are concentrated in three departments. Clinical Sciences had 92 patents. Laboratory Medicine had 72 patents. There were 45 patents at the Experimental Medical Sciences.

Within these three respective departments, patenting activity in the Department of Clinical Sciences, the Divisions of Surgery and Medicine Studies have higher number of patents. In the Department of Laboratory

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[44] On 01/01/2005 the Medical Faculty was reorganized into six main departments (located at the University Hospital Lund or at Malmö General Hospital – MAS): Health Sciences, Experimental Medical Sciences, Clinical Sciences (Lund and Malmö) and Laboratory Medicine (Lund and Malmö). Some of the previous divisions were merged with other divisions and some were subdivided. It was therefore problematic to establish agreement between the previous divisions and the current divisions at the MF.

[45] <http://www.med.lu.se/english/about_the_faculty> retrieved 05/04/2008

Medicine, the Division of Clinical Chemistry & Pharmacology and the Division of Cellular & Molecular Pharmacology have higher numbers of patents. In the Department of Experimental Medical Sciences patenting is concentrated in the Division of Cellular and Molecular Pharmacology.

Table 5. 4 Patents at Medical Faculty (9/1990-9/2004)

Departments & Divisions at MF	***Patents***
Clinical Sciences	**92**
Surgery	37
Medicine Studies	20
Orthopaedics-Dermatology	13
Clinical Physiology	9
Cardiology	7
Experimental Brain Research	6
Laboratory Medicine	**72**
Clinical Chemistry & Pharmacology	22
Cellular & Molecular Pharmacology	21
Microbiology, Immunology & Glycobiology (MIG)	17
Experimental Medical Sciences	**45**
Cellular and Molecular Pharmacology	24
Bacteriology	12
Immunology	9
Cell and Matrix Biology	8
Neuroscience	4
Total	209

Researchers at MF are also involved in centres among others like the Strategic Centre for Clinical Cancer which is funded by the Swedish Foundation for Strategic Research (SSF) and the Lund Centre for Stem Cell Biology and Cell Therapy which is also funded by SSF.

The aim of such platforms is to bring together different research groups and resources to do translational or interdisciplinary research by integrating clinicians and researchers from University Hospitals with researchers from the Faculties of Medicine, Natural Sciences and Engineering.

Such research platforms together with industrial partners may induce patenting activities among researchers. A reflection on the impact of such research milieux in comparison to smaller research groups on the research and patenting activities of scientists will be addressed in Chapter 7.

5.3.2 Basic Characteristics LU-Inventors

In this section, I present the basic characteristics of the 250 inventors who were identified as inventors in the EPO-SE database. This is an important step in order to understand why some university researchers become inventors. To do this individual-level analysis, the academic rank, scientific field, employment status, gender and age of inventors are investigated. This analysis is useful in finding the basic socio-demographic characteristics of inventors. The basic profiling in this chapter sets the background for an in-depth analysis in Chapter 6.

Table 5.5 (below) summarizes the distribution of inventors by gender, academic ranks and scientific fields. Out of 4,214 university researchers employed between September 1999 and September 2004, a total of 250 scientists were listed as inventors. Hence, almost 6 per cent of the researchers at LU have been involved in patenting activities.

Most of the patenting activity was concentrated among professors (12.7 per cent), followed by associate professors (7.6 per cent). Almost 5 per cent of the post-doctoral fellows and assistant professors were found to be inventors. University researchers and instructors who are adjuncts (working part-time at LU) constitute a special group; 4.2 per cent were inventors (i.e. of 366 adjunct employees, 14 were inventors). Approximately 3 per cent of the doctoral students were also inventors. The reasons behind the higher number of professors can be explained by life-cycle theories, which argue that scientists start patenting once they are established in their careers. It is also expected that professors can better identify the patentability of research results and in most cases they are the principal investigators in their projects. Hence, they become inventors. Professors may also have developed better contacts and networks with industry or TTOs which can help them to patent more. Differences in the nature of patenting activities of inventors will be further discussed in Chapters 6, 7 and 8.

The classification of inventors according to their faculties reflects which faculties are the most patent intensive. According to Table 5.5 below, 138 scientists out of 1,802 scientists from LTH were identified as inventors. Thus 7.7 per cent of all scientists at LTH were inventors. LTH has the highest number of inventors; 138 of the 250 inventors were affiliated with LTH, thus constituting more than half – 55 per cent – of all inventors. Of the MF's 1,610 scientists, 97 were identified as inventors. Thus 6 per cent of all scientists at MF were inventors, and almost 40 per cent of all inventors (97 out of 250 inventors) were affiliated with MF. There were 15 inventors affiliated with NS, constituting around 2 per cent of all scientists at NS, and 6 per cent of all inventors.

Table 5. 5 Basic Characteristics of Inventors at LU (9/1990-9/2004)

	Average number of University researchers at 3 faculties during 1990-2004	*Inventors (1990-2004)*	*Percentage of all university researchers*	*Percentage of all inventors*
Population	4214	250	5.9%	100.0%
Academic Ranking				
Professor	814	103	12.7%	41.0%
Associate Professors	698	53	7.6%	21.2%
Adjuncts	336	14	4.2%	6.0%
Post-Docs/Assistant Professors	621	30	4.8%	12.0%
Ph.D. Students	1715	50	2.9%	20.0%
Faculty				
Engineering Faculty (LTH)	1802	138	7.7%	55. %
Medical Faculty (MF)	1610	97	6.0%	39.0%
Natural Sciences Faculty (NS)	802	15	1.9%	6.0%
Employment				
Full-time	3200	226	7.1%	90.0%
50%-80%	514	10	1.9%	4.0%
Less than 50%	500	14	2.8%	6.0%
Gender				
Women	1170	30	2.6%	12.0%
Men	3044	220	7.2%	88.0%

Table 5.5 above, also displays the distribution of inventors by employment status. Some 90 per cent of the LU-inventors are employed full time. The inventors who have less than half-time employment are mostly adjunct researchers. Ideally, it should be investigated whether their patents were the direct results of their activities at their industrial jobs, or a result of interaction with their university colleagues. Another implication of the work of adjunct faculty concerns the ownership of collaborative patents. Further investigation is needed to understand whether the patents resulting from collaborative work with industry belong to the firm directly or are co-owned with the inventor. (See discussion in Chapter 7 and 8).

Finally, Table 5.5 above presents the distribution of inventors by gender. Out of 1,170 women scientists, 30 were inventors. These 30 women inventors constituted 2.6 per cent of all women scientists and 12 per cent of all inventors at the three LU faculties. Out of 3,044 men scientists, 220 were inventors. These 220 men scientists constituted 7.2 per cent of all men researchers and 88 per cent of all inventors at the three LU faculties.

In one further step, (shown in Table 5.6 below) the inventors were grouped into three main ranks: senior (full professors and professor adjuncts), middle level (associate professors), and junior (post-docs, assistant professors and Ph.D. students). In accordance with this classification by three main academic rankings, the inventors were distributed by their scientific fields. Table 5.6 shows the distribution of inventors by academic rank and faculty.

Table 5. 6 Inventors by Academic Rank and Faculty

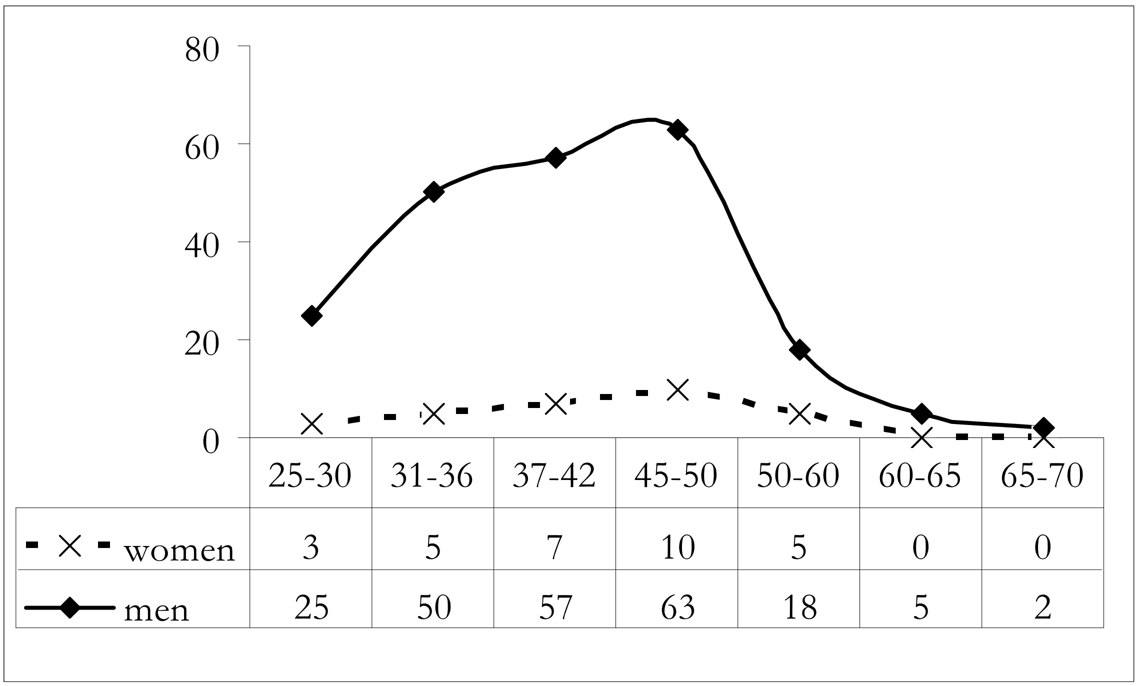
Academic Rank	LTH	% of inventors at LTH	MF	% of inventors at MF	NS	% of inventors at NS
Senior	55	39.9%	48	49.5%	10	66.7%
Middle	37	26.8%	17	17.5%	3	20.0%
Junior	46	33.3%	32	33.0%	2	13.3%
Total	138	100.0%	97	100.0%	15	100.0%

At the LTH, almost 40 per cent of the inventors were senior (55 out 138), 33 per cent of inventors were junior, and 26.8 per cent were middle-level scientists. At the MF, 49 per cent of all inventors were senior (48 out of 97), 33 per cent were junior, and 17.5 per cent were middle-level scientists. At the NS, 66.7 per cent of all inventors were senior (10 out of 15) compared to 20 per cent of the inventors at the middle level and 13.3 per cent of the inventors at the junior level.

Age and Gender

The following Figure 5.2 shows the distribution of inventors by gender and age. As in the discussion of academic ranking, it is problematic to determine the impact of age on the productivity of the scientists. The findings show that the number of men and women inventors is highest between the ages 45-50.

The oldest man inventor at LU is around 60, while the oldest women inventors are around 50. The age of the youngest inventors for both men and women is around 26 to 30, which may correspond to doctoral study. Most women inventors have started to patent later in their career than men inventors.



	25-30	31-36	37-42	45-50	50-60	60-65	65-70
women	3	5	7	10	5	0	0
men	25	50	57	63	18	5	2

Figure 5. 2 Inventors by Age and Gender (9/1990-9/2004)

Co-invention: Number of inventors per patent

Figure 5.3 below shows the number of co-inventors per patent. Around 80 patents have single inventors, while patents invented by groups of two to three inventors together number almost 250 patents out of 458. The number of patents decreases to 100 as the number of inventors increases to four to five together. The number of patents with six inventors or more is less than 50.

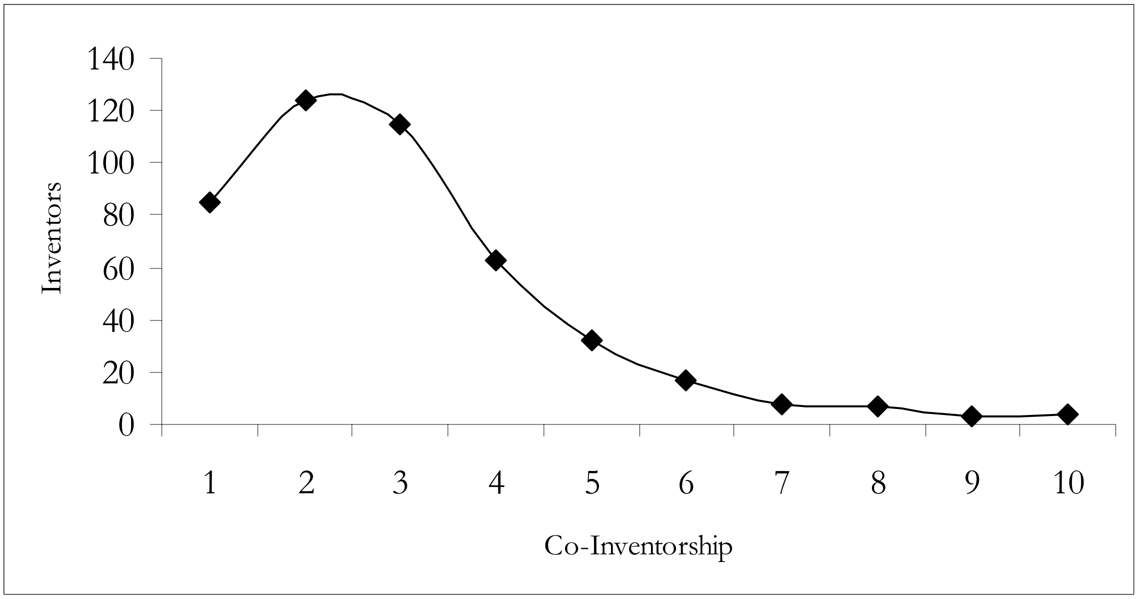


Figure 5. 3 Number of Co-inventors per Patent

The number of co-inventors and the size of research groups (e.g. co-authorship), and the researchers who are not listed as inventors, are investigated further in Chapter 7.

Distribution of patenting activities

Figure 5.4 below shows the distribution of patenting activity among inventors. Out of 250 inventors, 135 only have one patent. After the second patent, the number of inventors decreases sharply. There are a few inventors with three or more patents. Most inventors, however, have one or two patents. Basic explanations behind this skewed distribution of patenting could be, for instance, that some scientists may be more skilled in recognizing the patentability of research results or they may have more resources or networks to utilize in applying for patents. Possible reasons for the skewed distribution of patenting and the role of different types of inventors are analysed in Chapters 7 and 8.

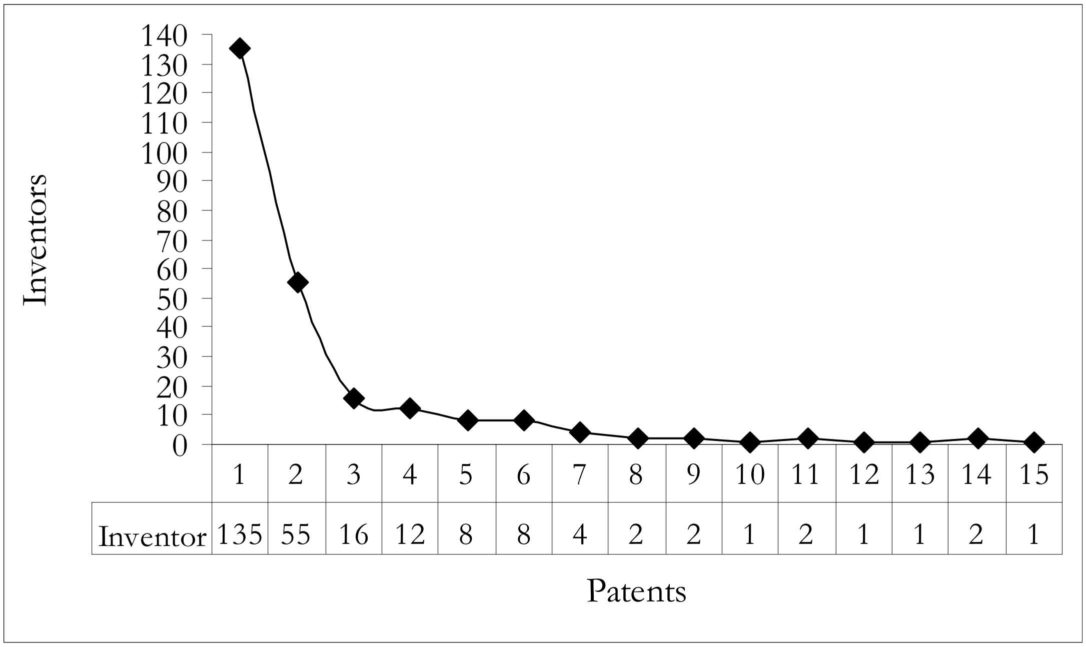


Figure 5. 4 Distribution of Patents

5.3.3 Basic Characteristics LU-Patent Applicants

In this sub-section, I investigate the LU-patent applicants. I will specifically focus on where LU-patents are used by describing the applicants according to the type, the sector and the location of firms.

Types of Applicants

In Sweden, university inventors may choose different routes to patent such as: patenting individually, patenting through TTOs, choosing among different TTOs to patent through, or patenting through industrial firms. Table 5.7 shows how LU-patents are distributed according to different types of applicants. Firms are the main LU-patent applicants. In all, 117 firms applied for 363 patents. This constituted 79.3 per cent of all patents. Inventors applied for 12.9 per cent of all patents, or 59 out of 458 patents. These patents were not assigned to any company at the time of application. Inventors most probably transfer (license, sell or give) their patents to firms later.

In total, 11 different TTOs (e.g. Forskarpatent, BTG International[46]) or, in a few cases, universities or public research institutes (e.g. university TTOs) applied for 36 patents out of 458. TTO patents constituted 7.9 per cent of all LU-patents. The choice of different patenting routes (individual applications or through the use of TTOs or firms) and are further examined in Chapters 7 and 8.

Table 5. 7 Distribution of Patents by Type of Applicants (9/1990-9/2004)

Type of Applicant	Number of Applicants	Number of Patents	Percentage of all University Patents
Firms of all types	117	363	79.2%
Inventors	35	59	12.9%
TTOs	11	36	7.9%
Total patents		*458*	*100.0%*

Types of Applicant Firms

Table 5.8 shows the distribution of patents by type of applicant firms. Large firms accounted for 57.6 per cent of the patent applications made by firms; they applied for 209 of the 363 patents for which applications were submitted by firms. In total 42.4 per cent of the patents (154 patents) were applied for by small or medium sized companies and spin-off firms. Out of 85 small sized firms, 27 SMEs applied for 51 patents. 58 spin-offs which are closely related to LU applied for 103 patents. These spin-off firms were checked whether they have been initiated (founded) by either former or current LU-researchers, and/or received some kind of support from the TTOs discussed in Chapter 4. I have also checked whether they have close relations with the department or research group they spun-off. Some spin-off firms have for instance employed students from the research group. These findings have implications for the

[46] British Technology Group (BTG) International is a technology transfer organization. In 1948, the British government set up the National Research Development Corporation (NRDC) to commercialize publicly funded research in Britain. After merging with the National Enterprise Board (NEB) in 1975, this organization was renamed BTG. It was privatized in 1992. It was one of the LU-patent applicants.

understanding of whether university research results are absorbed by existing firms or whether they are essential for the creation of new firms.

Table 5. 8 Distribution of Patents by Type of Applicant Firms (9/1990-9/2004)*

Type	*Number of firms*	*Number of patents*	*Percentage of all patents applied for by firms*	*Percentage of all applicant firms*
Large Firms	32	209	57.6%	27.3%
Spin-offs	58	103	28.4%	49.6%
SMEs	27	51	14.0%	23.1%
Firms total	117	363	100.0%	100.0%

* Excludes patents applied for by individual inventors

These figures reflect the dominance of large firms in the Swedish economy and their relatively easier access to university knowledge. Nevertheless, despite the dominance of large firms there have been a substantial number spin-offs closely related to Lund University researchers. There is no evidence that Swedish universities are not generating spin-offs at all or that all of their research results are taken by existing firms.

Distribution of patents by technological field

LU-patents have been classified according to technological field.[47] According to Table 5.9, pharmaceuticals, biotechnology and ICT (including telecommunication) are the most important technological fields.

The number of patents in telecommunications-ICT (TEL-ICT) is 109, followed by biotechnology (BIO) with 87 and pharmaceuticals (PHA) with 74 patents. In medical engineering (MED) field there are 40 patents and 36 patents in analysis, measurement and control (ANA). It is followed

[47] The scheme is based on the International Patent Classification and provides a disaggregated view of patenting by distinguishing thirty technological sectors. The classification scheme was originally developed by the Fraunhofer Institute in collaboration with the French Science and Technology Observatory (OST) and IP agency (INPI) (Meyer et al. 2003). For a full overview of the list and abbreviations see Appendix A2.

by chemistry (CHEM) including organic fine chemistry, chemical industry, petrol industry and basic materials chemistry with 33 patents. There are 24 patents in the fields of materials, metallurgy and material processing (MET-MAP), which is closely followed by machine tools and mechanical elements (MCT-MEC) with 23 patents. Electrical devices and electrical engineering (EDE) has 20 patents.

Table 5. 9 Distribution of Patents by Technological Field (9/1990-9/2004)

Technological Field	Patents
TEL-ICT	109
BIO	87
PHA	74
MED	40
ANA	36
CHEM	33
MET-MAP	24
MCT-MEC	23
EDE	20
AGR	12
Total	458

Most of the telecom-ICT patents are reflecting the dominance of the telecommunications sector in the Swedish economy and the presence and physical proximity of Ericsson and Sony-Ericsson to Lund University.

The dominance of biotechnology and pharmaceutical patents is closely related to the Medical Faculty and the Department of Chemistry at LTH as well as university-industry competence centres in these scientific fields (e.g. Swegene, Bio-separation, etc.). The importance of strong patent protection, the recognition of these fields as important sectors, the availability of investors and the industrial demand for these fields have led to higher numbers of patents.

Though Skåne (Scania), the region of Sweden in which LU is located, is traditionally strong in the agriculture sector, there have been relatively few patents in the field of agriculture. This was partly due to the lower needs for patent protection in agriculture and a lack of connections between the agricultural sector and university researchers. This has recently been changing, however, due to development of functional foods, alternative production methods and needs for better methods of preservation. As a result, a number of patents (12) in agriculture (AFM-AGR) have been applied for. They resulted from research in the Divisions of Food Engineering and Food Technologies in the Department of Chemistry at LU, together with industrial participants from the Food Innovation Network.

Distribution of all applicants by type and technological fields of patents

Table 5.10 shows the distribution by different types of applicants – firms, inventors and TTOs – and by technological fields of patents. As shown in Table 5.10, individual applications in pharmaceuticals and chemistry are relatively more common compared to other technological fields. These sectors are dominated by traditional large firms, and while these firms are sometimes ready to apply for a patent, they may occasionally be reluctant to apply for patents, for instance on the basis of the embryonic nature of the research results. Reasons for individual patent applications, use of TTOs to patent and patenting through firms will be investigated in Chapters 6, 7 and 8.

Table 5. 10 Distribution of Patents by Type of Applicants and Technological Field (9/1990-9/2004)

Technological Field*	Firm Applicants	Inventor Applicants	TTO Applicants	Total
BIO	78	5	4	87
CHEM	17	13	3	33
TEL-ICT	105	2	2	109
EDE	8	6	6	20
PHA	50	20	4	74
MCT-MEC	19	0	4	23
MET-MAP	17	5	2	24
MED	31	4	5	40
AGR	4	4	4	12
ANA	34	0	2	36
Total	363	59	36	458

* For a full overview of the list and abbreviations see Appendix A2.

Distribution of applicant firms by technological field and types

Table 5.11 shows the distribution of the applicant firms by technological fields and types. There are 105 patents in ICT and telecom-related fields. Of these ICT- and telecom related patents, 80 were applied for by either Ericsson or Sony-Ericsson.

As in the case of ICT patents, most of the patents in pharmaceuticals were also applied for by large firms. In sectors such as mechanics, materials and biotechnology, there were more SMEs and spin-off firms as LU-patent applicants. In biotechnology and related fields, 39 patents were applied for by the 19 spin-off firms, and 14 SMEs applied for 24 patents. In materials and related fields, 17 patents were applied for by 4 spin-off firms.

Table 5. 11 Distribution of Patents by Firm Types and Technological Field (9/1990-9/2004)

			Large Firms		Spin-offs		SMEs	
Technological Field*	Total patents by firms	Total firms	Patents by large firms	# of large Firms	Patents by spin-offs	# of spin-offs	Patents by SMEs	# of SMEs
BIO	78	38	15	5	39	19	24	14
CHEM	17	10	12	7	2	2	3	1
TEL-ICT	105	8	95	3	4	3	6	2
EDE	8	7	0	0	6	5	2	2
PHA	50	16	35	8	5	4	10	4
MCT-MEC	17	15	1	1	14	13	2	1
MED	31	10	18	3	10	5	3	2
MET-MAP	19	6	1	1	17	4	1	1
AGR	4	3	1	1	3	2	0	0
ANA	34	4	31	3	3	1	0	0
Total	363	117	209	32	103	58	51	27

*For a full overview of the list and abbreviations see Appendix A2.

Distribution of patents by location of applicant firms

Table 5.12 display the location of the applicant firms. Most of the LU-patents (312 out of 363) were applied for in Sweden. This implies that most of the LU-patents were applied for by firms located in Sweden. Firms located outside Sweden applied for 51 of the 363 patents. Of these 51 patents, 39 were applied for by firms located in other European Union (EU) countries, while 12 patents were applied for by firms located outside the EU. These findings underline the fact that there is no strong evidence from the LUP database that Swedish research results are flowing out of Sweden.

Of the 312 LU-patents that were applied for by firms located in Sweden, 212 patents were applied for by firms located in Lund. 28 patents were applied for by firm located in the region (other than Lund). Even though no data are collected on the economic consequences of patents applied for by the firms in the Skåne region and Lund; university patents can be argued to be important and relevant for the regional industrial activities. 72 patents were applied for by firms located in the rest of Sweden like Stockholm, Uppsala, Gothenburg and Västerås in Sweden.

Table 5. 12 Distribution of Patents by Location of Firms (9/1990-9/2004)

Distribution of Patents by Applicant Firms' Country	Patents
Sweden	312
Europe	39
Outside EU	12
Total	363
Distribution of Patents by Applicant Firms' located in Sweden	Patents
Lund	212
Skåne (excluding Lund)	28
Sweden (excluding Skåne and Lund)	72
Total	312

Distribution of patents by key applicants

Table 5.13 shows that when key applicants are taken as point of departure LU-patents has become concentrated in a small number of firms. Ericsson, Astra-Zeneca, ABB and Gambro are the key LU-patent applicants. Obducat AB, Amersham AB, Bioinvent and Probi AB are small firms that have spun off from LU, and they still have links with the respective researchers at LU.

Table 5. 13 Distribution of Patents by Key Applicant Firms (9/1990-9/2004)

Key Applicant	*Number of patents*	*Percentage of patents*
Ericsson-all	80	38.5%
ABB AB	26	12.5%
AstraZeneca AB	22	10.6%
Gambro AB	16	7.7%
Obducat AB	10	4.8%
Amersham Bio.	9	4.3%
Siemens AG	8	3.8%
Telia AB	7	3.4%
Bioinvent Int. AB	7	3.4%
Probi AB	6	2.9%
Hansa Medical AB	6	2.9%
Cellavision AB	6	2.9%
SwitchCore AB	5	2.4%
Total	208	~100.0%

5.4 Concluding Remarks

As discussed in the Chapters 1 and 2 except for some individual studies in European countries (e.g. Finland, Norway, Belgium, Italy, Germany and France), there has been no similar comprehensive data available for Sweden at the time this study has been conducted. The primary implications for this chapter concern the *extent and patterns of university patenting at* LU.

458 patents were identified as LU-patents and 250 university researchers from LU were identified as LU-inventors in the EPO patent database. Inventive activity is shown to be concentrated in terms of both inventors and faculties. I have identified 60 serial inventors who have had three or more patents. Some departments (e.g. electronics, telecommunications, physics, mathematics, chemistry, biotechnology, pharmaceuticals and laboratory medicine) account for the highest number of LU-patents. LU-patents were concentrated in several large firms. Furthermore, a total of 11 TTOs applied for 36 patents, and there are around 58 spin-offs and 27 SMEs which have applied for LU-patents. Additionally most of the LU-patents are applied for by firms located in

Lund or in Sweden. There is therefore no strong evidence that Swedish universities are not generating spin-offs at all or that all of their research results are taken by existing firms or utilized outside of Sweden.

Most LU-patents are applied for by firms located in Sweden, and two-thirds of these patents are applied for by firms located in Lund. In countries where individual ownership is a common practice, the share of contributions to technological development in terms of patenting can best be determined through tracking university patents by the names of university inventors rather than by universities. Close but often informal connections between university researchers and industry existed before the recent legal changes. Specifically, the importance of links to industry established individually over the years through consulting, contract research, as well as through abovementioned university industry competence centres should not be neglected in the nature of university patenting in Sweden.

The insight yielded by this approach is more cautious and appropriate with regard to the extent and patterns of university patenting. This insight may constitute an important basis for understanding in relation to the design and revision of institutional set-ups concerning university patenting.

6. Why and How Do Researchers Patent? Typology of Inventors [48]

6.1 Introduction

As discussed in Chapter 2, the focus on the organizational and institutional aspects and outcomes of patenting in the literature on university-industry relations has hitherto largely overlooked the identification of factors that may explain why university researchers patent. Inventors are among the principal actors in the university patenting process. Despite their importance, however, they constitute a much neglected unit of analysis compared to organizations and institutions in university-industry technology transfer (UITT) studies. Little systematic information exists about university inventors. For instance, since the initial discovery of the basic technique for recombinant DNA at Stanford University and the University of California, an increasing amount of research has been conducted on patenting at universities. Scholars have rarely tried to investigate the inventors behind these discoveries (Stanley Cohen and Herbert Boyer), their motivations to patent, how they managed to patent and the problems that they faced. Except for a few studies on individual scientists, inventors have generally, not received the same amount of attention and interest in UITT studies as TTOs, spin-offs and universities (Siegel and Phan 2005; Phan and Siegel 2006; Rothaermel et al. 2007).

In the light of the analytical framework developed in Chapter 2, the aim of Chapter 6 is to address the second research question for this dissertation: *Why and how do Lund University researchers patent?*.

University researchers in Sweden were involved in patenting activities long before the initiation of the third task or the formation of TTOs and

[48] This chapter is based on Goktepe, 2006b. Earlier versions of this Chapter (6) have been presented at SPRU 40th Anniversary Conference in Brighton UK, 2006; CIRCLE internal seminar, Sweden, 2006 and the Technology Transfer Society Conference in Palm Springs, US, 2007. I thank to participants for their useful comments. Special thanks go to Pablo D'este, Olof Ejermo, Marina Ranga Claes Malmberg and Adam Lederer.

at that time they engaged in such activities without any institutionalized forms of external support. Moreover, many Swedish university inventors continue in the same way today. There is a need, therefore, to understand the extent to which internal factors such as individual motivations, characteristics, skills, backgrounds and other external factors are influencing the patenting activities of university researchers. On the other hand, a focus on internal factors should not be interpreted to underestimate the importance of external factors such as TTOs or patent legislation as well as research milieux for the patenting activities of scientists. Therefore, I have also investigated the influence of external factors.

Chapter 6 aims to provide both qualitative and quantitative insights about university inventors and to address factors that may possibly explain the patenting activities of inventors at Lund University (LU). In this chapter, I also investigate the multifaceted process of patenting, including both individual applications for patents and the use of TTO services. The empirical material on which this chapter is based was generated by a survey of inventors at LU. Chapter 6 is organized as follows. After a brief introduction in Section 6.1, Section 6.2 presents the methodology and design of the inventor survey. Section 6.3 describes the university inventors who responded to the survey and presents an initial descriptive analysis of the survey results. Section 6.4 discusses the factors that may influence researchers' patenting activities. In Section 6.5, a typology of inventors is proposed, based on the identification of two key dimensions – i.e. levels of patenting and modes of applying for and commercializing a patent. This typology of inventors enables me to see whether there are related differences among four types of inventors in terms of socio-demographic features, factors influencing their decisions to patent and the use TTOs, and so forth. Section 6.6 summarizes the main findings.

6.2 Survey of Inventors

The collection of the data presented in Chapter 6 was accomplished through a survey of LU-inventors and a series of interviews with them (see Appendix A3 for the survey). These inventors were identified in the

Lund University Patent (LUP) database as described in Chapter 5. To check for possible interpretation errors and mistakes in the formulation of questions, the questionnaire was read by a number of colleagues. In addition, a pilot survey was conducted with eight inventors from Linköping University and one from LU. The questions and comments raised by the pilot survey respondents were taken into consideration in the design of the final questionnaire.

An important issue of concern in designing a questionnaire is whether the respondents are able to answer the questions. Do they actually have access to the type of information requested in the questionnaire? Questions such as the financing of the patent, the growth impacts of a single patent and other specific economic aspects of the patent were avoided, since some inventors may not have the exact information or may avoid responding to such questions.

The design of the questionnaire was also based on the literature. Previous studies on technology transfer and academic entrepreneurship and available interview guides and questionnaires were consulted before the inventor survey was constructed.

The questionnaire had four parts. The first part introduced the project in general and the aim and content of the survey. The second part dealt with individual demographic and professional information (age, gender, academic title and education). The third part inquired about the patenting activities of the inventors. The inventors were asked to choose their latest patent if they had more than one patent and then describe the nature of research behind that patent and their position at the time of the research and patenting. The fourth part asked questions about factors influencing the inventors' patenting decisions, the roles and activities of different actors such as research group members, TTOs, etc., as well as success factors, problems and the outcomes of their patenting activities.

The questions were designed in two main forms: (i) Closed Items: These questions allowed the respondents to choose from two or more alternatives such as 'Yes/No', 'other'. These questions had greater uniformity and reliability, making respondents answer in a manner that fit the response category. (ii) Scale Items: The second type of question used a 5-point scale ranging from 'not relevant (important)' to 'extremely relevant (important)'. Additionally, the option of 'other' was provided to allow freedom of response.

Questionnaires were sent to 250 inventors by e-mail on the 25th of April 2006, together with a cover letter. Two e-mail follow-ups and telephone reminders were carried out in May and June 2006. A total of 50 inventors responded after the first distribution and reminders. An additional 25 inventors participated in personal interviews based on the same questionnaire during August and September 2006. By the end of September 2006, the number of responses totalled 75 inventors out of 250. The overall response rate to the survey was thus around 30 per cent.

The relatively low response rate to the survey had several explanations. First, out of 250 inventors, although a lot of effort has been exhausted to find the right contact addresses of all inventors, 40 inventors could not be reached because their e-mail addresses were not correct and they had not been updated. Some inventors were deceased. Second, approximately 10 inventors responded by e-mail or telephone that their patenting activities were no longer current and they had forgotten the details of the patent application process. Another 10 inventors stated that their patents and the research on which these patents were based were not related to their activities at the university. Third, around 10 inventors recommended contacting their co-inventors (e.g. supervisors, project leaders, or industrial partners) since they had not had any active role in the patent application and it was their colleagues or industrial partners who had taken care of the patent application. Finally, a few inventors mentioned that they had already participated previously in other similar studies and they had no time for another one.

6.3 Who Were the Inventors?

In order to answer the second research question of this thesis presented in Chapter 1, the survey results were reported to describe all inventors who responded to the survey in relation to all LU-inventors who were identified in the LUP database. This exercise made it possible to relate the survey data to the first research questions concerning the identification of the extent and patterns of patenting at LU. However, it should be underlined that because of the relatively limited number of respondents and the low response rate to the survey, I am not generalizing the findings at the scale of university employees as a whole.

This survey aims to provide more information on characteristics of individual university inventors and their motivations to patent.[49] Table 6.1 shows the basic distribution of respondents in relation to the whole population of university researchers between September 1999 and September 2004 and that of inventors in the LUP database, covering the years between September 1990 and September 2004. I also checked the response rate by each group (i.e. gender, academic ranking and faculty).

Table 6.1 Proportion of Inventors Who Responded in Relation to Total LU-Inventors

	Lund University (1999-2004) 3 Faculties	Inventors (EPO: 1990-2004)	Number of responses	Response rate (per cent)
Population	4,214	250	75	30%
Gender				
Women	1,170	30	11	37%
Men	3,044	220	64	30%
Academic Ranking				
Seniors (Professors, Assoc. Profs.)	1,878	170	54	32%
Juniors (Asst. Profs., Post-Docs, Ph.D.s)	2,336	80	21	26%
Faculty				
Medical Faculty	1,610	97	32	33%
Engineering Faculty	1,802	138	38	28%
Natural Sciences Faculty	802	15	5	33%

Table 6.1 presents the LU researchers, LU-inventors, number of responses and response rates per each group. Overall response rates were quite similar, although junior inventors and inventors from the LTH (Engineering Faculty) responded slightly below the average 30 per cent. Based on similar response rates from different groups, it is accepted that sample (responses) was not biased towards any group.

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49 By the time this survey was designed and sent out, another PatVal survey had been conducted to investigate inventors and patenting in six European countries (Giuri et al. 2006). This survey did not make a distinction between university and corporate patents.

Employment status of the inventors is also relevant to understand further if the patent is closely related to the research at LU or not. Table 6.2 below, displays that almost all inventors were employed full-time by LU (86.7 per cent) at the time when their research was conducted and their patent applications were made. Except for 10 inventors who responded to the survey, 65 inventors were employed full-time at LU during the patent application. There were 5 inventors (6.7 per cent) who were employed partly by another university during the period under investigation, and another 5 inventors (6.7 per cent) who were employed partly by industry. This result ensures that most of the patents reported in the survey were related to the inventors' university positions.

Table 6.2 Employment Status of the Inventors during Research & Patent Application in Relation to Total LU-Inventors (250)

Employment at LU	Inventors responding	Percentage of LU-inventors
Full-time at LU	65	86.7%
Partly by industry	5	6.7%
Employed partly at another university	5	6.7%
Total	75	100.0%

Table 6.3 below, shows the academic position of the inventors when they carried out the research on which their most recent patents were based. Senior scientists (i.e. professors, associate professors, or docents) accounted for 72 per cent of the inventors, while the rest (28 per cent) were junior scientists (i.e. assistant professors, post-doctoral fellows, or Ph.D. students). Further, 16 per cent of the inventors were also heads of departments or divisions. More than half of the inventors (55 per cent) were also project leaders (principal investigators) of the research that led to their most recent patents.

Table 6.3 Academic Position of the Inventors during Research & Patent Application

Project leader of the research behind the patent	55%
Head of department (or division)/Chairperson	16%
Senior researcher	72%
Junior researcher	28%

Most research groups were composed of a principal investigator, senior and junior researchers as well as, in some groups, technicians. The academic position of the inventors at the time of the research behind the patent and patent application implies that it is more common that senior researchers and researchers with higher ranks have patented more than junior researchers.

6.4 Why and How Do Inventors Patent?

Table 6.4 reports on the main factors influencing the patenting activities of the inventors. I report the descriptive statistics (mean and standard deviation). These factors were divided into two main categories. As summarized in Chapter 2, I grouped the factors that may influence scientists' patenting activities into *internal* and *external* factors. Inventors were asked to rate the given factors from 1 (not important) to 5 (very important). The aim here is to investigate the extent to which these different factors are important motivations for university researchers to patent. The averages are given in parentheses.

Internal factors

Among different factors behind university researchers' patenting activities, inventors noted an interest in solving research questions (4.31), getting access to materials and funds from industry (4.15), and job satisfaction, i.e. doing something professionally interesting and enjoyable (4.11) as important. These findings indicate that even if university researchers are involved in patenting, their main motivation to patent is highly related to their aims in doing research. As emphasized also in previous studies, doing something professionally interesting and enjoyable and increasing job satisfaction were also deemed to be important factors for inventors to patent (Gulbrandsen 2005; Giuri et al. 2006; Stephan et al. 2007).

In addition to curiosity-driven research, researchers are motivated to achieve reputation and recognition among their peers (Merton 1957). Patenting can enhance scientists' prestige and increase their productivity by reaffirming the novelty and usefulness of their research (Owen-Smith and Powell 2001). The findings of this study also underlined the importance of increasing recognition and reputation (3.04) by showing that the quality and novelty of the research were deemed to be another factor that strongly motivates scientists to patent. Inventors considered academic promotion possibilities (2.43) and publication possibilities (2.46) to be relatively less important factors for patenting than the factor of increasing reputation and recognition.

Slaughter and Leslie (1997), Etzkowitz (1998) and Stephan et al. (2007) questioned the impact of financial rewards and the profit motive in their analyses of the rise of academic entrepreneurship. The findings of this study indicate that even though patents may generate some financial benefits (such as equity shares or royalty fees), increasing personal income (2.37) was not found to be an important factor for researchers to patent. Patenting is not reducible to the profit motive but entails a more sweeping transformation of preferences and representations. That is, the findings showed that any material and monetary gains which scientists sought through patenting mainly involved obtaining materials, research equipment, funding and resources from industry for their research groups and projects (see below).

Inventors were also asked if intentions to have job options in industry or to change from an academic to an industrial career were important reasons for them to patent. Inventors regarded having job options in industry or changing from an academic to an industrial career (2.43) as less important factors influencing their patenting behaviours. This explains why university inventors preferred to remain at the university. One factor stood out as particularly important among a series of different personal traits such as previous experience in patenting, industrial networks and reputation, credibility to attract money and financial and business skills. Having the credibility to attract enough money to be able to finance patenting activities was deemed a relatively important factor (3.63) affecting the patenting activity of the inventors.

Table 6.4 Factors behind Researchers' Patenting Activities

Variable	*Responses*	*Mean*	*Std. Dev.*
To solve research questions	75	4.31	0.59
Materials & data and funds	73	4.15	1.24
For job satisfaction	73	4.11	1.20
Local colleagues	72	3.90	1.23
Industrial partners decision	72	3.79	1.39
Research group decision	69	3.75	1.06
Credibility to attract money	75	3.63	1.15
Financial & Business skills	75	3.37	1.19
Keep industrial links/collaboration	44	3.18	1.72
Having industrial networks & reputation	75	3.17	1.22
For Recognition & Reputation	68	3.04	1.41
Experience in commercial /industrial works	71	2.75	1.09
Political support & interest e.g. third task	63	2.63	1.50
Univ. Administration's interest & support-	61	2.61	1.15
Ownership of patents	47	2.46	1.66
For Publication possibilities	71	2.46	1.10
Foreign colleagues	55	2.45	1.30
Job creation/spin-off	60	2.43	1.29
For Promotion	67	2.43	1.22
Personal income	60	2.37	1.20
TTO support	44	2.36	1.57

* Factors are shown in descending order of importance as rated by the inventors.

External Factors

University research is often performed collectively. Bercovitz and Feldman (2004) and Louis et al. (1989) have argued the importance of local group norms and culture, training effects, and leadership effects for patenting. I found that researchers adopt the behaviours of other researchers in their research environments. Local colleagues, e.g. peers or supervisors (chairperson), act as role models and influence the patenting activities of researchers (3.90). Industrial partners or collaborators (3.79) and the decisions taken within the research group (3.75) are also important factors for researchers to patent their research results. Inspiration from foreign colleagues (2.45), e.g. through educational or work experience in the US, exposure to the US UITT model, was rated as a relatively less important factor influencing researchers' decision to patent compared to the roles of local colleagues and actors (e.g. senior colleagues, supervisors).

Consistent with previous studies (Lee 2000), this study showed that scientists were motivated to patent in order to supplement their own academic research. Researchers mainly patented to secure funds for graduate students, gaining access to lab equipment, seeking insights into their own research, and acquiring access to industrial funds and materials either free or at a reduced cost (4.15). Similarly, keeping industrial links that provide access to data, research problems and industrial research expertise (3.18) is also found to be an important factor. Patents can be used to attract industrial funds and may provide a basis for industrial networks and connections.

Although a substantial amount of research underlines the importance of TTOs and university culture and strategies, the survey found external factors such as TTOs and patent legislation not to be critical for the patenting activities of the inventors. The third task mandate is an effort to signal the beginning of a concerted policy effort to change the academic culture of universities towards an entrepreneurship or enterprise culture. However, inventors in this study did not consider such external factors to be important influences on their patenting activities. TTO support (2.36), patent legislation (ownership of patents) (2.46), political support and interest, e.g. the third task (2.63) are considered to be relatively less important factors. Previous studies have found university tradition, encouragement of entrepreneurship and a university strategy and culture for entrepreneurship to be influential in researchers' commercial activities (Roberts 1991; Franklin et al. 2001; Etzkowitz 2004). In this survey the university administration's interest and support (2.61) are found to be relatively less important factors for university researchers to patent.

6.5 Typology of Inventors

Inspired by earlier studies on different typologies, or classification of scientists' technology transfer or entrepreneurial activities, in this section I investigate whether, and if so, to what extent, there were any differences among inventors regarding the importance of different factors for their patenting activities. As discussed in Chapter 2, Etzkowitz (1998: 830, 2002: 134) identified four technology transfer styles among researchers.

Meyer (2003b) distinguished between academic entrepreneurs and entrepreneurial academics. Gulbrandsen (2005: 55-56) also suggested two types of university scientists: the basic researchers, or researchers who have a clear academic orientation, versus the liminal scientists, who generally have a certain detachment from academic science as well as from the commercial world.[50] In line with these previous studies, I aim to develop and further our understanding of differences among individual inventors.

The discussion in this section specifies the main differences among inventors. On that basis, I propose a typology of inventors which is derived inductively from the empirical data and on the basis of the previous literature.

Inspired by the two dominant features discussed in the existing literature, the typology is developed on two key dimensions: (1) the *level of patenting activity by inventors* and (2) *the way in which the inventors applied for and utilized their patents*. The classification is thus based on two axes of comparison: (1) serial inventors (who has three or more patents) versus occasional inventors (who have less than three patents); and (2) active inventors (who have formed a firm to apply for the patent) versus passive inventors (who have patented with firms, TTOs – i.e. who sold, licensed, disclosed or gave their research results to another organization). Further analysis is based on the classification of inventors according to scientific background, age, rank and gender. While individual differences are addressed in detail, it is important to note that some of the responses may suffer from ex-post rationalization, whereby inventors may interpret and respond in an overly positive way or give more reasonable and acceptable answers.[51] However, their responses may still provide important information about the inventors' perception of different factors in relation to their patenting activity.

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[50] See Chapter 2 for further discussion on different types that have been proposed in these studies.

[51] When people find themselves in unexpected situations, they may modify their preferences and beliefs in order to justify the current situation and avoid appearing irrational. This is a process of ex-post rationalization, namely a form of rationality that allows agents to organize (and reinterpret) past experiences and actions by relating them to their current situation in a positive way (see Doyle 1992).

The theoretical grounds for the selection of the aforementioned dimensions are derived from two sets of studies. The first group of scholars looked at the differences in the *productivity of inventors* over the researcher's career life cycle (Narin and Breitzman 1995; Ernst et al. 2000). These studies were inspired by the work of Lotka (1926). The second group of scholars emphasized two paths for the commercialization of patents, i.e. (i) *formation of a spin-off firm to apply for and commercially exploit the patent,* or (ii) *patent application and commercialisation by a third party to whom the inventors sell (license, give or transfer)* the rights to the patents (Amesse et al. 1991; Jaffe et al. 1993; Audretsch and Stephan 1996, 1999; Henderson et al. 1998; Zucker et al. 1998; Jaffe and Lerner 2001; Jensen and Thursby 2001; Thursby et al. 2001; Zucker et al. 2002; Lockett et al. 2003, 2005; Shane 2003, 2004; Thursby and Jensen 2005).

With regard to the typology's first dimension – the level of patenting activity – the LUP database indicates that patenting activities have been concentrated to a small number of inventors, as shown in Chapter 5, Figure 5.4. 135 inventors have only one patent, 55 inventors have two patents, and 60 inventors have three or more patents. In the survey, 44 inventors out of 75 have three or more patents. Inventors who have three or more patents are labelled *serial inventors*. Inventors who have less than three patents are labelled *occasional inventors.*

The typology's second dimension concerns the mode of applying for and utilizing or commercializing patents. Here, owing to the nature of the data available for operationalizing this dimension, commercialization should not be regarded as a complete development of a product or process based on a patent (including marketing and sales),[52] but rather as a matter primarily of intention.

Out of the 75 inventors who responded to the survey, 51 applied for a patent through *a third party* (firms, TTOs) to whom the inventors transfer (license or give) the knowledge. The other 24 inventors applied for and

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[52] Some of the patents have not been turned into products or processes or have not led to any commercial success. This typology is a snapshot of patenting activities of inventors as described by the inventors. Therefore, possible changes, if any, in the inventors' mode and number of patenting activities cannot be captured. Patents which might be utilized to create a spin-off firm may later be sold and licensed to existing companies, or vice versa. I address this issue in Chapter 7.

commercialized their patents either by forming a spin-off firm or through spin-off firms they had previously established. Based on these two dimensions (level of patenting, and mode of patent application and commercialization) I propose a typology. The typology of inventors is sketched in Figure 6.1. Figure 6.1 indicates how the 75 inventors who responded to the survey are distributed along the two dimensions of the typology of inventors. The distribution is as follows: 17 serial-active inventors; 7 occasional-active inventors; 27 serial-passive inventors; and 24 occasional-passive inventors. As explained above, this typology was developed inductively by grouping inventors along two dimensions. Descriptive statistics were then calculated for these four types. I then investigated whether there are any differences between the four types of inventors. This analysis complements the discussion in sub-section 6.4 about factors that explain university inventors patenting activities.

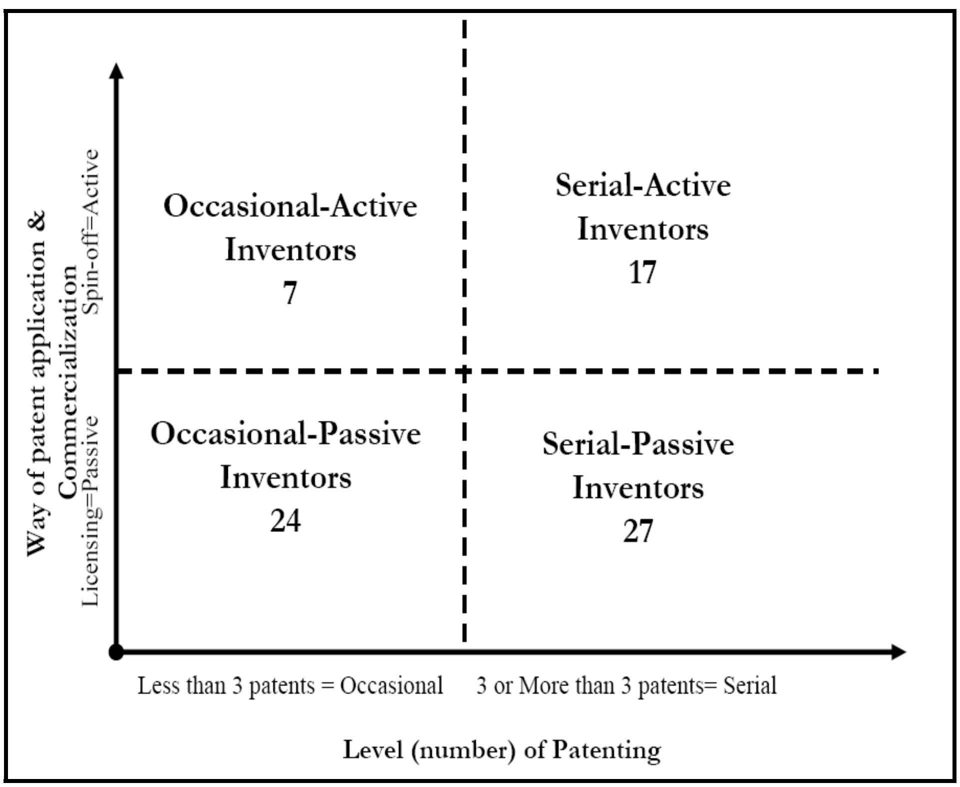

Figure 6.1 Typology of Inventors
(Source: Author's compilation)

Serial-Active Inventors: SA-inventors have three or more patents and have utilized their patents by means of spin-off firm formation while keeping their affiliations with the university. Thus, university inventors of this type correspond roughly to the earlier classifications of 'knowledgeable partners' (Etzkowitz 1998) or 'academic entrepreneurs' (Meyer 2003b) (see Chapter 2).

Serial-Passive Inventors: SP-inventors also have three or more patents. However, they differ from the serial-active inventors in that they have had relatively more passive roles in the application and utilization of the patent. They have patented e.g. through close relations with firms. To some extent, the SP-inventors are similar to the categories of Etzkowitz's (1998) 'seamless web' or Meyer's (2003b) 'entrepreneurial academics'.

Occasional-Active Inventors: OA-inventors have fewer than three patents so far. Their patents have been utilized through the formation of spin-off firms.

Occasional-Passive Inventors: OP-inventors have fewer than three patents so far. In most cases they have either patented with their experienced colleagues (e.g. serial inventors) or have used TTOs to apply for a patent.

6.5.1 Profiling Inventors in Relation to the Typology

The basic description of different types of inventors (background, education, gender) provides insights about the main internal factors that may influence university researchers' decisions to patent. Table 6.5 summarizes the basic socio-demographic characteristics and backgrounds of the inventors. The aim here is to describe the inventors.

Academic Rank & Employment: Senior university researchers (i.e. full professors) account for 90 per cent of all SP-inventors and OP-inventors, and 75 per cent of all SA-inventors. In contrast, only 40 per cent of all OA-inventors have senior positions. Almost all inventors are full-time employees at LU. Some of them have taken a leave of absence, e.g. during the formation of their firms, or they may have been partly employed by industry.

Table 6.5 Basic Traits of Different Types of Inventors

	SA	SP	OA	OP
Number of inventors	17	27	7	24
Senior (assoc.prof./ full prof.)	75%	90%	40%	90%
Junior (post-docs/ assistant prof.)	25%	10%	60%	10%
Full-time	90%	90%	80%	80%
Adjunct	10%	10%	20%	20%
Mean year of birth	1955	1954	1962	1951
Latest year of birth	1940	1931	1950	1937
Earliest year of birth	1971	1969	1973	1976
Mean year of Ph.D. graduation	1986	1982	1993	1982
Latest year of Ph.D. graduation	2000	2002	2002	2005
Earliest year of Ph.D. graduation	1970	1967	1980	1968
Ph.D. at a Swedish university	90%	90%	70%	90%
Ph.D. abroad	~11%	~9%	~28%	~11%
Medical Faculty (MF)	~40%	~44%	~42%	~41%
Engineering Faculty (LTH)	~60%	~48%	~58%	~46%
Natural Sciences Faculty (NS)	0%	8%	0%	~13%
Female	0%	5%	20%	20%
Male	100%	95%	80%	80%
Average no. of years at LU	19.5	18.5	10.3	19.7
Average years at university (in total)	22.5	22.5	14.7	22.7
Industrial experience (min. 2 years)	40%	30%	0%	30%
Collaboration with firms	100%	100%	93%	70%
International network	100%	~90%	~71%	~90%
Non-Swedish	~17%	~13%	~42%	~7.5%

Year of Birth: On average, OP-inventors are the oldest group, with 1951 as the mean year of birth. The youngest OP-inventor was born in 1976, and the oldest OP-inventor was born in 1937. However, while the mean year of birth for SP-inventors is 1954, the oldest inventor is an SP-inventor (born in 1931). The youngest SP-inventor was born in 1969. The mean year of birth for SA-inventors is 1955. The youngest SA-inventor was born in 1971 and the oldest one was born in 1940. The youngest inventors are OA-inventors, with 1962 as the mean year of birth. The youngest OA-inventor was born in 1973 and the oldest OA-inventor was born in 1950.

Year of Ph.D. Graduation: OP-inventors and SP-inventors received their Ph.D. degrees earliest, in 1982 on average. They are followed by SA-inventors, who received their Ph.D. degrees in 1986 on average. OA-inventors received their Ph.D. most recently, in 1993 on average.

However, it should be noted that the most recent PhD graduate (in year 2005) is an occasional-passive inventor.

The information about the mean year of birth and the mean year of PhD graduation should be interpreted cautiously as it can be misleading, since within each type of inventors, there are substantial variations. For example, despite having the oldest mean birth year of 1951, OP-inventors are graced with an individual who was born in 1976 and received his PhD in 2005. This is an indicator of the heterogeneous distribution within each of the four types. Accordingly it is not clear to what extent age and academic experience determine the patenting activities of researchers.

Ph.D. University: Almost all of the inventors obtained their Ph.D. degrees at LU or at other universities in Sweden, such as Uppsala University, Karolinska Institutet and Chalmers University of Technology. Only a few of the inventors received their Ph.D. degrees abroad.

Scientific Field: As shown in Table 6.1, out of 75 responding inventors, 32 inventors are from the Medical Faculty (MF). 38 inventors are from the Engineering Faculty (LTH) and 10 inventors are affiliated with the Natural Sciences Faculty (NS). SA-inventors are either affiliated with the MF (7 of them) or with LTH (10 of them). OA-inventors are also affiliated with the MF (3 of them) and LTH (4 of them). Inventors from NS are either SP-inventors (2 of them) or OP-inventors (3 of them). There are 12 SP-inventors affiliated with the MF, and 13 with LTH. Finally, 10 OP-inventors are affiliated with the MF, while 11 are from LTH.

Stephan et al. (2007), and Mowery et al. (2004) have underlined the importance of emerging fields (biotechnology, nanotechnology, new materials, information communication technology) as a factor that may trigger scientists to patent. This is consistent with the distribution of patents and inventors by faculties at LU. Most of the patenting activities are concentrated in the Medical and Engineering Faculty compared to the Faculty of Natural Sciences.

Gender & Nationality: Male inventors are overwhelmingly dominant among inventors of each type. Female inventors are represented mainly among OP-inventors and OA-inventors. Although women patent less than men, the difference is smaller since the number of female scientists employed in universities relative to males is low. Female researchers are also under-represented in upper-level positions. The female researchers might tend to drop out sooner than the males, or not advance as quickly, and the result might therefore be that they will never reach the same level of patenting activity. Furthermore, most female researchers are employed in areas where there is much less patenting activity taking place than in engineering, which is generally a male-dominated field.

Work Experience: Three types of inventors – SA, SP and OP – all had an average of almost 22 years of work experience at LU and other universities. In contrast, OA-inventors had lower levels of work experience, on average 14.7 years, at LU and other universities. With regard to industrial experience, 40 per cent of SA-inventors and 30 per cent of both SP-inventors and OP-inventors had at least 2 years of professional industrial experience (excluding internships and summer jobs). In contrast, none of the OA-inventors have had any industrial experience so far, except for short-term internships.

Collaboration with Industry: All SA-inventors and SP-inventors and almost all OA-inventors were currently involved in collaborative projects and interactions with industry. In contrast, only 70 per cent of the OP-inventors were engaged in some form of collaboration with industry.

International Networks: International collaboration is defined in terms of a researcher having been involved in any common projects with research groups located abroad. It is also in terms of whether researchers have received international funding from, e.g. the European Commission, international research foundations, or firms located abroad. Most inventors of all types have engaged in international collaborations with other research groups, although there are slight differences among different types of inventors. 100 per cent of SA-inventors and 90 per cent of SP- and OP-inventors have international networks, compared to 70 per cent of OA-inventors.

6.5.2 T-test Analysis: Differences among Inventors

In order to assess whether there are differences among the factors behind the patenting activities of inventors as grouped in the typology of inventors, I have conducted two-sided tests examining whether the means of the responses regarding internal and external factors that were presented in Chapter 2 were statistically different.[53] I performed this analysis in order to assess whether there were differences between (i) active versus passive inventors and (ii) serial versus occasional inventors. The analyses of differences in the means of internal and external factors between active and passive inventors are reported in Table 6.6.

The results of the t-test analysis show that active and passive inventors differ significantly (at the 0.01 level) with regard to the importance of different factors behind their patenting activities such as: job creation, spin-off formation, the role of foreign colleagues and the role of TTOs. For passive inventors, job creation/spin-off formation is less important than for active inventors. It should be noted that even though the t-test analysis shows a difference between active and passive inventors regarding the factor job creation/spin-off formation, in the typology these groups were actually defined on the basis of the way they utilized their patents. This factor therefore should be interpreted carefully meaning that it rather confirms the relevance of using 'spin-off versus licensing' in the categorization of inventors as showing to some extent the differences in the motivations of active and passive inventors.

Passive inventors on the other hand found the TTOs' support relatively more important than the active inventors did. This could be taken to suggest that while active inventors may not need TTOs in their patenting activities, passive inventors, especially those who may not have industrial networks patented with TTOs. This prompts questioning the roles of TTOs. As discussed later in Chapter 7 and 8, differences among inventors concerning the role of TTOs suggest that while some inventors may prefer or need TTOs, some inventors do not need TTOs at all.

Active inventors on the other hand found foreign colleagues relatively more important in influencing their patenting activities than the passive inventors did.

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[53] The t-test was conducted assuming that the variances in each respective group were not equal.

Table 6.6 T-tests of Differences in Means of Factors to Patent between Active and Passive Inventors

Variable /Type of inventor	Active			Passive			t-test
	Obs	Mean X	Std. Dev.	Obs	Mean Y	Std. Dev.	H_o: X=Y H_1: X≠Y
To solve research questions	24	4.33	0.13	51	4.29	0.80	-0.2659
For job satisfaction	24	4.29	1.23	49	4.02	1.26	-0.8911
For promotion	23	2.57	1.30	44	2.36	1.18	-0.6185
For recognition & reputation	23	3.22	1.44	45	2.96	1.39	-0.7149
For publication possibilities	24	2.54	1.14	47	2.43	1.09	-0.4108
Personal income	22	2.45	1.29	38	2.32	1.16	-0.4138
Job creation/Spin-off	23	3.00	1.50	37	2.08	1.01	-2.5846 ***
Experience in commercial/industrial work	24	3.17	1.12	47	2.53	1.01	-2.3146 **
Having industrial networks and reputation	24	3.42	1.13	51	3.06	1.25	-1.1277
Credibility to attract money	24	3.83	1.37	51	3.52	1.04	-0.9613
Financial and business skills	24	3.58	1.05	51	3.27	1.25	-1.1097
Research group decision	24	4.00	0.97	45	3.62	1.09	-1.4660 *
Local colleagues	24	3.96	1.42	48	3.87	1.14	-0.2488
Foreign colleagues	22	3.00	1.41	33	2.09	1.10	-2.5451 ***
Industrial partner's decision	24	4.21	1.28	48	3.58	1.41	-1.8820 **
Materials, data and funds	24	4.42	1.28	49	4.02	1.21	-1.2612
Keep industrial links/collaboration	22	3.73	1.57	22	2.63	1.73	-2.1822 **
TTO support	19	1.56	0.96	25	3.00	1.65	3.6965 ***
Ownership of patents	19	2.53	1.80	28	2.42	1.59	-0.1907
Political support and interest, e.g. third task	23	2.57	1.37	40	2.67	1.59	0.2877
University administration's interest and support	22	2.27	0.88	39	2.79	1.26	1.8922 **

(* significant at p<0.10 level, ** significant at p<0.05 level, *** significant at p<0.01 level)

At the 0.05 level, active and passive inventors differ with regard to earlier experiences in patenting, industrial partner's decision, keeping industrial links up to date, and university administration support and interest. Individual characteristics (skills and background) and networks are also relatively more important factors for active inventors to patent than for the passive inventors.

Finally, active and passive inventors differ (at the 0.10 level) with regard to group decision. This factor reflects the influence of research teams or the collective nature of university research on the individual activities of scientists.

There are no significant differences in the means of inventors' perception of factors such as solving research problems, job satisfaction, promotion, reputation, publication possibilities, increasing income, local colleagues, the third task, ownership of patents, having industrial networks, having the credibility to attract money, having financial and business skills, and getting access to materials, data and funds. This finding underlines the common factors that motivate all types of inventors towards patenting activities.

Table 6.7 reports the tests of differences in means between serial and occasional inventors.

The results of the t-test analysis show that serial and occasional inventors differ significantly (at the 0.01 level) with regard to the importance of different factors on their patenting activities such as: job satisfaction, having industrial networks and reputation, having financial and business skills, getting access to materials and data and funds from industry, and keeping industrial links/collaboration up to date. Serial inventors found 'job satisfaction' to be relatively more important than occasional inventors did. Since occasional inventors have not yet achieved high-levels of patenting activities they might have realized more difficulties in the procedure. Interestingly, occasional inventors have lower expectations of attracting industrial funds and materials through their patenting activities.

Serial inventors have also rated internal factors, such as having industrial networks and reputation, having financial and business skills as relatively more important factors for them to patent than occasional inventors did. It is more likely that most occasional inventors have lesser financial and business skills.

Table 6.7 T-tests of Differences in Means of Factors to Patent between Serial and Occasional Inventors

Variable /Type of inventor	Serial	Occasional	t-test

	Obs	Mean x	Std. Dev.	Obs	Mean y	Std. Dev.	Ho: x=y H_1: x≠y
To solve research questions	44	4.36	0.92	31	4.22	0.10	-1.0084
For job satisfaction	42	4.43	1.01	31	3.61	1.40	-2.6344 ***
For promotion	40	2.38	1.21	27	2.52	1.25	0.4690
For recognition & reputation	41	3.00	1.28	27	3.11	1.60	0.3022
For publication possibilities	41	2.49	1.09	30	2.43	1.13	-0.2025
Personal income	36	2.47	1.20	24	2.21	1.21	-0.8264
Job-creation/Spin-off	34	2.71	1.31	26	2.08	1.19	-1.9328 **
Experience in commercial/industrial work	42	2.90	1.10	29	2.52	1.05	-1.4939 **
Having industrial networks and reputation	44	3.50	1.1.7	31	2.71	1.16	-2.8934 ***
Credibility to attract money	44	3.75	1.16	31	3.45	1.15	-1.1010
Financial and business skills	44	3.70	0.95	31	2.90	1.35	-2.8415 ***
Research group decision	43	3.86	1.60	26	3.57	0.90	-1.1401
Local colleagues	41	4.00	1.32	31	3.77	1.11	-0.7842
Foreign colleagues	34	2.56	1.30	21	2.28	1.30	-0.7520
Industrial partner's decision	41	4.12	1.24	31	3.35	1.47	-2.3338 **
Materials, data and funds	42	4.50	0.91	31	3.68	1.46	-2.7468 ***
To keep industrial links/collaboration	24	3.83	1.55	20	2.40	1.63	-2.9635 ***
TTO support	26	2.15	1.54	18	2.67	1.60	1.0575
Ownership of patents	30	2.40	1.67	17	2.59	1.69	0.3671
Political support and interest, e.g. third task	38	2.55	1.48	25	2.76	1.56	0.5259
University administration's interest and support	36	2.58	1.07	25	2.64	1.28	0.1805

(* significant at p<0.10 level, ** significant at p<0.05 level, *** significant at p<0.01 level)

Serial and occasional inventors differ (at the 0.05 level) with regard to factors like job creation/spin-off formation, previous experience in commercial/industrial work and industrial partner's decision. Serial inventors rated job creation/spin-off formation as more important than occasional inventors did. It can be interpreted that due to the lower activity levels, the latter group has not identified the possibilities of initiating a new business based on a single patent. Since only a small portion of their research has led to a patent, occasional inventors may think it is not enough to start a company around a single patent.

Serial inventors rated their previous experience in commercial and industrial sectors as relatively more important for them to patent than occasional inventors did, who may lack such experiences. Industrial partner's decision also played a more important role in the patenting activities of serial inventors. It is more likely that most occasional inventors have fewer industrial contacts or that they are less known or recognized by the industrial partners.

There are no significant differences in the means of inventors' perception of factors such as solving research problems, promotion, recognition and reputation, publication possibilities, personal income, having credibility to attract money, research group decision, local colleagues, foreign colleagues, TTO support, ownership of patent), political support and interest (e.g. third task), having industrial networks, university administration's interest and support.

6.5.3 Roles of TTOs

In order to understand further the roles of TTOs on the patenting activities of inventors, inventors were asked in the survey why they had – or had not – used the services of TTOs. Due to the relatively low number of inventors (24 out of 75) who have used TTOs, it is not desirable to compare the use of TTOs by different types of inventors.[54] A reflection on the differences among how the inventors perceived the roles of TTOs can nonetheless be summarized as follows.

Among the active inventors, six SA-inventors out of seventeen utilized some of the services of TTOs. These services were sought not in relation to patenting, with which they did not need help due to previous experience or links with industry or investors, but principally for the purpose of getting financial help for the formation of spin-offs. Two SP-inventors out of twenty-seven used the services of TTOs. Since they had patented with the help of existing firms, these SP-inventors used TTOs not to apply for the patent but to get help finding an industrial partner.

Among the occasional investors, three OA-inventors out of seven, and thirteen OP-inventors out of twenty-four used the services of TTOs to patent. Their main reasons for doing so were lack of patenting experience,

[54] Due to the low response rate to the questions about TTOs, I will address the roles of external factors (TTOs, patent legislations and research milieux) in the patenting activities of serial and occasional inventors in Chapters 7 and 8 respectively.

no time, and no desire to get involved in the legal and administrative aspects of patenting. They also used TTOs to obtain financial help and guidance in finding licensee firms.

The analysis of the fifty-one inventors who applied for patents individually or with the help of existing firms – that is, without using TTOs – can be summarized as follows. Eleven SA-inventors did not use TTOs because they found TTOs not very helpful and ineffective. Several SA-inventors also stated that no TTOs existed at the time they had patented. Seventeen SP-inventors did not use TTOs because they patented through their industrial contacts and most of them had already patenting experience. Six OA-inventors identified less bureaucracy and direct relations with investors or industrial partners as their most important reasons for not using TTOs. Seventeen OP-inventors specified existing relations with firms or the existence of an interested industrial partner as their most important reasons for not patenting with a TTO.

The following analysis, which is based partly on the interviews, is important for understanding the extent to which TTOs played a role in motivating inventors to patent. Inventors were asked to assess the reasons behind their successful patent applications. Almost all inventors confirmed that the patent's potential commercial value based on industrial interest in, and need for, the patented idea – implying the willingness of firms and/or investors to pay for the patent – were the most important factors that led them to apply for a patent.

SA-inventors deemed patenting experience and knowledge about patenting to be important factors that enabled them to apply successfully for patents. Some SP-inventors found that previous relations with the applicant or licensee firms and achieving consensus with the firms about further payments and royalty fees were important factors that enabled them to apply successfully for patents. They also stated that previous experiences such as education and/or work experience in a university where patenting was common were important factors that led them to make successful patent applications.

OA-inventors stated that agreement within the research group and obtaining support from colleagues and heads of department were important factors behind their successful patent applications. Most of the OP-inventors, on the other hand, considered support from the university administration or the use of services offered by TTOs to be important factors for their successful patent applications. They received assistance from TTOs in such areas as covering the costs of patent applications and help in writing the patent application.

6.5.4 Summary of the Typology of Inventors

This sub-section summarizes the main findings of the foregoing analysis by highlighting the commonalities and differences among inventors. Heterogeneities among inventors will be further investigated and strengthened through an analysis based on in-depth interviews with the serial and occasional inventors in Chapters 7 and 8.

SA-inventors: These inventors are mainly seniors by age and rank. They are also mainly men. They have commercialized their research results by forming spin-off firms. They have high scientific status, credibility and reputation. This makes it easier for them to be involved in risky activities such as spin-off firm formation. Their credibility and reputation have also lent credibility to their projects and enabled them to attract funding. They have been actively involved in the formation of their companies and have maintained their roles in these companies, even though it is very unlikely that they will change their careers from university to industry.

SP-inventors: These inventors are seniors by age and rank. They are also mainly men. Relations with large Swedish firms are an important basis for patenting for inventors of this type. These inventors have high scientific status, credibility and reputation. They have strong industrial networks, and most of them participate in industry-university research collaboration projects. The external relations of this group implicitly reflect the influences of competence centres and other types of collaborations between researchers and firms. At that time, universities were expected to conduct industrially relevant research and respond to the problems and needs of industry.

OA-inventors: Occasional inventors are distinguished from serial inventors by a relatively lower level of patenting activities. The occasional-active inventors are relatively the youngest group. There are more inventors with foreign background in this type than in the others. They are junior researchers such as former Ph.D. students and post-doctoral fellows who were mainly men from LTH. Some of them have stated that they have had minor roles in the legal and financial aspects of the formation of their spin-off firms. Some have been employed by these spin-offs. Inventors in this group have a higher possibility of changing career to industry and are more flexible in their plans than inventors belonging to the other types. As some of them consider themselves to have average skills for identifying commercial opportunities, as well as lack of social networks, reputation, credibility and financial means, they have patented with their senior colleagues (i.e. SA-inventors). For their future commercialization activities they need guidance and help to patent. In the past, they have required and received some kind of assistance from TTOs or other actors such as colleagues or industrial partners.

OP-inventors: These inventors also have lower levels of patenting activity. They have utilized their patents through licensing agreements with firms or TTOs. They have become involved in patenting activities recently, but they are senior or mid-level researchers and have a scientific visibility almost as high as that of SP-inventors. There are more women among OP-inventors than in the other types. OP-inventors are one-time inventors and members of large research groups. They have either patented with others in the group who are more experienced (e.g. SP-inventors) or with the help of TTOs. They have a strong academic career focus and minimal ownership and responsibility when it comes to commercialization. They have difficulties in identifying commercial opportunities and have not yet become competent in patent applications. They have patented with TTOs and have preferred to license rather than to form a spin-off firm. Their relations towards patenting and commercialization are the most 'hands-off' of the four types. In the past, they have required and received some kind of assistance from TTOs or other actors such as colleagues or industrial partners.

6.6 Concluding Remarks

This chapter identified the factors behind university inventors' patenting activities, and it has proposed a typology of inventors based on two main dimensions of the patenting activities of inventors. First, inventors have been divided into two groups: Serial versus Occasional based on the number of patents they have had. Second, inventors have also been divided into two groups: Active versus Passive based on the way they applied for their patents.

These four types of inventors (*serial-active, serial-passive, occasional-active and occasional-passive*) have different but also similar characteristics and backgrounds. Factors influencing their patenting activities and their patenting process differ to some extent. Inventors have generally considered as important the 'personal satisfaction involved in showing that something is technically possible and in solving industrial or societal problems' as more important than money or career advancement. External factors (such as TTOs, patent legislation, university support) have generally not been the most important factors motivating inventors. However, the roles of TTOs and patent legislation merit further research beyond their sole function of facilitating patenting activities. I therefore investigate such factors in the interviews with different types of inventors in order to capture whether there are any differences among inventors' perceptions of the impact of external factors.

Limitations notwithstanding, the typology proposed here provides important insights concerning differences among inventors. The aim here is to stimulate a discussion about the fact that inventors are not necessarily alike, not only in terms of their patenting outputs, but also in the sense that their patenting activities may depend on different enabling and/or motivating factors. The results presented above may be considered as a snapshot of the activities and views of a number of inventors. To complement and strengthen the arguments put forward in relation to the typology of inventors, I have pursued an in-depth investigation of different types of inventors in the following chapters.

7. Understanding Serial Inventors and External Factors[55]

7.1 Introduction

This chapter focuses mainly on serial inventors and the external factors surrounding them. The objective of Chapter 7 is to address the second research question, (i.e. *why and how do Lund University researchers patent?)*, in a more detailed way. In particular, I address internal factors, i.e. factors related to the characteristics of the inventors, such as skills, competences and experiences and external factors, i.e. factors related to institutions and organizations surrounding the inventors, such as research milieux, patent laws, TTOs, etc. The results of the interviews with selected serial inventors are used to enrich and complement the findings in Chapter 6.

Chapter 7 proceeds as follows. Section 7.2 presents the methodology of the interviews of serial inventors (sample and data-collection procedure). Section 7.3 presents the empirical findings, first by presenting the internal factors regarding the roles and characteristics of serial inventors and second by discussing the relationship between serial inventors and external factors, e.g. research groups and TTOs. The final section summarizes the chapter and outlines the next chapter.

7.2 Interviews with Serial Inventors

This chapter pursues an interview approach and a qualitative analysis to understand the complex relationship between the roles and characteristics of serial inventors and the external factors relating to their activity. Serial inventors have been identified in Chapters 5 and 6. Forty serial inventors

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[55] This chapter is based on Goktepe 2007. Earlier versions of this chapter were presented at the DRUID Winter Conference in Aalborg, Denmark, 2007; the DRUID Summer Conference in Copenhagen, Denmark, 2007; and the IASP Conference in Barcelona, Spain, 2007. Many thanks to Keld Laursen, Bart Verspagen, Lionel Nesta, Martin Woerter, Jerry Thursby, Marie Thursby and other participants for their useful comments and suggestions.

out of sixty agreed to be interviewed. These inventors have had at least three patents (Figure 5.4 and Figure 6.1). Seventeen of the interviewees were from the LTH, affiliated with different departments such as chemistry, mathematics, physics and electronics. Seventeen interviewees were from microbiology, clinical chemistry, cancer research, orthopaedics, neurology and cardiology at the MF. Six interviewees were from the NS in departments such as chemistry and physics. Eighteen of the serial inventors have applied and utilized their patents through a spin-off (serial-active inventors), while twenty-two of the serial inventors have applied and utilized their inventions through existing firms (serial-passive inventors).

The interviews were semi-structured and aided by an interview guide (see Appendix A4). Both the serial-active and serial-passive inventors were contacted by e-mail and later by telephone to book an interview date. Interviews were done during the autumn of 2006. The interviews were done face to face at the departments (offices, meeting rooms) of the interviewees. The interviews lasted from one to two hours. With the permission of the interviewees, the interviews were recorded and notes were also taken during the interviews.

After a brief introduction of myself and the aims and preliminary findings of the thesis, I started the interview. The questions were structured under four main themes. First, I aimed to identify the internal factors, e.g. characteristics, background, skills and experience of the inventors that may have been relevant for their patenting and their motives to patent. I aimed to capture specific factors that might have enabled or motivated them to patent serially. Second, I asked questions about the implications of patenting, what sort of changes they had experienced and to what extent they were able to undertake multiple tasks such as teaching, research and commercial activities. I also aimed to capture what sort of changes they have experienced in their activities, roles and motivations over time. Third, I asked about the impacts of external factors, i.e. research milieu (size of a research group, relations within the group, and social and cultural issues). Finally, I focused on the inventors' relations with and perceptions of the second set of external factors, i.e. patent legislation, TTOs and the third task.

The main parts of the interviews were transcribed and supplemented with the notes taken during the interviews. In addition to the interviews and patent data, archival data about the inventors, their research groups and their firms were also collected. For the inventors, I gathered information about their career history, CVs and activities from university magazines and newspapers.

In order not to reveal the identity of the inventors, even though empirical findings were analysed individually for each inventor, all findings and responses were aggregated to reach a more all-encompassing understanding. I have made cross-case comparisons among SP-inventors and SA-inventors. In some cases, I have given direct quotations without revealing the names of the inventors.

7.3 Internal Factors: Profiling Serial Inventors

Here I describe the impact of internal factors in order to explain the patenting activities of serial inventors. The patenting activities of serial inventors were closely related to their skills and networks. In particular, the leadership and entrepreneurial skills of serial inventors and the way they utilize their research groups and networks were important factors for their patenting activities. Many serial inventors have shown great interest in, commitment to and enthusiasm for active involvement not only in research activities but also in establishing networks with industry and other actors that may enable them to patent. Serial inventors are independent thinkers with a strong commitment to and trust in their inventions.

They are also good team workers and have strong supervisory skills. This has enabled them to build strong networks both locally and globally. They often have work experience from industry or from other universities which gives them a broader perspective in assessing potential outcomes of their research results. Previous experience in patenting or experience from both academic and industrial sectors, as well as specific traits such as reputation, their social capital and industrial networks, the credibility necessary to attract money for patenting, and financial and business skills, are important factors that influence the patenting activities of both active and passive serial inventors.

Despite their patenting activities, all of the serial inventors claimed that they have kept their academic, basic science perspective and have not steered their research agendas towards commercial activities. Serial inventors considered using patents as means to trade with industry in return for increased research funding and access to material, equipment and research expertise from industry. Creating job options in industry, providing networks for students and keeping industrial networks up to date are important for factors behind the patenting activities of both types of inventors.

An SP-inventor from the MF perceived himself and other serial inventors as follows:

> From birth, humans are driven by curiosity, search and learning. Humans are the most curious creatures in the world. Probably as scientists we are more driven to do research, question and seek new answers. Yet we may be a little bit more curious or have more luck than other scientists to pursue our research further on. We have the chance to take our research one step further to discover what the next answer is. Overcoming one challenge, another challenge – e.g. starting the spin-off company or discussing with investors and firms – stimulated my interest to do more and more. We may have better supervisory skills and strong, restless minds which enable us to identify commercial aspects of our research results.

One SA-inventor from the MF who initiated a spin-off and also helped to initiate several other spin-offs made the following remark:

> We are not thinking as strategically as it is written in entrepreneurship guide books. Something made us think that the results were very interesting and need further development. It could not be done within the university labs, or with the university resources. I know it is important and I did not want it to be forgotten in the papers or books, either. So I basically followed my inner voice and looked for possibilities to apply for a patent and established a company to attract further resources and researchers to develop my idea. I have not done marketing search or cost-benefit analysis. It is not as in the management or entrepreneurship books. It is something I wanted to do, and I believed in doing. It is difficult to assume that all inventors and scientists are thinking and acting as I did.

An important issue I have observed is that serial inventors have been less concerned with job security or financial benefits even though they have been involved in the patenting activities. They have been less motivated by economic rewards or recognition and promotion. For them, the main goal is to show that they can achieve something interesting. They have been motivated mainly by doing something scientifically challenging as well as professionally satisfying and enjoyable.

Serial inventors have also been important actors in facilitating technology transfer. Many serial inventors have also provided a kind of structure for technology transfer when there have been organizational or institutional gaps. They have almost provided technology transfer structures, for instance, by writing the patent application themselves, paying for the patent application, and finding venture capitalists or industrial partners, etc. They have motivated and have been one of the main driving forces for patenting in their research groups.

At the same time, serial inventors have benefited very much from their networks and research environments. In order to increase their patenting and research activities, they have collaborated intensively with other researchers and have also motivated other scientists to consider the commercial aspects of their research and the possibility of patenting. Subsequently, in many cases, they have even led the initiation of entrepreneurial cultures at their departments (see Section 7.4.1). In their research groups, patenting and other technology transfer activities have become a common practice among researchers. In those departments patenting activities are not criticized or discouraged. Patenting is rather accepted within the research group. Although they have strong relationships with their spin-offs or industrial contacts, they do not want to change their career from university to industry.

7.3.1 Two Types of Serial Inventors: Active and Passive

In the typology of inventors (Figure 6.1), two types of serial inventors, *active* and *passive,* have been distinguished based on the criteria of how they actually apply for and commercialize their patents, i.e. through spin-off company formation or through existing firms. Here I describe in detail both the active and passive serial inventors.

Serial-Active (SA) Inventors: University inventors who have initiated a spin-off firm and applied for a patent through their spin-off firms are termed serial-active inventors. They have been associated with the term 'active' since they have been practically involved in every aspect of the patent application as well as in the firm formation. They can be described as hands-on inventors who want to be part of the commercialization process instead of delivering their invention to existing firms.

All of them have indicated that they have had some sort of industrial interaction, e.g. work experience, consultancy, contract research or previous patenting experience with an industrial firm. They have become familiar with the concept of patenting during such earlier interactions. Similar to Etzkowitz's (1998) definition of 'Knowledgeable partners', serial-active inventors want to play a significant role in the transfer of their research to industry since they have business insight and are aware of the potential commercial value of their research results.

There are different reasons why inventors have initiated their spin-offs. First, a *lack of interest from existing firms* has motivated as well as necessitated their looking for an alternative solution. In many cases, a firm refused to invest in their idea from the very beginning. In some other cases, even though a firm bought the patent, it was never interested in developing it further. In the worst cases, some serial inventors have experienced that even though a firm bought and patented their idea, it has neither used the patent nor allowed the inventor to use the patent. As exemplified by one SA-inventor from LTH:

> Big firms think that independent inventors simply cannot come up with inventions that their own engineers have not already thought of. They consider independent inventors to be dangerous. They are so sure that no one knows more about their field than they do. And even if an outsider does invent something meaningful, he or she is infringing in their domain, and the firms therefore think that it is a fair game to ignore or crush the independent academic inventors. We call it the 'not invented here' syndrome.

By the same token another SA-inventor from MF told:

> It is nice to collaborate with industry as long as we are trying to solve their problems and bringing some incremental developments to the firms. However when a scientist brings something disruptive or too risky they are not ready to accept it. So then it would be scientists' job to bring it into the market.

Second, the Swedish economy has many large firms, collaborating with scientists on individual bases. However, *the end of stable long-term relationships with existing firms* (for instance, many inventors from the MF mentioned the shutdown of Pharmacia's research activities) has terminated different types of industrial contacts that scientists used to have. Such disturbing experiences have also motivated and triggered them to start spin-off firms as a replacement for their previous partners.

Third, many serial-active inventors (e.g. those approaching retirement) have seemed to have an implicit motivation. They consider spin-off firms to be places to retire to. (One interpretation may be that some senior scientists have a kind of fear of becoming useless and being outside the research life once they have retired.) They therefore build companies in which they will be able to continue their research even after retirement. Some of them consider their spin-offs as substitutes for research institutes which are largely missing in the Swedish research system.[56]

A fourth reason for many serial-active inventors to initiate spin-offs has been the expectation of becoming *free and independent*. Increasing budgetary constraints, limited funds and increasing dependence on external funds have affected the freedom of research at the universities. An SA-inventor from LTH stated:

> I wanted to do something without someone telling me what to do or how to do it. I believe I would achieve much more independence and autonomy in a spin-off company.

An SA-inventor from the MF compared the nature of research in a big company, a university and a small spin-off company, as he stressed:

> When we do research in a spin-off company, we have the freedom and openness of a university environment, but the resources of a project conducted at a company. It is a nice, privileged feeling. We are not restricted by the research priorities and financial concerns of firms, and we are not restricted by the financial and resource constraints of university projects either.

Serial-Passive (SP) Inventors: Serial-passive inventors resemble to some extent the combination of the seamless web and the hands-off types of

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[56] In the Swedish research system, universities are expected to do teaching, research and entrepreneurial activities. There are not so many research institutes [similar to e.g. Fraunhofer (in Germany) or CNRS (in France, Italy and Spain)] (Edquist 2004).

relations that Etzkowitz (1998) has described. Despite their higher number of patent applications, SP-inventors do not want to take the risks and the full responsibility of applying for a patent themselves, and they do not have the motivations to start a spin-off. They prefer to hand over the research results to a partner firm and expect the firm to apply for a patent. They have not participated in the patent application process as much as the serial-active inventors have. Their patents were owned by existing firms, and most of the time they received an 'inventor's fee' from the applicant firm as a kind of financial compensation or reward for transferring the ownership rights to the firm. Some of them have continued their relations with the firms for further development of their patent into a product or a process. Most of them have also continued their relations with these firms by initiating different research projects.

The technology transfer activities of SP-inventors often represent the so-called 'reverse linear model' of innovation, where research questions are generated by industrial needs and problems. These scientists have established long-term relations mainly with large Swedish industrial corporations (e.g. Ericsson, ABB and Volvo). Much of the funding comes directly from these industrial partners in return for the ownership of any intellectual property resulting from the project. One of the SP-inventors from LTH working closely with the automobile industry commented as follows:

> I am not interested in being listed as an inventor in a patent. This does not give me any kind of merit. I am happy and satisfied to be the author of peer-reviewed journal articles. Importantly, I am happy to generate research funding for my research, create job options for my students and see my research utilized by industry. I do not want my long-term, trustworthy relations to be ruined by such claims either! I do my work, teach, educate, research and collaborate with industry to solve their problems. I do not want to start a company… Actually, we cannot start a company in our field. You need big firms to utilize our research (Volvo, Saab or Toyota). And these firms do their work: to utilize and apply the research results – or the patents – as you may wish to say.

Two other SP-inventors who are collaborating with an industrial firm showed their entry-cards to the firm's labs, implying how their relations have developed over the years. One of them also explained further how the project with the firm provided them with access to funding, research problems, practical applications and job options for their students. Both agreed, and one of them said:

> We will not be able to get any collaborative projects and thus funding and so on, if universities start asking for patent rights, licensing fees, royalties etc. in addition to what we [scientists] get as research funds!

Some of these serial-passive inventors are cooperating with a group of industrial firms in a Vinnova-funded competence centre for instance. Similar to the agreement mentioned above, the partner firms have the first right of refusal of the inventions that are generated within these competence centres. Research results are disclosed to the partner firms and interested partner firms may apply for the patent. In these types of arrangements the teacher's exception facilitates the relations with industrial partners, since scientists can easily transfer the ownership rights of their intellectual property to the partner firms. Almost all the serial inventors who are working closely with industrial firms underlined the importance of this law in facilitating their relations with industrial partners.

As shown in previous studies, decreasing public investment in university research has forced scientists to look for alternative funding sources. All serial-passive inventors mentioned that they have had to compensate for the lack of public investments in their research by increasing their relations with industry and relying on external funding. One SP-inventor from LTH sadly admitted:

> We are now doing research which is almost totally financed by firms. If we have twelve projects – let's say twelve new Ph.D. students – we should at least have two company-independent projects which might be more risky, and we may not know if the results are going to be useful or not for any specific company. Yet we may then have the potential of having revolutionary results. The university should finance some of the projects.

However, he continued:

> Having said this, I am not saying that research done in cooperation with industry is less interesting or less important. Students at LTH have always found company projects more attractive than the projects they are free to design as their own projects.

On the other hand, many serial inventors agreed that there has been too much political focus on and push towards commercial activities. Almost all the serial inventors agreed that university researchers are having much more difficulty nowadays in finding research funds than in focusing on improving the possibilities of funds and/or agents for commercial activities. Many serial inventors were critical that although there has been an increasing interest and more investment in technology transfer infrastructure, investments in research have not received the same interest and attention. As an SA-inventor from LTH emphasized:

> It seemed much easier now to get investments for applying for a patent or even for initiating your company. The difficult thing is to get funding for doing research. Everyone is interested now in paying for a patent, but not for the research.

Intensive patenting activities require an investigation of how serial inventors balance their different tasks. For instance, in answer to the question whether their research has become increasingly dependent on industrial needs and problems, many serial inventors from the MF responded that a medical doctor cannot isolate him- or herself from the reality of the patients' needs or the needs of pharmaceutical firms. Both industry and university researchers are trying to solve the same problems that humanity faces. One SP-inventor from the MF further clarified:

> Even though the problems for both industry and us are similar, such as curing sick people, our motivation is not to make money out of people's illnesses in the end. The starting point is the problems, but the motivations or incentives to solve them may differ. When a company understands that they cannot make money out of that research because there are not enough sick people to sell the product to, they can easily close down the project or never invest in the project. So lack of industrial support should not kill our research interest and motivation, of course. Funding should then come from public sources. If not, the research becomes very much industry dependent, and the real danger starts.

An SP-inventor from LTH who has been participating in a competence centre said:

> We are not necessarily doing what industrial partners ask or are interested in. There has always been some room [opportunity] to do something that had not

> been planned. We may always find some surprising results during experiments. During sample trials, or even through accidents in the labs, research may lead to something unplanned, unexpected. This is the way of doing research, whether in a collaboration with industry or all alone. And we actually cannot disconnect ourselves from industry, either.

Most of the serial inventors claim that 'publishing ideas and commercializing ideas' are not that opposite. They state that a combination of scientific and commercialization activities at least appears feasible most of the time. This argument is supported by a large base of evidence from other studies as well. This is strongly demonstrated for biomedical science and some other 'transfer sciences'. An SP-inventor from the MF also made a critical remark:

> Postponing a journal article while applying for a patent? The true dilemma is if you want company support, Nutek, Vinnova or any kind of external money …you are supposed to show that you have patents. On the other hand, to get funding from VR [VetenskapsRådet, the Swedish Research Council], you need to publish. Since you don't know where the next funding source would be, you face a true dilemma. This situation has to be changed. However, it should not necessarily harm the cooperation with industry or industrially useful research.

On the other hand, almost all serial inventors have accepted publication delays due to the patent application procedure. They argue that the main problem occurs when they need to allocate a lot of time to apply for funds and to administrative tasks.

However, accomplishing multiple tasks simultaneously – teaching, research and commercial activities – leads one to ask if these inventors are all superhuman. Many interviewees responded to this question in more or less the same way. They mentioned that possible tensions among these different tasks, if any, are mostly likely to be encountered by inexperienced researchers. In other words, when they were at the beginning of their patenting activities they might have experienced a kind of trade-off between their different tasks and roles. The interviews have highlighted four main strategies that serial inventors mentioned as necessary to balance their teaching, research and entrepreneurial tasks.

- **Selectiveness:** Serial inventors are more selective in their research, teaching and patenting activities. Since they are mostly experienced and merited researchers with safe positions and senior positions at the university, they have far fewer career and promotion pressures and hence have the freedom to select what activities to pursue.
- **Freedom:** Most serial inventors are more or less at liberty to arrange their employment contracts since especially some of them are partially employed by the firms. Consequently, they seem to experience fewer conflicts among their different tasks.
- **Delegation:** Serial inventors can also delegate some of the research tasks within their research group. While they are engaged in getting funds for their research and commercial activities, most of the research work in laboratories is being conducted by their research team members.
- **By-products:** Serial inventors have a relatively greater degree of overlap between their different tasks of teaching, research and entrepreneurial activities. They act in a way that makes patenting a by-product of the other two main tasks, i.e. research and teaching. The multi-task agenda is feasible and manageable when the third task is considered as a by-product of the other two tasks rather than a joint product. When such by-product logic is maintained, the sense of priorities and hierarchy between different objectives is not lost.

7.3.2 Changes in the Patenting Activities of Serial Inventors over time

In most cases, the serial inventors have done their first patent application together with an industrial company, or through more passive involvements, e.g. licensing to firms or patenting with the help of their senior colleagues. Some of the inventors have continued their relations with the firms and have become serial-passive inventors.

The interviews with the serial inventors have revealed a number of reasons behind the changes in the way they apply for and commercialize a patent. For instance, I have found that several serial-passive inventors have changed the way they commercialize their patents over time. Some of them have experienced that their relations with firms have ended due to closure of R&D departments, mergers and acquisitions or changes in the research agenda of the firms. Additionally, various types of conflicts (see Section 7.4.3) with industrial firms have motivated scientists to commercialize their patents through spin-offs. Consequently, some serial-passive inventors who used to commercialize their patents through established firms have changed their paths of commercialization from licensing to spin-offs and have become serial-active inventors.

On the other hand, some of the serial-active inventors have been patenting mainly through their spin-off firms. They eventually have to be considered serial-passive inventors, as they have utilized their patents exclusively through the spin-offs they started. They have thus moved from being type SA-inventors to being SP-inventors. Over time, however, new actors (e.g. investors, entrepreneurs) have gained control of some spin-offs, and the original university inventors have had to continue their own way of doing research. Although most of them have kept their links with the spin-off while it has been growing, these inventors have started new projects and have applied for patents, and this may lead to new spin-offs. There is a movement of inventors from one type to another. Possible changes in the activities of inventors and the reasons behind the changes merit further study. An SA-inventor from the MF described the way he and his research group members have been working:

> I believe we have already done something that is good for society. It is a job of trying to act outside the academy with its academic rules and concerns, or probably we aim to act entrepreneurially within academia with some industrial concerns. Our activities are often constrained by our traditional values but driven by realities. Our culture, values and activities should be evolving. One must be open to the new needs of the society and responsive, yet I believe we always respected and protected the academic values, the quality of research and academic curiosity in our patenting activities. The aim was never patenting per se but being able to do good research. If the patent is the outcome of the good research, then it is a bonus.

Several SA-inventors have initiated spin-offs but have later continued with their own research. As clarified by an SA-inventor from LTH:

> When the spin-off company becomes mature enough, it needs people other than us. When our research interest and the company's needs were no longer overlapping, we realized that we could no longer continue our relations with that company just on the basis of our research competence. The company has become much more in need of marketing competence. We have kept our relationships, of course, but by being on the scientific advisory board.

These inventors have realized that it has actually been time for some other types of actors with more entrepreneurial and financial skills to take over the company. Such a shift in power is often a necessary condition for the successful growth of a spin-off company.

Most of the time, these researchers are more interested in new research questions than in pure solutions, product development or marketing. They want to spend more time on the research processes, theoretical principles and new research questions. Yet they want to see their ideas being utilized. On the other hand, too much early involvement by investors may cause inventors to lose their influence and participation. In such cases, spin-offs come to be owned by the investors too early and the inventors do not have enough time to actualize their research endeavours. In sum, while some inventors have been willing to move on with their research and to create new patents or more spin-offs, some have experienced resentment in letting investors take over a company too early.

7.3.3 Changes in the Motivations of Serial Inventors over time

Serial inventors' motivations to patent for the first time have not differed much from their motivations in the later instances. The main reason for them to patent is normally and mainly to realize and achieve scientific results and to solve industrial or societal needs, but at the same time to do something professionally enjoyable and challenging. However, during their first patenting experiences, some serial inventors have thought that they would make lots of money and become rich. But most of them have realized after a short while that a patent is just the beginning of something that would be very unlikely to yield high financial benefits, if any. As they have become more competent in realizing the potential commercial impact of inventions, their main motivation to patent further has been to be able to do something interesting and to achieve something challenging. As a response to the question 'What were your motivations to patent and have you experienced any change in your motivations?' an SA-inventor from LTH turned the question back at me:

> What do scientists want? Why do *you* do research? All scientists – me, you, your teachers and your fellow Ph.D colleagues – want their ideas, findings to be useful. You want to solve the research question you asked some years ago,

> or that your findings will solve problems of other people. If you do not have this motivation, why do you do research then?

Another SA-inventor from LTH responded to the question why they patent as follows:

> We are putting our pride into the project; we would like to see it succeed. There is no better kick, driving force or feedback than to see the utilization of your ideas. Scientists are married to their research. The results are their babies. We want to see our babies being useful, interesting and gratifying us.

An SA-inventor from the MF elaborated more specifically:

> The business world is claimed to be the real world, while the academic world is full of dreams and self-satisfaction. This is a wrong image, our world is not less real than business. Our reality is the patients and the contact with the hospital. We got our questions and thus the driving force from the clinical facts. We want to solve health problems. I do not think there could be any other kind of reality or unconditional driving force.

An SP-inventor from the NS remarked:

> There are always some financial hopes, if you patent with a company, you get an inventor's fee (around 20,000 SEK ~2,000 Euros) which is almost the same compensation that firms usually pay their researchers. However, it has never been the main driving force. As professors we have decent salaries; many of us have already given up the idea of becoming rich in Sweden.

Another SA-inventor from the MF expressed his motivations to patent and to initiate the spin-off company formation as follows:

> If we had kept economic gains as the main driving force, we would have stopped patenting and never developed the spin-off company already after the first patent application! When we first realized the patentability of our research results and its potential implications, most of us in the research group were thrilled. We thought we would earn lots of money, since there has been no treatment yet. We went to several companies; they were not interested in the idea because it had not been proven and there had been no clinical trials yet. We were disappointed, some of us just stopped after the initial patent application. Some of us continued (including an American scientist). I realized that it is a different kind of satisfaction – maybe internal validation; you need to see that your research is useful for patients. Or you want to prove it to yourself. I now know that companies do not invest in our ideas at an

> embryonic stage so we have to work on it, apply for a patent and even take it to the clinical trials. After that we will very likely find a company to pass it on to.

Many serial inventors mentioned that Sweden is a high-tax country when it comes to personal income and earnings. This has led inventors not to have any strong incentives to increase their personal income. Increasing financial means for research, on the other hand, is found to be an important factor both in the survey (Chapter 6) and during the interviews. An increase in personal savings is not deemed to be the most important driving force.

In addition to their internal commitments to their research and desires to solve research questions, the interviews have highlighted two important issues that may contribute to the patenting activities of serial inventors. The first factor is *learning-by-doing* or *experience*. One SA-inventor from the NS commented on the role of experience as such:

> After our first experience in the patent applications, we talked to patent attorneys, industrial partners, as well as patent agents to discuss the entire patenting process in a different language than I expected. But we got to learn a lot from those experienced patent attorneys and entrepreneurs. We understood how to safely patent an invention without delaying your publication, to secure corporate financing, and to market it to the public. With this experience, we learned to know what questions to ask, how to effectively and efficiently use a patent attorney, which patent attorney to go to, which industrial partner to talk to, etc. We learned how to avoid being victimized. This of course speeds up and facilitates our next patent application. This saves a lot of time and energy.

The second factor is *constant curiosity* in seeking out new questions along with the desire to solve new problems. Another SA-inventor from the NS commented on why they can patent serially as follows:

> Even though researchers love their research, it is not an obsession. Our aim is to solve a research question and then move to another research question and then to another one. If you are a good researcher and inventor, there is always one more research question to be investigated and more inventions to be conceived. And you always have the hope that one will succeed or it is worth doing anyway. This may explain why we have patented many times.

In brief, in the course of their patenting and post-patenting activities (e.g. licensing, spin-off company formation), serial inventors have experienced that their tasks and motivations may change over time. When a number of different actors come together around a patent, their activities cannot hold strongly to the initial or individual motivations. Research and commercialization activities are not as simple and straightforward as might be expected. They co-evolve with the needs and motivations of the participants. The behaviours of the group and the inventors thus become more complicated and expand beyond the initial plans, needs and motivations. Further implications of the patenting activities of serial inventors are discussed in the next section.

7.3.4 Implications of Patenting Activities

Most of the interviewees have stated that the research group has benefited a great deal from the patenting experiences and from the interactions with patent consultants, industry and venture capitalists. During these interactions, serial inventors and their research groups have learned more about the practical – commercial – sides of their research. Some of them have mentioned that sometimes the research results that were so interesting to the inventors were not necessarily the most interesting parts for the firms or for commercial applications. As a result of continued relations, serial inventors often develop new points of view of a kind that help them to identify commercially interesting parts of their research results.

With regard to writing a patent application, most serial-active inventors argued that they had developed the skills to write reasonably good patent applications, but almost all serial-passive inventors preferred to delegate the writing process to the patent engineers of the partner firms. Both active and passive inventors have stated that they have helped the patent engineers with the technical aspects of the invention in order to clarify the claims. An SP-inventor remarked:

> Even though I have been an inventor of several patents, I am a very lousy patent writer. Maybe what patent engineers do is simply to play with every single word, stage of research and so on to state as much of a claim as possible. But it is beyond my time and competence.

Serial-passive and serial-active inventors have different views when it comes to comparing patent applications with publications. Most serial-passive inventors have stated that patent applications are made in a different type of language than that of journal articles. Most serial-active inventors on the other hand have found that patent applications and articles are not that different from each other, as highlighted by one SA-inventor:

> We first write the application, send it in to the patent office, generally first to the Swedish PRV. When we get the application number from the PRV we simply readjust some parts and convert them into a journal article and submit it to a journal editor right away.

Serial-active and serial-passive inventors considered their leadership and entrepreneurial experiences differently. For example, as an SP-inventor commented on his patenting activities and its implications:

> It is a learning process. We learned something different than doing research and writing research applications. But I don't think I have adopted any entrepreneurial skills yet. It should be somehow in your genes. I don't believe I have become more entrepreneurial since the age of forty. If it could have happened it would have happened. But I am still here in my white coat. I don't think I can wear the business suits and learn their language, either. I have learned to negotiate, though. I am not giving it up very easily now. I don't want to be a project leader outside either, but I learned that I actually can influence the patenting processes. I can make the ideas available to industry, and then firms can make it possible. It is a kind of relay race. I start the research, find it and give it to someone to undertake, develop and sell it. I believe this will not reduce my contribution to this process.

On the other hand an SA-inventor from the MF, commented on the entrepreneurial implications he himself experienced as follows:

> There is something called entrepreneurial spirit. It is the combination of curiosity for doing research and desires for putting them to use. So it is the research life and the business life. I am not in either world. I guess I learned to be in the intersection of those two vectors. I think this position has created the phenomena that I am experiencing. I think it is much broader than being solely a researcher or being solely an entrepreneur. I am not driven by pure research results; I don't believe we can isolate ourselves from the rest of the world. Even Einstein had not done that while he was doing the purest

> research. But I am not driven by pure financial rewards either; maybe social demands and problems. There are certainly social benefits of that learning.

The general implications of patenting for serial inventors are summarized as follows. New activities and learning experiences have led to a new mind-set or additional perspectives. Most of them have experienced new ways of thinking and approaches to their research questions. They have become more observant, not only with regard to research results but also for industrial opportunities and applications. They have been internally driven in their patenting and research activities, since these activities have been done mostly for personal satisfaction. However, they have become much more aware of the problems and possibilities beyond academia. They have developed networks outside the academic community as well, with investors, patent engineers, TTOs and other similar actors. However, they have also learned to keep the vital balance between research and commercial interests. Many of them mentioned that they had to learn many nuts-and-bolts skills for patenting, such as how to identify patentability, finding the right patent engineer, finding the industrial partner or investor, planning and organizing for further steps of commercialization, how to finance, how to attract talent and resources, and so forth.

Both types of serial inventors mentioned that they have learned how to deal (negotiate) with industry. They adapt their presentations, research findings and business plans in a way that will attract industrial partners or venture capitalists. Many of them have understood that they should not expect business people to understand the scientific and academic implications of their research results. This is not because business people do not know the science but because they are not as interested in the scientific implications as a scientific audience is. Even if some technology transfer brokers or venture capitalists sometimes have scientific backgrounds or bring along other researchers to evaluate potential use of the research results, business people and investors are mainly interested in the invention's use and application.

7.4 External Factors: Research Milieu

The patenting activities of serial inventors are not independent from their research milieux. Patents are most often co-invented by a group of university researchers such as professors, graduate students, post-doctoral fellows and sometimes industrial researchers (see Etzkowitz 2003). A patent, then, is often the outcome of a collective piece of work by a research group. This section discusses the relations between serial inventors and their research environments. Interviews with occasional inventors are also used here partially to supplement the findings of the interviews with serial inventors.

The first aspect of a research milieu that the interviews have revealed is the *size of a research group* (Martin et al. 1993). Studies of research groups show that 'whatever the field of research, the relationship between group size and research productivity is far from simple' (Von Tunzelmann et al. 2003: 8). There are two views on the size and effectiveness of research groups. While some serial inventors work in smaller groups, some work in larger research groups. Their views are summarized as follows.

The smaller the cosier: Some inventors believe that a research group consisting of five to seven researchers is the ideal size to work in. The group can be composed of one professor, an associate professor, a post-doctoral fellow and two Ph.D. students and one or two technicians (research assistants). Most serial-active inventors have preferred smaller research groups or individual projects where scientists can actually shape their research agenda. In general, research projects coming out of smaller groups are commercialized in the form of spin-offs, although some patents resulting from smaller research groups or individual researchers are utilized in existing firms. In most cases, while the professors have kept their positions in the university, Ph.D. students and post-doctoral fellows have taken jobs in the spin-off company or have been paid partly by the company. Relatively older spin-off firms have already financed the Ph.D. students in the research group from which they have had spun off.

Most serial-active inventors are critical of larger research centres (e.g. centres of excellence, centres of competence). Many argue that investments and money are lost in administrative meetings, bureaucracy and personal struggles. Most of the serial inventors argue that in these centres the research agenda is likely to be set by the industrial partners for the purpose of solving the problems of existing firms. They state that there is little room to pursue something new and wild. However, they all admit the importance of networking and interaction with different research groups, but they are quite sceptical about the need to create large structures.

The more the merrier: On the other hand, a number of interviewees underlined the importance of larger research groups in order to get access to more funding as well as a large number of researchers. However, even if they are part of bigger groups, they work in groups of four to five researchers with a specific focus. Most of these larger research groups are the results of Vinnova-funded competence centres. Most serial-passive inventors have been participating in larger competence centres of this kind. For instance, the Vinnova-funded Bio-separation Centre is one of the most patent-intensive research groups. Research results coming out of these centres are utilized mostly by existing partner firms. There have been several spin-offs emerging from these centres as well as knowledge transfer from industrial partners to the university research groups. One SP-inventor from LTH who used to work at the Bio-separation Centre gave an example of this as follows:

> A scientist from the centre spent time at the company to learn a patented methodology and then utilized the application of the technique at the university. This is an example of reversed technology transfer.

Benefits of working in competence centres and technology transfer can also take the forms of job opportunities for students. Another SP-inventor from the MF explained:

> Employment of former Ph.D. students in a company is also one of our goals. Of the nine students that have graduated so far, three have been employed by Centre firms such as…. This is also one of the aims for firms to participate in such centres. It is a good way of exposing the company, collaborating with students and easily finding competent candidates for vacant positions.

Another example of technology transfer within a competence centre is described by another SP-inventor from LTH as follows:

> We had a project meeting with an industrial partner in Uppsala, where we discussed the literature and a number of possible options. It was decided that

an open-minded approach should be taken, allowing all technology platforms to be involved and addressing various aspects of the question. At the time, some approaches seemed very straightforward, whereas others seemed less likely to succeed. It turned out that this broad approach really paid off. Different views were combined; a method was developed, mostly in Lund in cooperation between two departments and with input from firms. One of the firms, especially, has actively interacted with us. The principal scientist made a one-week visit to the company. After additional refinements (due to problems discovered at the company during the visit) three papers and one patent application were produced.

Although size is an important factor, inventors agree that it is not the final determinant. Scientists in bigger centres can always create the efficiency and flexibility of smaller groups by subdividing the centre into sub-thematic areas. It is also observed that serial inventors who have been leading smaller groups try to enlarge their research group and network with other groups to gain access to other resources and talents.

The second issue that inventors have emphasized is the *heterogeneity of the research groups*. Diversity of the research group in terms of gender, age, background, nationality, scientific field, academic ranking and experience is deemed by the inventors to be a more critical factor in the success of research groups than their size. An important element for establishing a successful research group (milieu) depends on the ability to be big (networked) and to act in smaller, flexible constellations at the same time and thereby encouraging the entrepreneurial and inventive spirit among the members of the research group.

7.4.1 Role Models

Even though serial inventors have played central roles, they need complementary skills, knowledge and someone to work with in the laboratories while they are engaged in entrepreneurial tasks such as raising funds for their patent applications, contacting industrial partners and writing patent applications. They tailor their attitudes to the needs of each individual in the research group and let them participate; however, most of them admit that they have become more straightforward and focused in their attitudes. One SA-inventor from the MF explained this as follows:

> If a task regarding the commercial side of the project, not the research aspect, has to be done in that specific way, it has to be done as it is. You do not have the time to wait for their [colleagues'] mood to do the research on time as it is expected. Tasks at the spin-off company are not as easy as or as flexible as for academic posts. When we start a project in the academy, it seems easy and acceptable if one of my researchers takes a year or so off [e.g.] for parental leave. But when you start a company, it is not expected that you will take a leave. Then the company falls apart, we may miss the deadlines with the investors and we lose. In the academy the job can always be postponed. It is the only place where everyone can leave for six weeks of vacation. For this small company, we have to sacrifice all these benefits.

He further explained the changing roles between his supervisor and himself:

> Since I am the main responsible person [principal founder] of the company, I am now in a position to assign tasks to my former supervisor, who is now acting mainly as a consultant. In the beginning I found it quite awkward, but we got over it. For the sake of the company we very soon realized that we could no longer keep the veiled hierarchical structure of the university.

Serial inventors have strong personal impacts on the success of their research groups. Social imprinting is very important in university research. Junior researchers are motivated by the value systems and activities of their seniors. In Sweden and in academia there are a very few successful cases that have influenced the next generation's patenting activities. Most of the serial inventors mentioned former professors from LU such as Nils Ahvall, Torsten Almen, Stig Bengmark, Carl-Bertil Laurell, Klaus Måsbach and Karl-Johan Åström, who had not only made important contributions to their research fields but had also achieved industrial applications with success and integrity. These researchers were influential in establishing a patent culture in their respective departments. Today's serial inventors are also important actors in establishing and spreading the possibility of patenting with good research. Many serial inventors have assumed the role model of being a good teacher and a good researcher. They believe that good patents can come only after good education and good research, as an SA-inventor from the MF stressed:

> Role models, successful cases, are definitely important for the other generations to understand and dare to patent or commercialize their research results. But I believe it is more important that we open their horizons and

> show them different possibilities. There should be no emphasis on either of these tasks. It should go hand in hand. Only good research can trigger good patents. And it often happens by chance and mistakes rather than by repeating what we had done before.

Another issue is the roles of students. Desire and demand for patenting do not come only from serial inventors; students too may demand more industrially relevant projects or look for industrial applications. Many Ph.D. students want to see how university research might be used in industry, with the hope of better chances for employment in industry. Several serial inventors mentioned that their patents have resulted from interaction with students, their expectations as well as learning from them. An SA-inventor from LTH commented on the role of his Ph.D. students:

> It was in the air! No one knows where and how an inspirational model will hit a research group. It can be senior researchers, students, entrepreneurs or family… Students get inspired from everything. Students were also very much into the industrial application. They have friends who have recently started their ICT firms [late 1990s, early 2000]. And they inspired me as well. We had been lucky, not only in the sense of finding something new and useful but also in the sense of working in a time and place that allowed us to exercise our talents and aims to the full. We were just open to any kind of inspirational source.

On the other hand, students should not be forced to patenting, since each student has different expectations of the university world. An SP-inventor commented on his role like this:

> Science or inventions require capturing a student's interest early. We should establish the excitement of scientific exploration and discovery and motivate young students through the long and arduous learning process. As role models, we can put them in contact with different scientists and industrialists, to look for different ideas. But we should not put the main focus on patenting. It will distract them from science so early that they will not be able to think and produce something patentable. But they should be ready for a 'eureka moment' that can be patentable!

Although most of the serial inventors have not realized that they might actually have acted as role models for students or in their research environment, most of the serial inventors admitted that they might be a little bit more attractive to students who are interested in having industrial jobs or who want to start their own firms after or during their university education. Consistent with the findings of Bercovitz and Feldman (2004), this study found social factors such as inspiration from local colleagues, foreign colleagues as role models, the impact of chairpersons, and research group decisions to be influential in the patenting decisions of inventors.

As expressed by the interviewees the features of a good leader in a research group, based on the discussions with serial inventors, can be summarized as follows:

- Leaders should inspire scientific research and nurture scientific curiosity in the research group, encourage researchers to ask questions and look for answers. They should be able to provide intellectual freedom for risky and independent projects.
- Leaders should show the researchers that it is personally satisfying and intrinsically rewarding to pursue research. They should achieve the commitment of research members.
- Leaders should expose the research group to the outside scientific and industrial world, promote group members rather than promoting themselves and provide job and career opportunities to all.
- Leaders should be able to act promptly to prevent conflicts of interests within the research group.

The decisions of research group members and the activities of local colleagues were especially influential in this respect. A research group decision is an important motivating factor for researchers to get involved in patenting activities.

7.4.2 Identification of an Inventor in a Research Group

The rules for co-inventing are much stricter than the rules used for determining co-authorship. Typically, anyone who has made some contributions to a research project will be listed in publications relating to that contribution. However, the inventors have underlined that there is definitely a decrease in the number of inventors compared to co-authors.

A decisive factor in being accepted as an inventor depends chiefly on the intellectual and original contributions of researchers to the project.[57] The inventors should be the ones who have formulated the research questions and who have formulated claims or who have found the novel, unique and non-obvious aspects of the research results. Providing technical assistance (e.g. tasks of technicians), doing the routine or given tasks in the laboratories and sharing knowledge, data and advice will not qualify one as an inventor as long as these contributions has not changed the intellectual aspects of the research at hand.

In order to distinguish the authors and contributors from the inventors, scientists have developed the 'five-finger rule'. As expressed by some of the serial inventors from the LTH and the MF, according to the basic idea of the five-finger rule, in co-authored papers the first authors are generally considered to be the main corresponding authors unless otherwise stated. They have actually done most of the research and have been responsible for the intellectual aspects of the research questions. Authors in the middle have generally provided some basic technical knowledge. They may have done lab tests, shared their technical equipment and data, and/or they may have advised the group to some extent. The last authors have mainly provided broader knowledge, research questions and contributed to the analysis. When these co-authors apply for a patent, authors in the middle would very likely be excluded from the patent application since their contributions have not been original but undertaking a routine or an assigned task.

It is also possible that the name order of authors has been done in a different manner (as in most cases in the alphabetical order of the surnames of the authors), e.g. authors listed as the last or the first could be excluded from the patent application due to the issues discussed above.

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[57] Under the European Patent Convention (EPC), identifying the inventor of a given invention is theoretically very important since '[t]he right to a European patent belong[s] to the inventor or his successor in title' (Article 60(1) EPC), according to the first-to-file principle (Article 60(2) EPC). In practice, however, the European Patent Office (EPO) never investigates whether the proposed inventor is indeed the true inventor. Retrieved 01/10/2007 <http://www.answers.com/topic/inventor-patent>

7.4.3 Conflicts of Interest

Most serial inventors have experienced different types of conflicts of interest regarding their patenting activities. The conflicts of interest are grouped into two types: *internal conflicts* and *external conflicts*. Internal conflicts of interest refer to problems that occurred within their research group, e.g. with co-inventors, other researchers in the same group, a department head, or peers (other colleagues). External conflicts of interests refer to problems between inventors (including other members) and external actors, such as TTOs, university administration, industrial firms, investors (venture capitalists) and patent consultants.

Conflict of interest within the group: Some serial inventors have had problems within the research groups. The most common conflict is, as discussed above, the identification of who is an inventor and who is not. This phenomenon is more common among juniors than among seniors. While some juniors have thought that they should have been listed as inventors, seniors have claimed that most of the time, Ph.D. students or technicians do the routine tasks given to them. However, if a Ph.D. student has come up with the idea behind the patent or has later formulated the claims, he or she will be listed as an inventor. In order to avoid such conflicts, some serial inventors have pursued a quite generous policy for the inclusion of all research members in the patent.

Publishing versus patenting may be another cause of conflicts of interest among juniors versus seniors. The delays in publication have been a matter of one to three months at most and inventors have in fact managed to publish work that did not divulge the commercially interesting part of the invention. In most cases, conflicts between juniors and seniors are overcome by the juniors' belief that a successful patent would boost their research group, increase their job contacts in the industry or create jobs for them through spin-offs.

Conflicts of interest with external actors: The views of inventors have sometimes differed from those of industrial investors and other brokerage agents. Some of the most common problems that serial inventors have faced were 'timing and a sense of being cheated, non-utilization of patents (ignoring them) and changes in the firms'. In some cases, the inventors have thought it was too early to launch a product or process and have demanded more time and investments from industrial partners. Industrial partners, however, have demanded a quicker process. On the other hand, when inventors have believed it was time to take further steps like production or marketing, industrial partners may have lost interest and/or changed the strategy of the firm. In some cases, inventors have lost their reliable long-term contacts in firms due to changes in management (e.g. Pharmacia's merger with Pfizer is given as the most common example of losing contacts with a company), leading to conflicts of interest or, mainly, to disagreements and communication problems with the new industrial contacts.

In some other cases, firms have bought patents but have never utilized them. This has made most inventors very unsatisfied and unhappy, since an important motivating factor for them to patent is to see their ideas put into use.

7.4.4 Social and Cultural Factors

During the interviews, several inventors described the Swedish culture with the term *Jantelagen*. In Scandinavia there is a term for fear of success called Jantelagen (the Jante Law), which has its roots in the book by the Danish-Norwegian author Aksel Sandemose (1933).[58] Loosely translated, Jantelagen can be rendered as *Don't think you are anybody/anyone special*. This attitude is claimed to be deeply ingrained and a typically Swedish value, as opposed to the Americans' striving for success and fame (Gustavsson 1995: 160). It is an attitude that may obstruct any type of personal initiative, such as the sort needed for entrepreneurship.

Serial inventors argued that the suppressive culture of the Swedish society – expressed in such manifestations as Jantelagen, 'end of challenges', 'conformist society', 'good enough' (*lagom*) – is not good for

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[58] This attitude could be said to follow logically from the egalitarian value: if people are thought to be more or less equal, nobody is allowed to stand out from the rest, at least not too much. This value has been formulated by a novelist into a law, called the Jante Law (Gustavsson 1995). It should be noted that, although Jantelagen has been a popular image among some Scandinavians, it is not a 'scientific concept' and does not have scientific basis. The discussion here is therefore based on the views of serial inventors.

entrepreneurship or for trying to do something beyond academic tasks, such as patenting. An SA-inventor from the MF emphasized that:

> You don't want to create any envious feelings among your peers. Nobody should draw any attention to themselves or stick out in any way which can threaten the social balance in the society. Mutual relations between people are important for life to work well in a small place. People are dependent on good relationships with peers and seniors to manage various tasks. Since people may meet often, most people find it is important that the social contacts should be peaceful and friendly.

At the university and in the research groups, old relationships of dependency still remain. Therefore, people avoid ideas or values that are too different. Junior researchers make the effort to have good contacts. Indisputably, being on bad terms with colleagues and conflicts between colleagues in the university are very difficult. Therefore, people often take care not to upset this delicate balance. This leads to caution with new ideas and changes that, in some way or another, are not accepted by others or could be interpreted as a threat to the interests of other researchers. One statement by an SA-inventor from the MF can summarize the view of the several inventors:

> When it comes to entrepreneurship, it is always seen as something very individualistic and selfish. Even though entrepreneurs are supposed to create employment, this has not been the case very much for entrepreneurs, especially not for the so-called academic entrepreneurs. Academic entrepreneurs or university spin-offs do not often aim at becoming large firms. Therefore their endeavours have not been justified against the burden of Jantelagen!

One SP-inventor from the NS stressed that Jantelagen and entrepreneurship as such do not go well together:

> Swedish society or culture kills the spirit of scientists for doing things. Science should be free and scientists should be free to tell what they found. However, many people are afraid of losing the game or their reputation. They don't dare to take risks. Many scientists, younger ones, are afraid of following new ideas. They are not wild thinkers!

Although one might expect that Jantelagen affects mostly native Swedish inventors who were raised within that culture, it has certain effects on non-Swedish inventors as well. A woman researcher from the US compared the cultural differences in the US and Sweden as follows:

> Here [in Sweden], everyone is expected to be conformist. This is bizarre to be in the academy. In the US, you try and you may fail. But you may try again. As a child you are always encouraged to try and fail but do it again. This is research at the end, we should not be sure. We should be ready to fail but also ready to try again. Don't ever try to become a star in Sweden.

Some interviewees also commented on a general lack of interest and ignorance from their colleagues. Although serial inventors admitted that they have not faced any kind of professional jealousy or secrecy, they all complained about ignorance and indifference on the part of their colleagues or a lack of appreciation and encouragement from their colleagues. A few of them stated that when they were younger or in the early stages of their career they had felt a kind of pressure as if they were doing something wrong. An SP-inventor from the MF commented:

> I had to ask to myself if I had been doing something wrong for my career. We talk about anything – research projects, students, administration, conferences, patients – but the patents or the company. No one so far has asked me how things are going in the company. They try to avoid talking about this issue. Researchers who are not patenting are ignoring patenting – or other commercial activities of their colleagues.

Although some studies found the local norms of behaviours and attitudes towards commercialization to be important factors in shaping the propensity of scientists to engage in commercialization activities (see Louis et al. 1989; Bercovitz and Feldman 2004; Audretsch et al. 2005), the potential impacts of Jantelagen on entrepreneurship is more suppressed compared to other factors discussed in this study. Partly because of the widespread journalistic and popular portrayal of Swedish society as dominated by Jantelagen, some interviewees may have pointed out its influence on entrepreneurship. The Jantelagen hypothesis thus merits further research to find more scientific support for it than that discussed by the interviewees or as depicted in some non-scientific publications.[59]

[59] Some observers hypothesized Jantelagen as a threat to Sweden's global competitiveness by potentially discouraging innovation, entrepreneurship and achievement (Robinowitz and Carr 2001).

Critically, while Jantelagen was derived from a rural small town perspective, this law may not necessarily apply to modern urban life-setting (Gustavsson 1995)

7.5 External Factors: Institutions and Organizations

Despite the fact that a number of studies have underlined the importance of TTOs and other similar actors in the patenting activities of universities, it was shown in Chapter 6 that external factors such as TTOs and the interest and support of the university administration were relatively less important influences on researchers' patenting activities. This section provides some in-depth views of serial inventors on external factors related to institutions and organizations such as the third task, patent legislation, TTOs and increasing political interest in the commercial activities at the universities.

7.5.1 The Third Task

As discussed in Chapter 4, the third task is concerned primarily with broad interaction with the surrounding society. In this study, I have focused on whether or not the existence of the third task as a law has motivated scientists to patent. A large share of the serial inventors found that the explicit formulation of this new assignment has not affected their research or technology transfer activities in any substantial way. Many admitted that they had already been collaborating with industry on an irregular, individual basis such as through consultancy and problem solving since the developed contacts with the surrounding environment have already been established. One serial inventor from LTH commented on the weaknesses of the third task as a motivating factor as such:

> Many of us have been collaborating with industry through consultation or student supervision, conferences or congresses. But if the third task was supposed to motivate scientists who are not collaborating with industry or who are not patenting, then it should definitely be considered a qualification to have experience from enterprise when recruiting staff or promotion.

Reactions to questions about the third task are mostly positive, but a common objection is that the third task shows its lack of academic significance. Many serial inventors have implied that commercial activities or successful outcomes of commercial activities can also be considered as an academic merit, along with teaching and basic research. Today many scientists are already overburdened with several different tasks that they have to carry out. Without the promise of possibilities of potential gains, scientists who are not interested in industrial collaboration or other types of entrepreneurial activities will not be motivated to spend time on such tasks. Many of them focus on activities that may ensure academic qualifications and merits for promotion. In most cases, commercial activities are seen as a distraction from the usual path of academic development. Scientists may consider such activities to be a waste of time. However, many interviewees have revealed the potential gains of interacting with industry. All three tasks could be integrated and strengthen each other. As one SP-inventor from the NS commented:

> The possibility to collaborate with industry is always interesting. We get to learn new problems that industry has not solved yet. And then we can receive feed-back on our research from a different angle that we might not consider. Moreover, teaching also benefits from the industrial world, which attracts students' interest as well as preparing them for industrial problems.

In sum, serial inventors who have already been collaborating with industry have not found the initiation of the third task to be an important factor for increasing their patenting activities. In addition, they have commented that if the aim is to motivate and enable scientists who are not patenting currently but who want or plan to patent, then there should be more obvious financial support and academic promotion possibilities linked to the third task.

7.5.2 Patent Legislation: The Teacher's Exception

Most of the serial inventors are critical about the recent level of political interest, the too strong an emphasis on commercialization of research results, the third task, entrepreneurship, and the discussions about abolishing the teacher's exception. Many of them are aware of the recent legislative changes in Germany, Norway and Denmark. Some of them have asked, 'If it isn't broken, why fix it?' And what to fix it with?

Researchers are also concerned about the so-called pendulum shifts in the political scene and in the university administration. An SP-inventor from LTH summed up the current debate like this:

> Once it was taboo to talk about any kind of commercial interest or close relations with industry. We were supposed to be the free thinkers and free researchers. Interacting with industry was criticized. Now they are forcing us to interact, and threatening us with smaller and smaller investments in basic research. This is annoying. Soon the pendulum may shift back again towards the non-commercial era (if I may call it so). This is tiring. Of course there will be some who will shift their agendas according to the political winds. But this is not what we are expected to do as scientists.

To many inventors, the success or failure of relations with industry is not dependent on the ownership of patents but on the commitment of partners as well as the establishment of reliable relations. An SP-inventor from the NS commented on the success of their relations with industry:

> The success of this technology was due to the frictionless cooperation between several departments and industry. Not because the university owns or does not own the patent. Before the application for a patent, a huge amount of know-how was shuffled between everyone involved (e-mail, phone, extensive and detailed minutes from meetings). Many visits to Lund by company personnel and to Uppsala by the scientists improved the technology transfer. The most important issue has also been that all involved academic scientists have felt that the company really had committed itself to this collaboration and had allocated enough time to make the collaboration work. A contributing factor to the successful collaboration was certainly the genuine interest in the project shown by the company scientists and their extensive complementary knowledge in the area. Ownership of the patents was a minor issue. It is a matter for the participant firms, but it is not a matter for me and other academics to own the patent or not. But I see no strong benefits giving the ownership to university administration.

One of the SA-inventors from the MF emphasized:

> You should be willing to do more than your job descriptions. If university researchers just followed their exact employment contracts and institutional and organizational agreements, then research, inventions, creativity would soon grind to a halt.

Another SA-inventor from the MF remarked:

> It is the individuals who should decide what they can do. They can either sell the patent or they can start a company. Different people have different courage and energy for taking financial risks. There could be a scale where people with less courage could find a form where they could invest less money and time and still receive some reward and therefore find an organization which could help them.

Many serial inventors are quite critical towards the increased political focus on creating technology transfer infrastructures and investing in science parks and incubators, instead of investing in basic research at universities. The education and knowledge capacity are in danger of coming to an end because investments in science are decreasing. Until now, commercial and industrial activities have been nourished by knowledge and competence that have been accumulating for many years. In the long run, due to decreases in funding for research at universities, there will be no ideas, research results that can be turned into industrial innovations. As stated by an SP-inventor from the MF:

> Innovation is not magic! What you see today is the result of hard work and investments for over thirty years. We can get the fruits of the seeds that were planted years ago. Now politicians expect that they can increase patenting by changing the laws and opening new small university colleges that fight for the same amount of resources. With this amount of money there will be no research to be done, no patent to be applied for, and no firms. There is money to start an incubator but there is no egg to put into the incubator. So if we don't have research to patent, why do we need a TTO to patent on our behalf?

Some of the serial inventors are concerned that politicians have a tendency to equate academic patenting and entrepreneurship solely with business opportunities, increasing revenues, regional growth, job creation and so forth, and that they do not comprehend the relevance of technology transfer to the needs of research and researchers. Interestingly, this study underlines that too much political effort to institutionalize university patenting may also change the research agenda of university researchers. Thus, it is not only and necessarily industry that may steer universities away from basic science to entrepreneurial activities. Politicians and university administrations may also force scientists to do more entrepreneurial activities at the cost of less research and less teaching.[60]

Moreover, most serial inventors are aware of their academic positions and tasks. Consequently, they develop different strategies to hold a balance between their different tasks (see Section 7.3.1). They are patenting in accordance with a set of academic values and principles in a way that is sometimes not the best solution for business. This partly explains why many university spin-offs or university patents are not often the most profitable ones. For many serial inventors, patenting is driven by more or less internal and non-pecuniary motives. TTOs and university administration on the other hand are often more profit and revenue driven than the inventors.

A basic impression from the interviews with serial inventors is that the teacher's exception can be kept as it is, since it is a good way to motivate serial inventors to apply for patents and even to start their own businesses. It is the individuals who should decide if they can start a company, because one cannot take a magic wand and turn university researchers into entrepreneurs. Yet starting a company requires not only research skills but also business skills and eagerness of the researcher to start a company and other complementary skills and resources. Therefore, as discussed below and in Chapter 8, it has been suggested that there should be TTOs also to help scientists who have smaller networks and less time and money to patent their research results.

7.5.3 Roles of Technology Transfer Organizations

In relation to the discussions above on the third task and the teacher's exception, it is important to present serial inventors' views on TTOs. The results have shown that there have been several reasons why serial inventors do not want or do not need to use the services of TTOs. First, when most of them started their patenting activities, there were either no technology transfer agents or none that were competent. Most of the serial inventors therefore had to learn the patenting process and have commercialized individually or through their industrial contacts. It seems

[60] See discussion in Chapter 2 about scholars who have different views (pessimistic or optimistic) on academic entrepreneurship.

very difficult for many of them to accept the role and involvement of TTOs in their patenting activities. From the perspective of SP-inventors, it would be impractical and unnecessary for any TTO to get involved in their patenting activities, since in most cases the firms that they are collaborating with apply for the patent, and it is not likely that the firms would accept having TTOs licensing patents that have resulted from collaborative projects. Serial inventors want to take the full responsibility for patenting. If they fail, they are prepared for a failure, but they do not want to fail because of someone else's mistakes. They have difficulties trusting and relying on TTOs.

An SA-inventor from LTH who started his own company with the help of his family resources commented on the involvement of the university administration as follows:

> It is very difficult to let someone do the job on your behalf. We were naïve and believed in our ideas even if they seemed unfeasible at some points. We kept a grip on it. We did not let it go. But a TTO manager who has to make a profit could easily have given up when things were not as profitable as they wish… You work for yourself in the university. Your success is your success. If you delegate your responsibility, their failures may fall on you. No one can serve the success to you on a silver platter. Scientists should decide what to do.

Some of these serial inventors or research groups have even initiated their own TTO activities, where they can share their experiences. Some research groups thus have their own internal technology transfer agent or patent consultants who sometimes come originally from the research group itself. They act almost as one-person TTOs, and can be seen as substitutes for a broader – or general – university TTO. For instance, the MF now has its own internal industrial liaison person who is aiming to help researchers at the MF in their commercial activities. Some research groups have hired one of their former Ph.D. students as their patent and liaison agent. More organized examples of such agents are PULS and S.A.L.E. PULS is a network of twenty partners with world-class skills and experience in life sciences from industry and university. S.A.L.E was started by several serial inventors from LTH and aims to help university researchers who want to patent and start firms.

The work provided by these organizations is less formalized and the patenting activities of inventors depend mostly on contacts made on an individual basis or on their internal skills and experiences. Many serial inventors have rated their private or individual contacts as more preferable routes to patent rather than disclosing their invention to a central unit that handles patent application and licensing on behalf of the scientists.

Another important issue that serial inventors are concerned about is the abolition of the teacher's exception and the establishment of central TTOs that lack the organizational capacity and resources to handle technology transfer, patenting, licensing and spin-off company formation. Almost all of the serial inventors have admitted that an efficient TTO can be helpful, but they all have strong doubts about what can be achieved by an organization that serves all university faculties. Yet it is quite expensive to have several specific TTOs dedicated for a specific scientific discipline.

Serial inventors are sceptical about the organizational capacity of TTOs in the process of selecting inventions for a patent application. Several serial inventors questioned whether a TTO would have the competence to evaluate and asses the patentability of ideas. TTOs might be overloaded and might not respond to the needs of the scientists. In a situation like that, scientists, the university and all parties would lose. A remark made by an SA-inventor from LTH can summarize the shared views articulated by many other serial inventors:

> A centralized organization for technology transfer is important only if they have the skills and resources to handle all sorts of invention disclosures from different scientific fields on cutting-edge technologies. If government or university can afford such an organization for each scientific discipline, I am ready to abolish the law. This is an alternate source of support that we approve of. But they should not create another agent between us and the industry.

Serial inventors are also worried about that too much policy interest would steer scientists away from research and teaching towards patenting. Most of them are critical about the assumption that TTOs and laws may motivate scientists to patent. Although they do admit that TTOs can enable and facilitate scientists to patent, TTOs are not the main driving force for them to patent. Otherwise, scientists might be inclined to disclose as many inventions as possible to the TTOs and TTOs would be under pressure to apply for as many patents as possible for all invention disclosures without considering whether the patent can be commercialized or not. By the same token, some serial inventors have implied that if a change happens in the ownership of patents (i.e. abolition of the teacher's exception), scientists may avoid invention disclosures; they may bypass the TTO or disclose fewer and second-rate ideas to the TTO. An SA-inventor from the MF remarked:

> Scientists will become opportunists. If the rules and regulations force them to patent, they will patent. Since they have to put the number and titles of their patents into their CV, or when they apply for funding they have to fill in certain boxes in web-pages of Vinnova, Nutek, VR, etc., number of patents, publications, and conferences and so on. If they feel that certain boxes are empty they will be insecure and will feel the pressure to patent in order to fill in some more boxes. These patents would remain as CV-patents or mandate patents.

Many interviewees commented that if the aim is to increase university patenting through the establishment of TTOs, then TTOs should provide help only to scientists who do not have the skills, resources and experience to do so. Some serial inventors remarked that there might be many good ideas which are not patented because the scientists have neither the individual skills or desires nor the time or money. Thus, if those scientists do not want to put effort and time into patenting, they may transfer their inventions to the university (see discussion in Chapter 8).

7.6 Concluding Remarks

This chapter has focused mainly on serial inventors and the external factors surrounding them. By interviewing forty serial inventors I have explored the internal factors in depth and reflected on the impacts of external factors on the patenting activities of serial inventors. This chapter has also substantiated the typology of inventors and has complemented the findings in Chapter 6. The findings suggest that creativity and inventiveness, just like scientific performance, are highly concentrated in the minds and abilities of a relatively small number of highly talented individuals. Internal factors are very critical. But this highly talented group is not isolated from their environment. They act to tap the external factors in order to nurture their inventiveness. They are also important role models for initiating an entrepreneurial culture in their research milieux and motivating others to patent as well. Chapter 8, which follows, aims to continue the discussion started in this chapter from the perspectives, roles and experiences of occasional inventors regarding the roles of TTOs.

8. The Roles of TTOs and Occasional Inventors[61]

8.1 Introduction

As discussed in Chapter 4, Sweden has formed several types of technology transfer organizations (TTOs), located either within or outside the university. These organizations have been created to facilitate collaborative relations between university and industry and, on this basis, to promote technology transfer from universities to industrial firms. The aim of this chapter is to investigate why some university inventors have used TTOs to patent and how TTOs have assisted these inventors in their patenting activities. The results of the interviews with selected occasional inventors are used to enrich and complement the findings reported in Chapters 6 and 7.

Chapter 8 is organized as follows. Section 8.2 presents the methodology for the interviews with occasional inventors and TTOs at LU and the collection of other, complementary data. Section 8.3 briefly reflects on these occasional inventors and Section 8.4 discusses why they have used TTOs. Interviews with TTOs are also referred to in Section 8.4 in order to present their views on their relations with university researchers and their roles in university patenting. Finally, Section 8.5 presents some concluding remarks where the discussion revolves around the issue of how TTOs can motivate and enable inventors to patent. This concluding section of the chapter ends by suggesting strategies for TTOs to improve their activities.

[61] This chapter is based on Goktepe 2006c. An earlier version of this chapter was presented at the DRUID Summer Conference 2006. I would like to thank the participants for their comments. An even earlier draft was presented at my half-time Ph.D. seminar and discussed by Martin Meyer in January 2006. I am grateful for Dr. Meyer's comments as well as for Mats Benner's.

8.2 Interviews with Occasional Inventors and TTOs

I conducted interviews with twenty occasional inventors who had used TTOs in order to patent. Both active and passive occasional inventors were contacted by e-mail and later by telephone to book an interview date. Interviews were done during the autumn of 2006. The interviews were done face to face at the departments (offices, meeting rooms) of the interviewees. The interview guide (see Appendix A4) that was developed for serial inventors were utilized to some extent for the initial questions (concerning traits, motivations, roles in a research group, etc.), but the main questions were about why they had preferred to rely on the TTOs, what sort of benefits they received from the TTOs, and how and to what extent the TTOs had enabled them to patent. The interviews lasted from one to two hours. With the permission of the interviewees, the interviews were recorded and notes were also taken during the interviews.

A semi-structured interview guide was also designed for the interviews with TTOs (see Appendix A5). As with all research, this research is subject to limitations. For instance, I have covered seven TTOs out of approximately fourteen in the region. Furthermore, I was only able to present the views of the representatives of the TTOs. They may, of course, have an incentive to give a positive picture of their roles regarding technology transfer and patenting. However, interviews with occasional inventors provided an additional perspective on the roles of TTOs and whether TTOs fulfil their tasks with regard to facilitating university scientists' patenting activities from the standpoints of inventors.

The resulting discussion is based on three sets of data taken from the interviews with both serial and occasional inventors and interviews with representatives from TTOs. Data gathered in this chapter were interpreted inductively to discover important categories and dimensions related to the central topic of occasional inventors and their relations with TTOs. Qualitative data are presented in descriptions of the patenting process. For the most part, the interview data are paraphrased, but direct quotations are used to convey personal perspectives and experiences (Patton 1990).

8.3 Occasional Inventors: A Reflection on Internal Factors

Current studies of TTOs are based on the assumption that a competent TTO will motivate and enable scientists to patent, and university patenting will thus increase. However, the empirical findings have so far highlighted that there are differences among inventors in their patenting activities. Only some of the inventors have used the services of TTOs or patented through a TTO.

Chapter 6 presented a typology of inventors (see Figure 6.1). In Chapter 7, the discussion concentrated on the serial inventors (both active and passive), developing further insights based on interviews with these inventors. Their extensive patenting activities were attributed mainly to internal skills and networks. In this chapter on the other hand, profiling occasional inventors (both active and passive) and investigating why and how they have used TTOs will provide further insights not only into the patenting activities of occasional inventors but also into the roles of TTOs and other external factors in patenting by university inventors. In Chapter 6 (Table 6.5), I have presented the basic socio-demographic information regarding all four types of inventors. In what follows, I further substantiate that information according to the results of the interviews with occasional inventors.

Occasional-Active (OA) Inventors: This group consists of relatively more junior researchers compared to other types. They have normally received their Ph.D.s from LU. Most of them have been involved in patent applications together with their supervisors or with the principal investigators of the projects in which they were employed. Although the occasional-active inventors who were interviewed stated that they had been fully involved in the research processes, it was clear that they had not been entirely involved in many important aspects of the patent application process, such as finding a patent consultant, writing an application for the patent, financing the patent application costs, meeting with industrial investors and other similar tasks.

OA-inventors are mostly Ph.D. students or post-doctoral fellows at LTH. Compared to the three other types of inventors, there have been more non-Swedish researchers among the occasional-active inventors.

They have come to LU as Ph.D. students and have stayed at the university. As expressed by several occasional-active inventors, some of them lacked strong social networks with TTOs, financers or firms partly due to their junior positions and relatively lower scientific visibility and recognition. Some of them have foreign backgrounds and have relatively little information about the technology transfer organizations and legislations for university patenting.

Compared to other types of inventors, most occasional-active inventors expressed greater flexibility in terms of their career plans. They have more possibilities of changing from academic to industrial careers, or starting to work in a spin-off company. They express more entrepreneurial thinking, willingness to take leadership roles and desire for ownership and responsibility. They also claimed, to a greater extent than other types of inventors, that they are ready to take risks and tolerate ambiguity. Despite their greater possibilities of changing careers from academia to industry, and also despite the fact that most of them have acquired jobs in academic spin-off firms, they have been less actively involved than other types of inventors in the financial and legal aspects of the formation of the spin-off firms in which they are employed. They also consider that they have only average skills in identifying commercial opportunities, although they admit to having entrepreneurial thoughts and intentions. It should be noted that occasional-active inventors are quite young and have relatively less academic experience. It can be expected that some of them can continue patenting and will increase their patents and thus becoming serial inventors. However, it is also possible that some of them may not continue and may shift into research areas with no interests in patenting. For instance, a few female occasional inventors shifted into teaching activities after their doctoral studies and they do not express any interest in or see possibilities of patent.

Occasional-Passive (OP) Inventors: The fourth type in the typology of inventors is the occasional-passive inventor. Individuals belonging to this category have less than three patents. They are part of bigger research groups, and some of them have co-invented with other colleagues (mostly with serial-passive inventors). Some of them, on the other hand, have received help from TTOs in applying for patents. They are not necessarily young or junior in rank, but they have started patenting later than most of the serial inventors. Most of them are quite successful researchers with a clear academic career focus. Many mentioned that they do not conduct patent searches before they design their research agendas. They have no plans to change career from university to industry, though some of them have worked in industry, e.g. during sabbaticals.

Due to their scientific reputation and visibility, OP-inventors are recognized and respected by the TTOs and have the credibility to attract money through networks with investors. They are mainly Swedish citizens. They have less desire than other types of inventors to take ownership of, or assume responsibilities for, non-academic tasks. They consider that they have difficulties in identifying commercial opportunities, though they can definitely see the novelty of their research results. Although most of the occasional-passive inventors found patenting activity to be important, they suspected that it may cause time-losses, and did not want to be involved in the legal and administrative aspects of patenting. They thus prefer to transfer their intellectual property rights to TTOs in return for possible financial returns (like a licensing fee), visibility or connections to industry. They also prefer to disclose their ideas to TTOs that are likely to sell or license to a company rather than to TTOs that are more likely to initiate an academic spin-off company.

8.4 Technology Transfer Organizations

In this section I discuss why occasional inventors choose TTOs to apply for a patent. In many cases, occasional inventors have not been able to allocate sufficient time and money for doing patent applications. The exploration of the roles of TTOs provides further insights into the internal factors associated with occasional inventors. A lack of competence and skills to handle the patent application procedure has led most occasional inventors to use TTOs to apply for a patent. The main reasons for using TTOs were summarized by one OA-inventor from MF as follows:

> First, patent application costs lots of money. Even if you have a great idea you need a different kind of money – not only for the application costs, but from the very beginning we cannot cover the costs of patent consultants. It is far

> beyond the budget of many of us. So you need someone to pay for you. Second, if you want your patent to be used, you need investors, entrepreneurs, engineers, etc. It is beyond our competences. Third, you need the time and energy to put into this project, since it moves far beyond the university lab. And it also needs a special forum to handle all aspects from idea to protection, development, testing, production and sales… Most of us do not have time to find the industrial and financial contacts. This is why we need agents to handle technology transfer on our behalf.

Along similar lines, most occasional-passive inventors have a pure academic career focus and are not interested in things like ownership of intellectual property and responsibility for its commercialization. They do not want to spend time on the administrative and legal aspects of patenting. Instead, they are content to delegate their rights to a TTO in return for a one-third ownership of the patent or a one-third of the accruing income. Many of the occasional-passive inventors stated that they are not very much interested in the further commercialization phases of the patent either. An important motivation for them to use a TTO is to save time and not to be involved too much in the legal, financial and administrative aspects of a patent application, as stressed by one of the OP-inventors:

> Writing a patent application is difficult and it is boring. The language is completely different from when you are writing journal articles. I think it takes so much time to write a good patent application. This is why I use the TTO. It is important of course to be able to write a patent application. But it is beyond my interest and time. I was asked to read and correct if there was anything wrong with the scientific aspects, but my input was not very critical in the formulation of the claims etc.

Another reason for using a TTO is to prevent conflicts within the research group. The lack of standard mechanisms – e.g., in the identification of who is an inventor, what the fair share for each inventor should be and the question of publication versus patent application – have encouraged occasional inventors to consider using TTOs. A few of the occasional inventors gave the examples of problems with their supervisors. One OP-inventor from the NS commented on his experience and the reasons he used a TTO as follows:

> I know patenting is good and important. It definitely gives you some power vis-à-vis industrial partners and visibility to attract money. But it depends on

> who owns the patent. I had to wait to publish the research results since my supervisor was planning to apply for a patent. I lost some time – maybe not so much, but I did lose some time, I suppose. But I was not in a position to oppose either. If there had been a standard system and time allowance it would have been fairer, given the fact that now I am not using that patent anyway. This is why in my second experience I have preferred to use the TTO when I had the possibility of choosing to use the TTO path.

On the other hand, it should be noted that although the inventors may expect that TTOs can resolve or prevent such potential conflicts of interest among the co-inventors or within the research group, most TTOs do not intervene in the so-called internal relations within the research group. One TTO representative explained their policy as follows:

> We are not involved in identification of who is an inventor and who is not. When a university scientist(s) come(s), we assume that he or she is the inventor-to-be. We cannot go into their labs and interrogate who has done what. We don't have time for such issues. Or we cannot help them about when and how to publish. We assume those problems should be handled internally before it reaches our table.

Furthermore, the interviews revealed that some occasional inventors had chosen to patent with TTOs in order to distance themselves from commercialization. Although occasional inventors have patented, some of them still have thoughts that going into business to commercialize these patents might not be compatible with their academic tasks, or that it might create tensions within the research milieu. While a few role models have institutionalized the culture of patenting in their departments, in some departments traditional academic values or expectations regarding an academic position have put implicit pressures on scientists. Therefore, not only their own values and beliefs but also those of colleagues and seniors may be decisive for scientists' decisions about whether or not to patent, or how to patent, as stressed by an OP-inventor from LTH:

> The society and university colleagues are not ready for this change yet. I don't want to call any attention to myself and to my research. Many people assume that we will be very rich and that we are demoralizing university research. In Sweden, you are not expected to become rich or stick out. By delegating the patent rights to a TTO, I believe I got rid of the attention and the criticism. It becomes more legitimate than doing it individually, which can be easily interpreted as personal enrichment.

Further reasons why some inventors used the TTOs were strongly related to the loss or lack of an industrial partner to apply for the patent with. Most university researchers and firms have had individual contacts and informal networks. Some of them have lost their networks because contacts in the firms or the firms themselves are no longer interested in their research field. This trend was exemplified by an OP-inventor from MF:

> We used to collaborate with Pharmacia, Kabi AB, or Astra. We did not need to patent anything. These firms were using our research results with great interest anyway. Now it is impossible for us to reach those contacts. Most of the common projects were closed down. You cannot just knock on the doors of big companies and present your publications. No one will buy it, or you will not be able to reach anyone. So now we need someone to apply for patents.

Another reason related to the discussion above is the inventors' lack of trust and confidence in firms. Inventors who do not have personal, high-trust contacts with firms have problems with the utilization of their inventions. This is one of the reasons that made inventors choose the TTO route. As described by an OP-inventor from MF:

> We identified that the idea could lead to an interesting diagnostic test. It was not very novel, but it could have done the existing diagnostic tests in a cheaper and more efficient way if it had been developed. It could be produced ten times cheaper than the existing market prices. We contacted several companies manufacturing similar products. A German company seemed to be the most interested. We applied for a patent ourselves with the Swedish Bureau [PRV], the company kept waiting. I was very disappointed. We believed our cheaper method could be used for third-world countries… I became suspicious; I am not sure but that German company was selling an American company's product in Europe with another name. We felt that we were cheated. They kept us busy, asked us to do further tests, experiments, coming up with questions we never understood. We should have dropped them, but we assumed that they were picky [thorough] Germans. And we could not utilize the patent and lost money, time and beliefs. In the second case, this is why we went directly to a TTO in the region to get help and advice.

Finally, different cultural experiences and educational backgrounds may also influence the patenting activities of researchers. The interviews highlighted that scientists who were educated or had worked in US universities had become accustomed to a process where scientists would disclose their inventions to the TTOs, which would evaluate the inventions and then, given a positive evaluation, apply for patents and cover the costs of patenting. During the interviews, five inventors who had some kind of experience or knowledge of the US system explained in detail the patenting, licensing and spin-off formation model in US universities. They seemed quite convinced that technology transfer in Sweden should be done the way it is in the US.

The main reasons occasional inventors had used TTOs can be summarized as follows:

- Lack of time and interest in the further commercial stages after patenting,
- Lack of necessary social networks with industrial and financial actors,
- Lack of credibility and financial means to apply for a patent,
- Lack of reliable contacts and networks with industrial partners,
- Experience and influence from the patenting procedure at US universities.

8.4.1 Roles of TTOs

Apart from other external factors that have been mentioned in Chapter 2, there are theoretical and empirical reasons for investigating TTOs further. First, even though TTOs have been some of the most discussed external factors for university patenting in the existing literature, the findings of research on the roles of TTOs in this process are not conclusive, since most studies are limited mainly to US or UK cases. Second, as mentioned already, even though Sweden has kept the teacher's exception, TTOs have also been established within the country's universities or university regions. This institutional and organizational set-up provides different paths for scientists to patent, either through TTOs, or individually – with or without the collaboration of an existing firm. It is important, therefore, to discuss further the specific factors behind the choice of using TTOs to apply for patents. The third reason, which is also related to the second one, is that data collected for this thesis show that TTOs have not been used frequently by inventors at LU. This observation too demands a further investigation of the role of TTOs. For instance, in the LUP database, 36 patents out of 458 patents (less than 10 per cent of patents) have been applied for by TTOs (Chapter 5). Out of the 75 inventors who responded to the survey, 24 have utilized some kind of services and help offered from TTOs (see Chapters 6 and 7). TTOs seemed to be important for some inventors or at least used by some inventors, and it would therefore be interesting to investigate further why some inventors have used TTOs to patent.

The university patenting system in Sweden is composed of several kinds of actors and organizations. The individual ownership for intellectual property at universities and the simultaneous existence of diverse TTOs make it possible to transfer technology through different mechanisms and through different agents. For instance, there are TTOs (e.g. Teknoseed, Lumitec, etc.), which focus mainly on venture creation. Such TTOs may focus on the inventors and assess the commitment and capability of the inventors (researchers) to initiate the business and realize the possibilities of new business areas. On the other hand, there are TTOs (e.g. Forskarpatent) which mainly patent and then license or sell the patent to an existing firm. Such TTOs may focus on the possible users and potential licensors of that invention rather than on the scientists. However, almost all the TTOs that were interviewed consider scientists and even inventors to be a homogenous group. The TTOs are providing similar or even overlapping services without taking into account the special needs, expectations and skills of scientists.

In what follows, I discuss how TTOs find and motivate inventors to patent. The analysis is based on three basic stages which have been derived inductively from the interviews with the selected TTOs. These three stages are (i) establishing contact with scientists, (ii) finding and mining research results and (iii) identifying the patentability of research results.

i) Establishing contact with scientists is the first step that TTOs need to take. Due to its closer relationship to the scientists as well as to the university administration, LU Innovation is a university TTO relatively well suited to establishing initial contact with the scientists. LU Innovation provides seminars and presentations to inform scientists about its activities and the various possibilities for, or different means of, technology transfer.[62]

This initial stage shapes most of the potential further successes of the TTOs in general. Most TTO managers found the first stage difficult. They commented that working with scientists is much more complicated than working with industrial firms. This is because firms are more aware of the terms of doing business, while inventors or scientists in general can be quite stubborn and do not want to change their mind-set in order to understand the expectations of industrial partners or TTOs. Furthermore, inventors can be very demanding and may have very high regard for their research results but may still not be aware of the potential uses of these results. At this point, the primary role of the TTOs is to establish and identify the potential economic implications of the research results and help the scientists to pinpoint the commercial uses of their results.

ii) Finding and mining research results is the second stage. As in the initial contacts it makes with researchers, LU Innovation aims to find possible research results that might be patentable. However, lack of resources was mentioned as an important problem for the identification of potential ideas. The better the research results a TTO receives from scientists, the more patents it will generate, and more licensing revenues will ultimately accrue and/or more spin-off firms will be initiated. One of the main decisive issues is the fact that industry may be taking the most outstanding research results and the TTOs may be left with the more complicated cases. Some types of knowledge can easily cross from universities to firms or can be commercialized in other ways, but some other types of knowledge – having to do with emerging technologies, for instance, or researchers without any industrial contacts – may need the guidance and assistance of a TTO. One TTO manager commented as follows:

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[62] During 2004 LU Innovation made approximately two hundred visits to scientists in different faculties at LU. It concluded that most of the research activities that might lead to a patent or to the development of a new product have been carried out by the MF (50%), LTH (40%) and NS (10%), (based on interview with staff of LU Innovation). It should be noted that the LUP database shows that most patents emerged from LTH rather than MF and NS (Chapter 5).

> We see a big potential for commercialization of research results at Lund University. However, because of limited means to support our activities and a lack of early-phase investments, many ideas cannot be identified and utilized. We have the ambition to employ more staff full-time to work with finding new research results and to support scientists with company formation. But we don't have the financial means today. Further financial support for technology transfer agents to identify the research results and to commercialize them will yield great opportunities for society.

iii) Identifying the patentability of research results is the final stage.[63] The organizational capacity of the TTO (e.g. the scientific knowledge and background of the TTO managers and staff) and the availability of patent engineers are very important in assessing whether to patent or not to patent. One TTO manager explained the process as follows:

> We ask the inventor several questions. It is almost like an interrogation of the scientists about their research results. The most common questions that we ask the scientists are: What is good about this research? Have they done any patent search, are they aware of other patents in the same field? Do they know which company may be interested in licensing the patent? Do they have any contacts with any potential company to license? Do they know who the possible customer/market is? Is the market long-lasting…? Is the invention a big issue with a big market or industrial interest and need?

The TTO managers also try to answer some of the last of these questions by helping and guiding the researchers, or they do the market search themselves and inform the researchers about the possibility of patenting and licensing. The commercial value of the research results is enhanced through a dialogue between the TTO staff and the scientists. As another TTO manager explained:

> We don't question the core of the research results, but we guide the inventors to make improvements of the invention for a better patent application.

[63] Even though the activities of technology transfer organizations are not limited to patenting, within the scope of this study, I will not discuss the further stages of technology transfer and thus the activities of TTOs.

After the identification of research results through these three consecutive sub-phases, TTOs further evaluate the research results, addressing the dimensions of technology, market and business.

8.4.2 Problems

The interviews with inventors (both serial and occasional) revealed that TTOs are not providing services and help in accordance with the needs of different types of inventors. Several inventors made critical remarks that most TTOs are actually trying only to contact and support the activities of the serial inventors. Most of them suggested that TTOs should instead find, identify and focus on university researchers who do not have the skills and networks to patent to the same extent as serial inventors. A similar concern was articulated by the occasional inventors, who actually found it difficult to get in touch with the right TTO and to convince it about the potential of their ideas. An OP-inventor from LTH made the following comment on the difficulties of getting access to the TTOs' services:

> In most cases it is difficult for TTOs to understand and believe in our ideas. They somehow focus very much on the well-known scientists. It is therefore necessary for many of us either to patent, commercialize with well-known scientists or wait for a TTO to decide.

Another OP-inventor from LTH remarked:

> It is almost impossible to work with this current system [referring to the fragmented structure of the TTOs]. The technology transfer system is quite confusing, especially when you haven't done it before. You don't understand who is doing what. I am a researcher; I don't want to spend time on figuring out which office is the most suitable and helpful. There is no clearly defined office. That is very confusing and misleading. The aim is to not lose time, but we are losing time understanding which agent is doing what.

On the other hand, an OP-inventor from MF described their difficulties in finding the right agent:

> We realized that we had got something interesting. We decided that we should get in touch with a pharmaceutical company. But we did not know which company and how to find it. We decided that we should contact the university and looked for someone to help us. We checked the university catalogue to

> find a relevant agent. It was so difficult to figure out who was responsible – the industrial liaison [näringslivsenheten], the legal division [juridiska enheten], or someone else. We finally got to find help outside the university administration. So if they are going to take away the 'teacher's exception', they should inform everyone clearly who is doing what, [but] we should not be prevented from contacting other external agents.

A problematic aspect of the set-up for university patenting is the existence of multiple TTOs with some overlapping as well as some different tasks.[64] Each TTO may consider utilizing research results according to its business area and competence, and this may lead to frictions or even competition and secrecy among the different TTOs. TTOs that have received the research results first or that have found researchers with commercially viable ideas may decline to pass such information on to another, more relevant (or competent) TTO for that invention. Since each TTO want to increase their own activities, there has been a kind of conflict and competition between the TTOs.

TTOs with a stronger orientation towards venture creation may neglect the possibilities of licensing and may thereby waste time and resources. For instance, in the case of licensing and spin-off company formation, Forskarpatent may evaluate and assess the invention disclosures (research results) from the perspective of patent application and eventual licensing, whereas another TTO (e.g. Teknoseed or Lumitec) may aim to initiate a spin-off company rather than licensing to an existing company. One TTO manager criticized the current system and the lack of interaction among the TTOs as follows:

> If you have a hammer, everything seems like a nail. Each small agent wants to interpret the problem from its own company mission and competence. Each agent is generally trying to utilize the inventor's idea not according to inventors' plans and expectations or according to the nature of the research results; but according to the possibilities within their [own] organization. While some TTOs may argue that university spin-offs are the most popular way of initiating business and generating income for the university, another TTO may opt for licensing. Each TTO will have the tendency to customize

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[64] Such a problem has been also observed among the scientists at Chalmers University of Technology (Jacob et al. 2003)

> the inventor and the research results according to its company's business area and competences, but not according to the needs of the inventor or the idea.

On the other hand, he also argued:

> The multiplicity of TTOs provides researchers with multiple channels or contact organizations to commercialize their research results instead of being forced to choose one option.

Another TTO manager reacted to these critical views on the multiplicity of TTOs. He underlined that even if the current system for university patenting and entrepreneurship seems to be fragmented; his organization is trying to act as an umbrella while providing multiple options and paths towards commercialization. He exemplified the importance of a multiplicity of agents as follows:

> University scientists are so lethargic and expect everything to be served on a silver platter. Technology transfer is not an easy process. They are not aware of that. Once they have got their research results, they believe they invented the wheel. That is not the case in most instances. They don't want to hear any criticism. They take their research results as their babies. And we are not allowed to say 'your baby is ugly, no one needs it'. When the idea is not worth patenting or worth commercializing, they can try their chances with another agent here or at the university. They do not appreciate this.

The individual ownership of IPR (the teacher's exception) and the existence of multiple TTOs in the university region have different implications for scientists' patenting activities. The current system provides the inventors with multiple channels and multiple technology transfer organizations. Thus, while some inventors stated that they had received some sort of financial or legal assistance from 'third agents' such as TTOs, some did not use TTOs. This nuanced heterogeneity among inventors suggests that a customized approach would likely be successful. Universities should aim to integrate and utilize all of these different types rather than marginalizing any of them. On the other hand, the multiplicity (or fragmented structure) of TTOs is not interpreted in the same way by inventors and TTO representatives. In general, one may argue that while multiplicity or fragmentation is perceived by some actors as problematic and even unnecessary, particularly given the small sizes of each actor, it is a logical outcome of the spontaneous way in which the system developed in its earlier stages (cf. Jacob et al. 2003), and it also offers the possibility of different routes of commercialization.

8.5 Concluding Remarks

Several different kinds of technology transfer organizations have been established in Sweden since the mid 1990s, parallel to the initiation of the third task. The aims of such organizations are to motivate and assist scientists with patenting, licensing and forming spin-offs and thereby to increase the commercialization of university research results. However, their level of activity in patenting, licensing and spin-off company formation is still fairly low compared to similar organizations in the US, due to the fact that these organizations are relatively new additions to the Swedish university system. The investigation of the roles of TTOs provides a detailed account of their impact as *external factors* in university patenting.

In the light of the discussions of TTOs in Chapters 2 and 4, Chapter 8 has shown empirically that the activities of TTOs are dependent not only on their capacity and resources but also on the type of inventor they deal with. In particular, what a TTO can do, and the extent to which it can help inventors depends on the individual skills, needs and expectations of the inventors. In line with the typology of inventors, there are similarities but also differences in the patenting activities of inventors.

For these reasons, the main objective of TTOs should not be simply the commercialization of university research results, either through licensing to existing firms or through the formation of spin-offs. The strategies of TTOs should focus rather on customizing their activities according to the needs and expectations of the inventors. TTOs can actually develop custom-made functions by specializing in certain aspects of university patenting. From a more general point of view, there could be advantages to having a centralized TTO, albeit with different sub-units that could guide different types of inventors, and other researchers as well, in different directions, according to the nature of the researcher and the research results. Further, scientists should be informed about the roles and tasks of these different sub-units.

9. Analysis and Conclusion

Chapter 9 builds on the theoretical and empirical material presented in Chapters 2 to 8 to summarize and explain important features of the extent and patterns of patenting by researchers at Lund University (LU). The discussion in this chapter also develops an explanatory account of the patenting activities of these researchers by referring to a variety of important factors identified in previous chapters.

Chapter 9 is organized as follows. After a brief overview of the study in Section 9.1, Section 9.2 analyses and discusses the empirical findings in relation to the framework outlined in Chapter 2 as well as in the light of the research questions of this thesis. Sections 9.3 and 9.4 draw the implications of this study for theory and policy, respectively. Section 9.5 summarizes the main conclusions of this dissertation.

9.1 An Overview of the Study

The literature review in Chapter 2 argued that most studies of university patenting have focused on institutions and organizations, e.g. the Bayh-Dole Act and TTOs, to explain the university patenting phenomenon. Except for a few recent studies on academic inventors, existing studies have not studied individual inventors as the main unit of analysis. This study has taken a different approach. Instead of focusing on universities or TTOs per se, the university inventors are studied as the main unit of analysis, together with a discussion of external factors.

In Chapter 2, I also sought to integrate a number of factors that have been proposed up to this time to explain university patenting. Although I classified these factors into two groups, internal and external, my aim in Table 2.1 was to recognize and identify different factors that are relevant for university researchers' patenting activities.

LU-inventors were identified, then surveyed and interviewed in relation to the factors that had influenced their decisions to patent. The results show that the reasons behind university patenting are not simply based on institutions and organizations. Nor is it enough to regard individual scientists' skills and motivations as the main driving forces behind university patenting. Nevertheless, the results of the survey and in-depth interviews with inventors as well as with TTOs demonstrate that the character of inventors is important to investigate in order to arrive at a more accurate and meaningful account of the factors behind university patenting and to capture the differences among them. This study has generated a typology of inventors.

In developing the typology of inventors, I argued that there were different types of inventors that differ to some extent with regard to their decisions to patent. Some inventors were influenced by institutions and organizations, while some inventors patented based on their experience or through their social networks. It can be assumed that inventors' views on the roles of for example TTOs, patent legislation and the third task of universities differed from what might be expected by the policy-makers. While some policy-makers and even scholars have proposed a positive relation between the organizational ownership of patents by universities and an increase in the number of university patents, I found that the aforementioned institutions and organizations do not automatically encourage university researchers to patent. The typology of inventors also indicates the need for caution in making generalizations about the roles and influences of patent legislation and TTOs in university patenting.

The patenting activities of university researchers depend on a set of diverse factors that trigger researchers patenting activities. In some cases, serial inventors act as role models in establishing and spreading the culture of patenting and other entrepreneurial activities in their research milieux. In such cases, local group norms and culture, training effects and leadership effects are more influential than institutions and organizations in the patenting activities of scientists. In some other cases, researchers' patenting activities are influenced by active collaborative relations with industrial firms, access to industrial funds and equipment and the existence of industrial problems that require solutions.

In addition to heterogeneity among inventors, there is also the issue of contextual heterogeneity. The findings of this study caution that emulating any kind of standard model that may seem to work, or even approximating 'best practice', in other contexts may not necessarily yield the same outcomes and be beneficial. Instead, policy-makers in different jurisdictions should try to establish competent organizations and efficient institutional set-ups that are adapted to particular – national, regional, or even local – contexts and that can be further customized to accommodate both the needs of the scientists and the nature of the technology.

Adaptive and flexible institutions and organizations may enable scientists to patent by providing them with the necessary resources and skills they may need for patenting, whereas simply applying standard solutions to different contexts may militate against such positive outcomes, as experienced in Denmark recently (Valentin and Jensen 2006) and implied by several serial inventors who were sceptical about the effectiveness of possible similar changes in Sweden. Emulation of standard models (in this case university ownership of patents) and related institutional and organizational changes may not be of any use for scientists' patenting activities or intentions.

The heterogeneity of both inventors and contexts highlights the importance of various types of technology transfer as well, like industrial collaboration, labour mobility, publications and conferences. This heterogeneous approach also helps to capture how variations in the mode of commercialization in university patenting may be linked to the nature of the technology and scientific discipline. For instance, while several serial-passive inventors underlined the importance of existing links with industrial firms, many serial-active inventors had the opportunity to apply for and utilize their research results in new ventures.

The theoretical insights, the typology of inventors and the empirical findings presented in this thesis point to the importance of studying university-industry relations from the scientists' perspectives in addition to the external factors. An approach of this kind enables us to understand how university patenting is affected by the interplay between a diverse set of institutions and organizations for university industry technology transfer (UITT) on the one hand, and by the differing motivations and skills of researchers, as well as by their scientific fields, on the other. This study may also provide insights to policy-makers and university administrators concerning the appropriate roles of institutions, organizations and research milieux in promoting and assisting university researchers' patenting activities.

9.2 Analysis and Discussion

9.2.1 University Patenting

I have investigated the extent and patterns of university patenting at Lund University (LU) Sweden and I have also sought to explain my findings on these questions by inquiring into the main factors influencing university researchers' patenting activity. Although the scope of the empirical work is limited to inventors at LU and the technology transfer infrastructure surrounding LU, it may still be possible for other researchers to derive some insights that might contribute to the studies on UITT and also guide further empirical research in this area. In what follows, I summarize the main findings of each empirical chapter in the light of the research questions.

Chapter 5 investigated the first research question. In this study, a total of 458 patents with 250 university researchers as inventors were identified at LU during the period from September 1990 to September 2004. I found that the number of university-invented patents was far greater than the number of university-owned patents: out of a total of 458 university-invented patents only 36 patents were university-owned. This result can be explained partly by the individual ownership of patents in Sweden and partly by the fact that TTOs are relatively new actors in university patenting in Sweden.

The findings reported in Chapter 5 also showed patenting activity at LU to be concentrated in terms of both inventors and faculties. Inventors who have had at least three patents were termed serial inventors. They account for 60 out of 250 inventors (or 24 percent of the inventors) and for more than half (56 per cent) of the LU-patents. The study also showed that some departments (i.e. electronics, telecommunications, physics, mathematics, chemistry, biotechnology, clinical sciences) account for the greatest number of LU-patents. Patenting patterns were additionally mapped in terms of distribution by type of applicant, firm size, sector location and main applicant firms. Mostly, LU-patent applicants are large firms (e.g. Ericsson or Astra-Zeneca). Local networks with firms in the Ideon Science Park or in the Skåne region are important, although some LU-patents have also been applied for by firms based outside the region.

Most of the university-invented patents were applied for and most likely utilized by existing firms (e.g. Ericsson, AstraZeneca, Gambro), yet there are also several SMEs, some of which are spin-off firms that applied for LU-patents. Only a few foreign firms have been LU-patent applicants.

The findings of this study confirmed the reliability of the methodological choices of previous studies of university-invented patents in other European countries (e.g Meyer et al. 2005; Iversen et al. 2007; Lissoni et al. 2007). Consistent with these studies, the empirical research carried out for this dissertation has also demonstrated that in countries where individual ownership is the common practice, the share of contributions to technological development as measured by patenting can best be determined by tracking university patents by the names of university inventors, rather than by searching for the names of universities or TTOs.

After the identification of the inventors and patents (as shown in the LUP database), I have aimed to identify the main factors that influence the patenting activities of the inventors through a survey of inventors and in-depth interviews with inventors. I will analyse and discuss the factors influencing university patenting and differences among inventors in the light of the framework that was presented in Chapter 2. In addition, a number of related themes are addressed, including researchers' networks, the roles played by TTOs, ownership of patents and the third task.

9.2.2 Factors behind University Researchers' Patenting Activities

The reader will recall that Chapter 2 presented a list of factors (a framework) that may explain university researchers' patenting activities. Based on this framework Chapter 6 reported the results of a survey of inventors. As shown in Table 2.1 (Chapter 2), I classified these factors into two groups. The first group comprised *internal factors*. Among different internal factors, this study showed that to a very large extent university researchers are motivated by, and find rewards in, traditional academic values. Solving the research puzzle, demonstrating the quality and novelty of the research, and enhancing professional reputation are the main internal factors that trigger researchers to patent. Although external factors such as TTOs and the third task are relatively more important for some inventors, the importance of internal factors in triggering the patenting activities of scientists can not be neglected. On the other hand, the roles of TTOs can be interpreted as factors that enable scientists who do not have necessary financial means or industrial networks to patent, as these inventors have received some help from TTOs.

Researchers' patenting activities are closely related to their other professional activities within the university. Consistent with previous research findings, solving research problems, gaining recognition and reputation, economic rewards, personal satisfaction, and doing something professionally enjoyable were important factors leading scientists to become involved in commercialization. On the other hand, even though patents may generate some financial benefits (such as equity shares or royalty fees), increasing personal income is not found to be an important factor in motivating scientists to patent. They rather leverage their patents to generate research funds and materials from industry or to facilitate their collaboration with industry. As discussed below, however, other economic incentives, such as job security and having alternative career options, are found to be important for some types of inventors.

The results of this study on the socio-demographic features of inventors are similar to the results of the previous studies. Inventors are mostly middle aged men. Some of them have technical and commercial knowledge and experience from both the academic and the industrial sectors. Most of them have also high scientific visibility (e.g. most senior serial inventors). Women patent less than men, although the effect would be smaller when the number of female relative to male researchers is considered. Consistent with Meyer's (2005) findings, even though some inventors have initiated their own spin-off firms, their doing so does not necessarily indicate that they have a growth motive or a desire to leave academic research. Younger scientists, however, often become involved in patenting for the sake of creating alternative job options or changing their career paths from academy to industry, while senior inventors may rather seek to establish spin-off firms in order to continue doing research even after retiring from their university positions. There are more specific traits – such as the image of scientists, networks and industrial contacts – that enable scientists to patent. Such factors may also influence inventors' levels of patenting over time. As discussed below, such internal factors are important counterweights to external factors such as TTOs, university culture, strategy and government policies.

The second group of factors, in the framework suggested in Chapter 2, comprised *external factors*. Among different types of external factors as discussed below, I found that an important factor which motivates inventors to patent is to complement their own academic research by securing funds for graduate students or access to lab equipment, and by seeking insights into their own research from industrial firms, rather than to acquire purely financial gains and personal income (Stephan and Levin 1992; Owen-Smith and Powell 2001; Mallon and Korn 2004).

The results of this research showed that local norms, behaviours, societal expectations, group norms and culture, training effects and leadership effects for the patenting activities of scientists. It also confirmed that those individuals who were trained at departments where chairpersons, supervisors or colleagues were engaged in patenting are more likely to patent. This study therefore emphasizes the importance of role models as a trigger for academics to patent. Researchers are very much influenced by decisions made within the research group. In particular, I found that social imprinting and research group norms are more influential in researchers' decisions to patent than are factors such as the university strategy and culture, and government policies regarding e.g. the third task of universities (Louis et al. 1989; Bercovitz and Feldman 2004; Audretsch et al. 2005).

The results of this study are consistent with the previous studies that have underlined the importance of scientific fields as factors that may trigger scientists to patent (Mowery et al. 2004; Geuna and Nesta 2006). I found that researchers in scientific and technological fields, such as biotechnology, nanotechnology, ICT are closer to industrial applications and they are more willing and motivated to patent in order to establish their emerging fields or ideas. Scientists also find it important to patent in such fields in order to attract industrial and public resources (in e.g. nanotechnology and stem cells).

Regarding institutions and organizations, some occasional inventors considered the possibility of utilizing TTOs and university initiatives to be a relevant factor in their decisions about patenting. At the same time, other findings indicated that inventors in general are not necessarily motivated to patent because of the existence of patent laws and technology transfer organizations. Rather, the decision to patent is usually made for other reasons. Once this decision is made, though, inventors' patenting activities have been facilitated in some cases by external factors such as TTOs.

Another external factor is the third task. This Swedish law can be regarded as an effort to initiate a concerted long-term policy effort to reform universities by imbuing them with a culture of entrepreneurship or enterprise. However, this study has not found any strong evidence that the third task actually encourages scientists to adopt technology transfer mechanisms that are more specifically oriented towards commercialization.

The findings of this study have indicated that culture and attitude at the departmental or research group level are relatively more important external factors than university structure and strategy in instilling a culture of entrepreneurship among university researchers.

The high cost of patenting, the expenditure of time and the difficulties of the application and commercialization process constitute thresholds which may discourage some potential inventors. Moreover, most patenting decisions have been made individually or within the research group (e.g. through the initiatives of project leaders or principal investigators), and the procedure of individualized decision-making may sometimes generate conflicts of interest, particularly among co-inventors (juniors versus seniors) or with research group members who were not included as inventors (inventors versus research contributors), or between researchers and industrial partners, investors and even third agents. Therefore, the resolution of conflicts of interest among different stakeholders is also important for the achievement of individual commitments and motivations to engage in patenting activities.

Patent application depends on identification of the possibility to patent, access to financial resources, the availability of time to pursue patenting, and so forth. Problems that academic inventors face in patent application include limited financial resources, lack of experience in patenting, disapproval from the department head or other colleagues and also, to some extent, poor performance by TTOs. In general, the survey findings suggest that, given the barriers that must be overcome, the involvement of university researchers in patenting activities is a highly voluntary kind of activity, requiring strong personal commitment.

9.2.3 Typology of Inventors

The typology of inventors proposed in this study builds upon the conclusions and insights of previous studies in order to comprehend the motivations and roles of researchers in further detail by taking into account two dimensions, i.e. both the mode of utilization of the patent and the level of patenting. Adopting these distinctions from the literature and applying them to my research findings, I have argued that even if inventors belong to the general category of university researchers or to even more specific groups within that category, they will differ both in their modes of utilizing patents and in their levels of patenting activity. I have accordingly proposed a typology of inventors: *serial-active inventors, serial-passive inventors, occasional-active inventors and occasional-passive inventors*.

Similar to Meyer (2003b) and Etzkowitz (2001), I have pointed to different modes of commercialization as a key distinction in my typology. Using the typology, I have also profiled different types of inventors who are involved in different modes of commercialization. Similar to Gulbrandsen's (2005) classification, I have provided information on the socio-demographic characteristics and backgrounds of the inventors. Meyer (2005) has underlined the importance of further exploring inventors' and other stakeholders' perception of support measures and motivations for entrepreneurial activity. In line with Meyer's (2005) suggestion, this research investigated the views and experiences of the different types of inventors regarding technology transfer support structures. Furthermore, I define the four different types of inventors in depth, and for each of them I investigate what factors are influential in their decisions to patent. In addition, I have investigated the relations among different types of inventors and the impact of research milieux on their patenting activities.

The framework that shows the internal and external factors in turn provides a basis for assessing the relative importance of different factors – which, as discussed in the preceding section, can vary among different types of inventors. This analytical framework was subsequently applied to the empirical data collected for this study, resulting in the empirical findings discussed in the foregoing section and displayed in Table 9.1.

In Table 9.1 I have positioned different types of inventors according to what they found to be important and influential factors for them to patent. In relation to the typology of inventors, this study argues that the impacts of internal and external factors are likely dependent on the type of inventor. In particular, what TTOs can do, and the extent to which they can help the inventors depends on the individual skills, needs and expectations of the inventors with regard to patenting (see the discussion below, in the following sections). Based on the survey of inventors and interviews with inventors, in Table 9.1 I try to summarize that there are similarities but also differences in the patenting activities of inventors.

I aim to construct and anticipate that certain external or internal factors will be more critical for motivating or enabling particular types of inventors. All types of inventors are triggered to patent mainly by the pleasure of solving research problems, doing something professionally satisfying and enjoyable, gaining recognition and reputation, and gaining economic rewards to complement or to increase their research funds. Scientific discipline and the industrial relevance of the research fields of scientists are factors common to all types of inventors.

Financial gains, job security or changing career paths are more important factors for occasional-active inventors. Scientific human capital, industrial experience, image reputation and social networks enable serial inventors to patent – in significant contrast to occasional inventors who have not yet established their academic careers or social networks with industrial partners. Due to their closer relations with industrial partners, serial-passive inventors consider getting access to industrial funding and resources to be particularly important factors motivating them to patent.

Compared to other types of inventors, occasional-passive inventors found the external factors (TTOs, patent legislation, the third task and university strategy and policy) to be important factors motivating them to patent. Occasional-active inventors found the attitudes of the research group and principal investigators towards patenting to be more significant factors motivating them to patent.

Table 9.1 Classification of Factors behind University Patenting, with Inventor Type

Internal Factors		*External Factors*	
Solving the research question ***All inventors***	Characteristics ***SA and SP***	Scientific discipline & industrial relevance ***All inventors***	University strategy & policy ***OP***
Social and personal rewards ***All inventors***	Scientists' career life cycle ***SA and SP***	Research funds & getting access to external funds ***Serial Inventors***	Patent legislation ***OP***
Financial Benefits/Reward ***OA***	Scientific human capital ***SA and SP***	Social imprinting & role models ***OP***	TTOs ***OP***
Job security & alternative career paths ***OA***	Social capital & networks ***SA and SP***	Location, society & culture ***SA***	Policy interest (Third task) ***OP***

Most of the serial inventors are not in need of the help and services of TTOs. Serial-active inventors have already developed their skills and competence when it comes to patenting, even with regard to firm formation. Serial-passive inventors, who have either been involved in university-industry collaboration platforms or else have industrial networks, will not need the TTOs either; the patents coming out of such relations will belong to the industrial partners.

The main objective of TTOs, then, should not be only the commercialization of university research results through licensing to existing firms or forming spin-offs. TTOs should focus rather on customizing their functions according to the needs and expectations of the inventors. TTOs can actually develop custom-made functions by specializing in certain aspects of university patenting or UITT.

Building upon the typology of inventors, I profiled the serial inventors in order to develop a more fine-grained and nuanced account of distinguishing characteristics of inventors that were broadly sketched in the typology of inventors. I mainly identified the roles and traits of serial inventors and their relations within their research groups. The discussion showed that academic researchers do not research, invent and innovate in isolation. However, everyone in the research group does not perform the same tasks. Inventors may contribute to patenting activities at different levels, and each researcher involved might have different but complementary tasks during the patenting process.

The study also underlined that serial inventors are important role models in their research milieux, especially for junior scientists and non-patenting scientists. Because they can combine patenting (commercial activities) with publishing (good research), serial inventors have played crucial roles in establishing a culture of patenting within their academic departments and research groups. These findings indicate that serial inventors and social imprinting are factors that have more influence on scientists' decisions to patent than e.g. patent legislation, TTOs or the third task. Serial inventors preferred their individual networks with industrial partners and patent engineers and firms to any services they could possibly get from the TTOs.

Moreover, for inventors of this type, subsequent acquisition of experience and learning breeds further patenting activities. Eventually, they become skilled enough to be self-sufficient in patenting and they do not necessarily need TTOs. Over the years, they become role models and transmit their patenting customs and skills to younger scholars. Serial inventors have also developed various strategies for balancing their different tasks.

Classifying inventors by means of a typology is useful for understanding different individuals' roles, motivations and needs in patenting activities. Results from the survey of inventors and the interviews indicate some variation among types of inventors in the factors that influence researchers' patenting activity. These initial analyses pointed to a need for further study on how and to what extent inter-individual differences influence the role of different factors in influencing patenting activities. These findings imply that it is necessary to provide different kinds of services and assistance or support according to the needs of inventors.

9.2.4 Reflections on TTOs

In this study, I have investigated both the TTOs and their relations to different types of inventors. The role of a TTO may differ depending on the type of inventor, as explained above. In addition, and more generally, TTOs do not appear to play a prominent role in UITT activities in Sweden. In my research, I found that 11 different TTOs had applied for a total of 36 patents belonging to the LUP database, which contained 458 patents in all. The small share of university patents applied for by the TTOs may be due partly to the teacher's exception, which allows university researchers to retain full intellectual property rights to their research results, and also partly to the relatively short history of these organizations. Further, as indicated by the interviews with occasional inventors, the roles of TTOs are not clearly understood by the inventors. Even inventors who have used the TTOs found it difficult and time-consuming to sort out which TTOs was doing what.

Even though external factors are generally important for patenting activities by occasional inventors, not every inventor may need the same type of help – if any – from the TTOs. When most serial inventors in this study started their patenting activities, there were no competent technology transfer agents (though perhaps some incompetent ones). Most of the inventors therefore had to learn the patenting process and commercialized their research results on an individual basis or through firms. Recently, some of these inventors have even initiated their own 'TTOs', as agents through which they can share their experiences. Some research groups have thereby acquired their own internal technology transfer agents, or patent consultants, who sometimes originate from within the research group itself. These organizational arrangements provide networks for scientists who want to commercialize their research results. The argument for their formation as alternative routes to the university TTO or regional technology transfer actors is that these agents aim to provide technology transfer services in a specific scientific area, with the help of scientific experts. This idea is similar to the concept of 'university angels' (Etzkowitz 2006). Serial inventors have developed the abilities to assess not only the scientific but also the commercial aspects of research, and they have the skills, networks and even the financial resources to invest in and develop their colleagues' ideas. Researchers' patenting activities are therefore based mainly on individual skills and networks that may vary greatly from one research environment to another.

The key message of all these inventor-initiated agents is the belief that researchers want to deal with someone who speaks their scientific language and who is still wearing the white coat, literally and figuratively.

For many researchers, it is very difficult to talk to someone outside their scientific field or from the business community. Their aim is not to compete with the university TTO or other regional TTOs, but to specialize in outreach and be the first contact to identify commercial opportunities, as well as to educate and motivate researchers to patent. These internal actors seem to be closer to researchers and able to provide more customized solutions. Thus, an alternative system in which they may play even more prominent roles would very likely decrease cultural clashes between scientists and TTOs.

On the other hand, not every department or research group has a serial inventor who can help to establish a culture of patenting or transmit his or her skills and networks to the others in the research group. For research groups which lack this kind of leadership, TTOs may help to establish an environment conducive to patenting. It is also indicated that occasional inventors are those most likely to rely on TTOs for assistance with patenting. TTOs may therefore be needed for helping, financing and providing incentives to university researchers who need some assistance, motivation and guidance to patent.

The flow of technology from university to industry or specifically patenting is rarely a smooth process that proceeds without interruption from one actor to another. For instance, there may be several critical gaps or 'valleys of death' in the transfer of research results to patents.[65] To the frustration of many inventors, in many cases the process of technology transfer may stop due to lack of interest from firms or lack of funds. At this stage, the inventors must overcome another challenge that may be seen as beyond research, but in most cased the aim is to nurture their research. Because they really believe in their discoveries, and most of the time there is not much to lose, they try their best to bring their ideas into the market. To accomplish this, some inventors have sometimes started

[65] The most well-known critical gaps are the following: recognition of patentability, identification of a potential technology, raising capital for a patent application, achieving proof of principles, getting a working prototype, testing the product to identify and correct flaws, and persuading an existing firm to take on the task of turning the invention into a marketable product (see Branscomb and Auerswald 2000, 2002; Etzkowitz 2002; Vohara et al. 2004 on critical junctures in the development of university high-tech spin-off companies).

their own spin-offs. TTOs and other actors (incubators, venture capitalists etc.) may enable researchers to bring their research results into market.

As shown by the findings of this study, researchers or research groups are important actors in university patenting and thereby to some extent contribute to the effectiveness of technology transfer from universities. It must also be acknowledged that universities are not homogeneous units. Universities are centuries-old organizations with great inertia. It takes time and effort to change the institutional and organizational structures of universities, and such endeavours are likely to fail if they consist only of 'top-down' initiatives. University researchers and research groups should therefore be considered as agents of change, since reforming a university system cannot be achieved by relying only upon academic leaders and administrators. Moreover, patenting activities of university researchers should be considered a kind of voluntary action, which is the by-product of their research activities.

A compliance policy of 'carrots and sticks' would not be useful for universities. To the contrary, such policies would be detrimental. Documented patenting activities of Lund University researchers go back to the 1970s (earliest available date), before the advent of political interest in, and influences on, patenting, licensing and spin-off company formation at universities. Since – and no doubt also before – then, entrepreneurial activities have resulted mainly from individual decisions and researchers' networks with industrial firms. This study suggests that scientists are likely to transform themselves in a gradual way, rather than suddenly making a complete transition of universities to entrepreneurial activities.

TTOs, along with researchers, may also act as agents of change that can help move universities towards greater emphasis on entrepreneurship. For instance, a number of entrepreneurial initiatives have been taken by LU, including the creation of incubators, the formation of technology transfer organizations, and the adoption of university policies and strategies for innovation and entrepreneurship. It should be noted, however, that entrepreneurial activities depend crucially on the people inside the laboratories. If they are not positively inclined towards entrepreneurship, institutions and organizations intended to support academic entrepreneurship will not be able to accomplish anything meaningful.

Returning to the serial inventors, the involvement of a TTO may cause social tensions by challenging the existing relations between serial inventors and industrial firms, private patent consultants and other actors. Serial inventors who prefer actors in their social network and patent with them rather than with TTOs and hence they may either by-pass TTOs or give their mediocre inventions to TTOs. Firms, on the other hand, may consider the intervention of TTOs to be costly and more bureaucratic compared to informal and direct relations with researchers. TTOs may thus waste university funds on a process which could be achieved anyway through existing relations. However, TTOs do not need to focus on the serial inventors. This group is not in need of TTOs, but TTOs can actually utilize and learn from their experiences. This nuanced heterogeneity among inventors suggests that a customized approach should be embraced. Universities should aim to integrate and utilize all of these different types rather than marginalizing any of them.

TTOs should also understand that technology transfer can occur in many different ways. Most researchers are still driven by traditional academic incentives, and TTOs should therefore put more emphasis on these incentives in their efforts to gain the commitment and approval of scientists. In order to attract and keep serial inventors, universities should accordingly aim to create conditions in which scientists are able not only to do good research but also to collaborate frequently with industry on an individual basis and have the right to pursue industrial application activities without pressures to generate licensing incomes for the universities.

TTOs need cooperative university researchers who are not only interested, or willing to engage, in invention disclosures. They need university researchers who, where necessary, are also ready to commit to the further development of research results from early invention stages to later more applied stages. Reaching out to cooperative scientists or at least those who are interested in patenting is not that difficult.

The first task of TTOs, therefore, should be to identify potential inventors and get in touch with them, as well as to convince and help scientists who are not yet aware of the commercial potential of their ideas. They should focus on the non-obvious, difficult cases, and on scientists who cannot patent without TTOs. Otherwise, if TTOs focus on serial inventors or patents that industry is ready to buy or license, they will just be spending their resources on ideas which can be patented and commercialized without their help.

The above description of a TTO is by no means general and based mainly on insights derived from the literature and my empirical research (interviews with inventors and TTO managers). It is not easy to describe a generic or ideal model for all TTOs. One interesting argument, though, is that a TTO should in fact act like a temporary organization whose aim is to fulfil current needs or solve current problems. Since it is not easy to change either the culture (traditions) of university researchers or the way industry does business, TTOs are expected to bridge these differences. A successful TTO should be able to provide what these different types of actors need in order to interact effectively with one another. TTOs are expected to be highly responsive and adaptive in relation to widely differing circumstances of technology transfer. This study does not propose a 'model' TTO, or a recipe for creating TTOs. Rather, it has tried to suggest how a TTO should facilitate university patenting by acting according to the needs, capacities and expectations of inventors, as well as taking the local context into account.

9.2.5 Impacts of the Teacher's Exception

The discussion in previous sections has repeatedly drawn attention to the importance of researchers' networks as sources of support for their patenting activities, most notably with respect to serial inventors. Such networks, however, may not be particularly visible, so that for other actors (for example, TTOs) they may effectively be 'hidden'. Sweden's teacher's exception plays an important role in the creation of these hidden networks. The law makes it possible for scientists to choose the best alternative patent agent for their specific field. Even though finding and paying for the right patent agent might be difficult, it seems much better to many scientists than being stuck with a weak infrastructure as a result of change in the patent legislation. Serial inventors often doubt that the university can provide a competent and efficient technology transfer infrastructure.

Patent consultancy firms have played an essential role in helping inventors to write their patent applications. Inventors who can afford to pay for these private patent agents are satisfied with these agents and the personal networks they have created, based on their trust in them. Moreover, most serial inventors have argued that the university will not be able to afford to have such good patent agents for every specific scientific discipline. They have argued that even if the university can afford to get such an agent for one discipline that agent will not have the same competence in many other disciplines, and it will be very costly to have several agents for each discipline.

These and other findings of my research have important implications regarding the ownership of patents at universities. An abolition of the teacher's exception and enforcement of the use of university TTO would be likely to challenge the existing networks between researchers and e.g. firms, private patent consultants and inventors. Social capital, networks, innate capabilities, previous experiences and relations with industry serve as counterweights to TTOs, enabling university researchers to patent serially without the assistance of TTOs. Serial-active inventors get much more help from those TTOs that are helping scientists to start and develop their firms than do serial-passive inventors. Instead of relying on TTOs, serial-passive inventors have used their existing networks with industry. Members of this group emphasize that university TTOs would bring more bureaucracy into the patenting process and might challenge their existing networks with industry. They are also critical of university TTOs, which they tend to think would not be as competent as private patent engineers and lawyers in their partner firms.

9.3 Theoretical Insights

A multitude of scholars have examined the university-industry technology transfer (UITT) process. As discussed in Chapters 1 and 2, except for a small number of recent studies on university inventors most UITT studies have mainly focused on the roles of technology transfer institutions and organizations or on academic entrepreneurs, new venture creation and the consequences of university-industry relations. The aim of this thesis is to address this gap in university patenting and to contribute to the current debate by compiling and recognizing different factors to explain university researchers' patenting activities.

The theoretical discussion in Chapter 2 attempted to integrate external and internal factors. In this study, several explanatory factors were derived deductively from the existing UITT research literature, particularly previous studies that had proposed explanations for university patenting.

Apart from the analytical framework discussed above, one of the main contributions of the theoretical work carried out in Chapter 2 was thus a systematic literature review investigating the various factors that influence university patenting. The utility of this framework is not limited to the specific purposes of this study. Rather, the framework is an instrument that can also be used, possibly with some adaptation, in other empirical research on, and analyses of, university patenting. Moreover, in a much broader sense, most innovation studies (e.g. systems of innovation, triple helix, etc.) in this subject area tend to treat universities and TTOs or other organizations as the main units of analysis.

This study has emphasized that neither external nor internal factors by themselves provide sufficient causes or conditions for scientists to patent. Depending on the type of inventor – and the associated set of needs and expectations – the importance of both kinds of factors may vary. Inventors are not homogeneous in their modes of utilizing patents and their levels of patenting.

9.4 Policy Insights

This study has some reflections add to a somehow unresolved policy debate on university patenting. The policy aspect of university patenting is closely related to the so-called European Paradox or the Swedish Academic Paradox in this case. This is an argument according to which European countries have a strong science base but also many problems in translating scientific advances into commercially viable new technologies (EC 1993, 1995). In this view, universities contribute to the European Paradox by disregarding or mismanaging technology transfer activities. Also in this view, the alleged scarcity of university patents is usually used both as a signal of the technology transfer deficit and as a problem to address through legislation (Lissoni et al. 2007).

Although Nelson (2008: 9) has suggested that the emergence and adoption of new institutions can proceed rapidly and successfully, he has underlined the importance of a reasonably well-defined problem that needs some solution, i.e. a situation commonly acknowledged as requiring the identification and implementation of tools to solve the problem. In such cases, institutional and organizational change can occur quickly and smoothly. However, in the case of European universities the argument that university patenting is low has been challenged by recent empirical studies. It may not be accepted as a problem that requires an institutional and organizational reform. Yet a number of European countries (e.g. Germany, Denmark, Norway and Austria) have already adopted legislations similar to the Bayh-Dole Act. Several other countries are considering similar changes. In addition to institutional changes, many European countries have been making extensive efforts over fairly long periods of time (in Sweden, for well over two decades) to establish technology transfer offices, science parks and university-industry research centres (incubators) – all with a view to accelerating and maximizing the returns from publicly funded research, albeit with mixed success (Mowery 1998).

The empirical investigation in this study has highlighted the importance of institutionalized behaviours (Sampat and Nelson 1999). Institutionalized behaviours can be associated with individuals, based on simple codes of conducts, customs, norms and ways of acting that individuals get used to over the years. Individuals learn to accept such institutions as the common way of doing things. A substantial number of the patents in the LUP database have resulted from individually initiated networks with industry and investors. On the other hand, programmes for university-industry relations like competence centres provide platforms for scientists to interact with industry that have led to a number of patents and spin-offs. The current system of university patenting is influenced by the combination of individual and organizational factors.

As argued by Sampat and Nelson (1999), institutionalized behaviours tend to promote efficiency, since the actors know the rules of the game and eventually get used to them to the point where they no longer require any time for deliberation. A change in the institutions that the actors have got used to will have different consequences. In line with this argument, the serial inventors in this study have used the teacher's exception as the main institutional set-up in their patenting activities. They naturally feel that they have the right to patent their findings individually and hence over the years they have developed the individual skills and networks to patent on their own. They have institutionalized their patenting activities according to the principles of the teacher's exception. Occasional inventors, however, are beginners in the field. They have no clearly established ways or routines of patenting. Their patenting behaviours are not institutionalized yet.

A sudden change in the rules of the game – e.g. abolition of the teacher's exception – would create a kind of transition period. The occasional inventors would adapt more easily to the changes, since they do not have any institutionalized behaviours today. They would be more likely to hand over their ideas to the university TTOs willingly. Serial inventors, however, would be less willing to adapt to the new institutions, since they are used to a different procedure. Instead of going to a university TTO with their ideas, which is what they would be expected to do, they may try to bypass the TTOs or not patent in any way at all. Thus, there is a risk that if the teacher's exception is abolished, the consequence may be a decrease in patenting.

The current Swedish system for university patenting provides inventors with multiple channels. Yet, neither the multiple paths for patenting nor the missions of multiple TTOs are clearly defined enough to become the preferred route for relatively inexperienced university researchers. For such researchers, it is difficult to judge which path to choose. Therefore, one of the policy suggestions arising from this study is to develop a clearer mission for individual TTOs and a more well-defined division of labour, or specialization, among all TTOs. Further investments should also be made in TTOs for this purpose, since TTOs with mediocre resources and competences will be less likely to provide effective help to inventors. Matching the specializations of TTOs with the typology of inventors would increase their potential to provide help to university inventors, and it would also decrease the currently large degree of overlap among the TTOs.

Although this study does not suggest any definite answers to the question of whether or not the teacher's exception should be kept or abolished and replaced by a so-called Bayh-Dole Act model, it has some reflections that can be summarized as follows.

First, abolishing individual ownership and implementing organizational ownership of intellectual property generated at universities would not necessarily increase university patenting or improve relations between universities and industry. Second, abolition of the teacher's exception may have a negative impact on some university researchers' motivations to patent. The overriding reason for most of the inventors to patent is the desire to solve an industrial or societal problem. In addition, most of them want to increase their scientific reputation and credibility. Most inventors tend to be self-driven and it is somehow in their nature to be creative. They are generally not motivated by external rewards, laws and regulations. At the same time, they are not isolated islands and some of them have benefited from technology transfer infrastructures and nearly all of them from their research environments. Therefore, I argue that inventive activities or university-industry relations do not necessarily need to be regulated in detail, but they definitely do need to be supported by patent legislation and nurtured by organizations such as TTOs, incubators and science parks.

Concerning the US context, Nelson (2008: 6-7) has argued that institutions which have been consciously designed tend to shape behaviours only relatively loosely, and are themselves often difficult to specify and control tightly. He further argued that beliefs about what is feasible and what is appropriate often play a major role in the evolution of institutions. Human purpose and beliefs (which can be exemplified in this case by the differences in patenting strategies and motivations among the four types of inventors) play an important part in generating the institutional alternatives on which selection works, and in determining what survives and what does not. Therefore, he argued, the evolution or structuring of institutions (in this context, e.g. patent legislation regarding universities) should involve both collective (governmental) and decentralized (individual) action of universities and researchers.

Laws and political interests should strike a balance between inventors' interest in scientific discoveries and societal and industrial needs in utilizing university research results. When researchers spend their time at work doing commercial activities, there is a great risk that their business activities will take time and attention from their research – which is their main task, after all. Since the long-term level of research productivity depends on how much time researchers spend doing basic research, it is important that their main focus stays with doing basic research, not business.

It should also be noted that while academic entrepreneurship may strengthen traditional academic norms and research and teaching activities, the potential dangers and implications (unintended consequences) of commercializing academic science merit further consideration for the design of policy initiatives. Any changes in incentive structures have to respect the balance between policy-makers' expectations from technology transfer and the traditional academic values that still govern the activities of university researchers to a large extent.

However, as Nelson (2008: 7) has claimed, the capability to design institutions [and organizations] that work as planned (or as observed, in other cases) is much more limited than the capability to design (or adopt) physical technologies (such as a new medicine or new aircraft design). This is not to deny the possibilities of learning from other experiences (e.g. the US university model and the Bayh-Dole Act), but due to fundamental differences in social context and other factors there may be risks that direct policy emulation will contradict human motivations, customs and beliefs.

In line with Nelson's (2008) arguments, I found that institutions and organizations (e.g. patent legislation, TTOs, the third task) do not automatically provide necessary and sufficient conditions for university researchers to patent. As mentioned above, university researchers' patenting decisions are triggered by individual or group decisions and often emerge as a by-product of research rather than resulting from the potential incentives which institutions and organizations may provide. Critically, the nuanced heterogeneity among inventors also underlines the need for caution in generalizations about the roles and influences of patent legislation and TTOs in university patenting. On the other hand, policy-makers should consider initiating adaptive and flexible institutions and organizations – which may enable researchers to patent by providing them with the resources and skills they may need for patenting, rather than applying standard solutions to different cases. This heterogeneity also highlights the importance of varied types of technology transfer, such as industrial collaboration and labour mobility between industry and university (e.g. through competence centres).

Without attention to the character of research life offered by universities, and particularly the extent to which it attracts researchers to stay at universities, politicians will devise incomplete policy solutions. These policy measures may neglect and even threaten the main sources of satisfaction and personal development that most researchers derive from their research endeavours. More combined measures should be considered to enhance the critical role of university researchers in deciding whether or not and, if so, how to patent. While I acknowledge the uncertainties about institutional changes and the difficulties of evaluating the impact of different institutions and organizations, I do not consider that these problems justify the untenable practice of developing and maintaining one-size-fits all policy instruments.

9.5 Overall Contributions and Insights

Before concluding the analysis and discussion of the findings, I will summarize the main contributions of this study as a series of seven key messages. The list below will help the reader relate the analysis and discussion contained in this chapter to the empirical findings presented in other chapters in a simple and direct way.

1. Patenting activities are common among Lund University researchers.
2. The main motivation for university researchers to patent is to solve the research puzzle rather than any kind of external factors such as laws, TTOs, or the third task. The most common external motivation is also related to internal factors – i.e. to get access to resources, materials, data and equipment from firms without or at reduced cost. Patents are used as signal attract industrial and/or to increase bargaining power of university researcher vis-à-vis firms. Local role models play important roles in motivating other researchers to patent and teaching them about patenting. These role models are very often instrumental in the formation of a so-called entrepreneurial culture in their departments.
3. Inventors differ both in the ways they commercialize their patents and in their levels of patenting activity. To capture and reflect these differences,

this study has proposed a four-fold typology of university inventors: serial-active inventors, serial-passive inventors, occasional-active inventors, and occasional-passive inventors.

4. Each type of inventor has similar but also slightly different needs, motivations and expectations. This heterogeneity among university inventors implies the need for a customized approach in services offered by institutions and organizations. Universities should aim to integrate and utilize all these different types rather than marginalizing any of them. While occasional inventors need some complementary skills from TTOs or colleagues, serial inventors patent through their own networks and individual capabilities.
5. TTOs have not been the most common route that inventors use to patent. TTOs have applied for only a few patents. Reasons for this low level of activity could include lack of information about TTOs, little need for TTOs, poor attractiveness of TTOs and little or no coordination of the roles of different TTOs associated with LU.
6. In general, patenting or commercial activities need to be considered as voluntary activities by academics. Researchers are likely to learn entrepreneurial activities in a gradual way, as by-product of their research activities; rather than making a sudden and total transition to entrepreneurial activities. Transformation of university researchers into entrepreneurs is unlikely to be achieved by changing the patent legislation or reforming the university system. However, institutions and organizations can be important mechanisms to protect and nurture the patenting activities of researchers.
7. It is difficult to overcome the inertia related to the culture and structures of universities. Even if TTOs can be considered signs of a transition towards more entrepreneurial universities, it is ultimately the researchers who will – or will not – generate the inventions on which universities' entrepreneurial activities must be based.

In this dissertation the analytical framework unifies individual motivations, characteristics with institutional and organizational factors to understand researcher's decision and behaviours with regard to patenting. Empirical investigation in the light of this framework suggests a number of findings and policy insights. It is therefore my hope that this book will trigger readers' curiosity and will provoke further research interest about university patenting, technology transfer and academic entrepreneurship.

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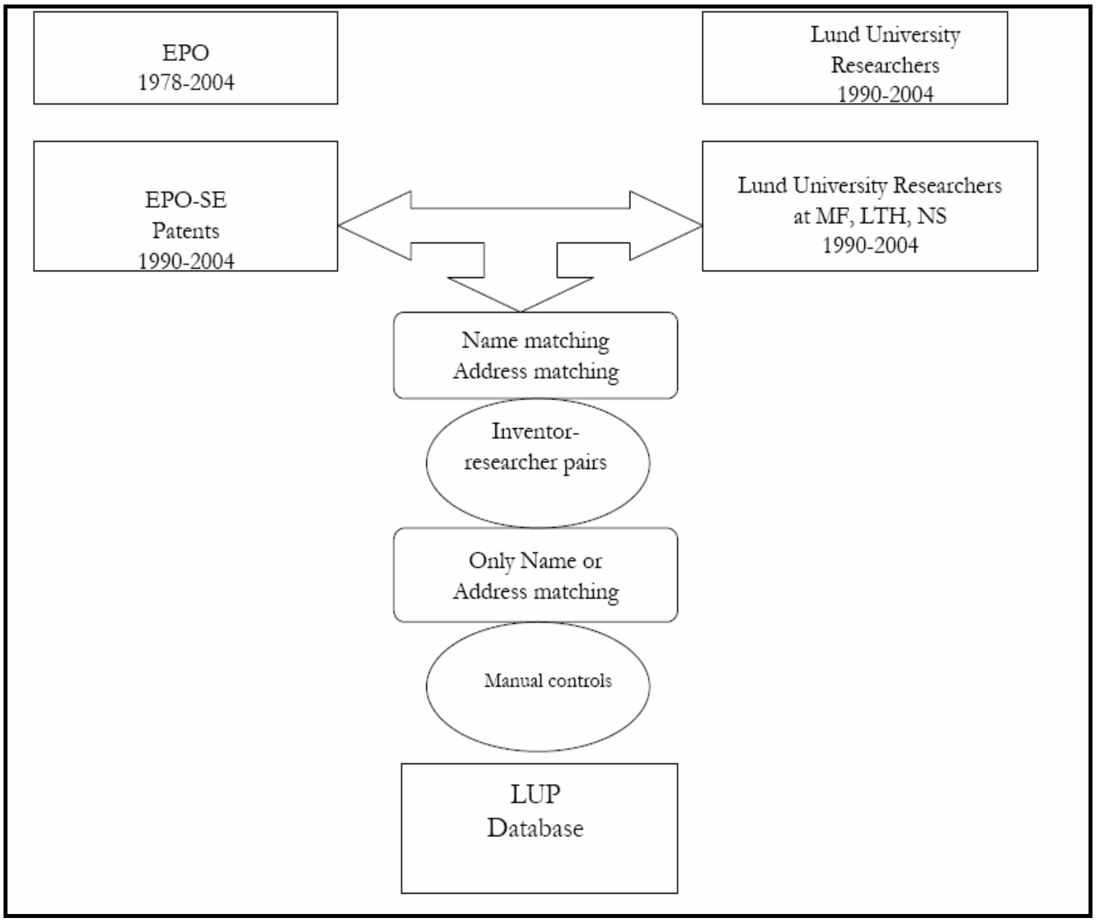
Appendices

Appendix A1: Matching Procedure between EPO-SE patents and LUR



Appendix A2: Technological Areas of Patents

AFM	Agricultural and food machinery and apparatus
AGR	Agriculture, food
ANA	Analysis, measurement, control
AVT	Audiovisual technology
BIO	Biotechnology
CIV	Civil engineering, building, mining
CON	Consumer goods and equipment
CPP	Chemical industry and petrol industry, basic materials chemistry
EDE	Electrical devices – electrical engineering
ENV	Environment, pollution
EPT	Engines, pumps, turbines
GEN	General technological processes
HAP	Handling, printing
INT	Information technology
MAC	Macromolecular chemistry, polymers
MAP	Material processing
MCT	Machine tools
MEC	Mechanical elements
MED	Medical engineering
MET	Materials, metallurgy
NUC	Nuclear engineering
OPT	Optics
ORG	Organic, fine chemistry
PHA	Pharmaceuticals, cosmetics
SEM	Semiconductors
SPW	Space technology, weapons
SUC	Surfaces, coating
TEL	Telecommunications
THE	Thermal processes and apparatus
TRA	Transport

Source: OECD (1994) (adapted according to Meyer (2003) classification.

Appendix A3: Survey of Inventors

***L*und *U*niversity Survey of inventors**
(April 24, 2006)

INSTRUCTIONS

- This survey is divided into 8 main themes. There are 25 questions. After some brief questions about your background, we will ask about your experiences related to one of your EPO-patents.
- Please click in the boxes to answer the questions. If you want to change your answer, re-click in the same box.
- Please mark all the relevant options; do not leave any options unmarked. If a given option is not applicable for you, click on "Not applicable (N.A.)".
- If you have another answer than the given options, please use the **"OTHER"** option to write your answers and comments. If you want, you may write in Swedish.
- If you need more space, please use the end of the survey or extra pages.
- Please **SAVE** your file often while responding to the survey and send it back by e-mail to academicinventors@innovation.lth.se
- Your answers and name will remain **strictly confidential.**

GLOSSARY

- **EPO**= European Patent Office, **PRV**= Swedish Patent & Registration Office, **USPTO**= US Patent and Trademark Office
- **Lärarundantaget**: (University Teacher's Privilege or academic exception). This term was introduced in the 1949 act on the right to inventions of university employees. In general, the employer owns the inventions of an employee. In the case of college and university employees, however, an exception is made, and the employee has the right of ownership. This gives university employees the exclusive right to sell, license, exchange or give away their results to anyone they wish.
- **Third Mission:** In 1996 the Higher Education Act was changed to state that Sweden's universities should co-operate with the surrounding society and provide information about their operations and outputs.
- **Industry/firm**: We refer to both private and public sector firms, or other organizations which may buy the patent or license (acquire rights to use) the patents**.**
- **Spin-off Firm (Avknoppningsföretag)**: A new firm that is formed on the basis of university research results or patents and where a university employee is involved in the formation of the firm.
- **Technology Transfer Organization (TTO)**: TTOs are organizations that help university scientists to commercialize their research results, through patenting, licensing and/or spin-off firm formation. Examples of TTOs are LU-innovation, Teknopol, Forskarpatent, Malmö Incubator (Minc), Innovationsbron etc.
- **Business Angels**: Informal investors; private individuals who, in addition to providing capital, may also offer their expertise on business development for start-ups and growing enterprises
- **Business Development & Support Organizations (BDSO):** These are organizations that provide researchers with financial assistance to start new businesses e.g. spin-off firms. Examples of such organizations are Nutek, ALMI, Teknoseed, Lumitec etc.
- **Venture Capitalist:** An investor or organization that invests in businesses with a considerable level of risk. The venture capitalist is willing to invest in a medium-to high-risk business in exchange for a very high level of return in order to accept this level of risk.

1. **Name:** *(we request your name for follow-up, e.g. to remind anyone who has not answered yet. Your name will* **NOT** *be publicized.)*

Female ☐Male☐

Year of Birth

2. **Please indicate all the relevant options about your current academic & employment status at Lund University.**

Full Professor ☐Adjunct Faculty Member☐Full-time☐Associate Professor☐ Post-doc ☐ Part-time☐Assistant Professor☐PhD Student☐Visiting/guest scholar☐ Lecturer/ Instructor ☐ Industry-doctoral student ☐Other (please specify)

Medical Faculty☐LTH☐

Natural Sciences☐

Department/Division

Other (please specify)

3. **Please indicate all the relevant options about your employment experiences.**

31. How many years have you worked as a university researcher at LU?

3.2.How many years have you worked at any university altogether?

3.3. Did you have at least 2 years professional work experience in industry related to your academic field before you were involved in any patenting activity? **YES** ☐ **NO** ☐

3.4 Are you currently participating in an international research group (e.g. including colleagues who are based in other countries) **YES** ☐ **NO** ☐

3.5 Have you engaged in any collaboration with a firm? **YES** ☐ **NO** ☐

Other (please specify)

4. **Please indicate all the relevant options about your educational background.**

Have you received all or part of your university education in Sweden? **YES** ☐ **NO** ☐

University at which you obtained your PhD. (If more than one, indicate all):

Year in which you obtained your PhD. (If more than one, indicate all):

5. **Please estimate the approximate share of your average weekly time allocation among your different tasks for the current academic year.** (The total number of working hours may add up more than 40 hours per week.)

Less than 10 hours
10- to 20 Hours
30- to 40 hours
More than 40 hours/
Teaching
Basic Research
Applied Research
Administrative tasks at Lund University
Clinical practices (only for Medical Faculty)
Third mission activities (e.g. interaction with industry and the surrounding society)
Consultancy
Working in a firm
Other (please specify)

6. **Please indicate the total number of patent applications submitted by you and granted patents in different patent offices during your employment at Lund University.**

Number of Patent applications Number of Granted Patents

- We will ask questions about your opinions, motivations, outcomes and problems related to one of your **granted EPO patents** that you applied for between the years **1990 and 2004.** You should have been employed full-time or part-time at LU when you applied for that patent.
- Even if you have filed patents in other patent offices (e.g. PRV, USPTO etc.), we ask you to select one of your **granted EPO patents,** not any other patent. However, the invention granted the **EPO patent** might have been granted a patent in other patent offices as well.
- If you do not have any granted EPO patents yet, please select one of your **patent applications to EPO**.
- While responding to the questions (**from 5 to 25**), please try to reflect on your experiences with respect to the specific EPO patent you have selected.

7. Please give basic information about the EPO-patent that you have chosen.

Year of Application
Year Granted (if granted)
Title of the Patent
If possible, please give the EP-number of the patent.
Number of inventors (other than yourself)
Was this patent based on a previous Swedish PRV patent? **YES**☐**NO**☐

8. Please choose the most accurate description of the research related to the patent. Please mark all the relevant options.

The research was done by researchers who were associated with Lund University
The research was done only by researchers associated with universities
The research was done by researchers from different universities and companies
The research was done when you were partly employed by a firm.
The research was initiated and financed by a firm.
The research was your free time activity. It was not related to your university activities.
Other (please specify)

9. Mark your position at the time of the patent application. Please mark all the relevant options.

Employed full-time at Lund University
Employed partly by industry
Employed partly at another university
Project Leader (Principal Investigator) of the research that led to the patent
Head of Department (or Division)
Senior Researcher (Professor, Associate Professor/ Docent)
Junior Researcher (Assistant Professor /Post-doc, Licentiate, PhD Student.)
Student (Master student, or undergraduate student)
Other (please specify)

10. **A patenting process often involves many different people who do different tasks. Please describe <u>who did what task</u> during the patenting process. Please mark all the relevant options that applied to different people.** (You, Project leader (other than yourself), Researcher from firm, Senior University Researcher (other than yourself), Junior University Researcher (other than yourself) , TTO staff, Financers, Other actor, please specify)

Who first identified the possibility to patent the research results?
Who was the main (1st) inventor?
Who was (were) listed as co-inventor(s)?
Who was (were) the applicant(s)
Who was (were) the main person(s) behind the scientific idea that led to the patent?
Who was (were) the most experienced actor(s) in patenting?
Who established contacts with TTOs, if any?
Who established contacts with financers, if any?
Who established contacts with industry, if any?
Who had existing relations with the industry?
Who formed the spin-off company, if any?
Who continued relations with the licensee or spin-off firm?
Who resolved conflict(s), if any, among different actors?
Who negotiated the terms of licensing (e.g. royalty fees)?
OTHER (Please describe other roles and activities of different actors in patenting.)

11. How did you (or co-inventors) <u>recognize the possibility to patent</u> the research results? Please mark all the relevant options.
You realized yourself that the research results could be patented
You did a patent search yourself in different patent databases (e.g. EPO, PRV, USPTO)
Your colleagues in the research group recognized the patentability of research results
You learned it through discussions/communications with industrial partners
You got help from TTOs (e.g.LU Innovation, Teknopol, Forskarpatent, Innovationsbron etc.) to evaluate the possibility to patent
You asked for professional help from patent consultants to evaluate the possibility to patent
Other (please specify)

12. <u>Whom</u> did you inform about the possibility that research results could be patentable? Please list the people (1st---10th...and so on) by order of contact. If a contact was made with several people at the same time, use the same number. If an option is not applicable, please mark N.A.

Family members/friends
Head of the Department (if it was not you)
Industrial financer of the research project
Industrial Partners (manager, researchers) of the research project
Potential firm(s) which might be interested in applying for a patent.
Patent Consultant(s)
Principal investigator of the project (if it was not you)
Business Development and Support Organizations (e.g. Nutek, ALMI and so on.)
Technology Transfer Organizations (Teknopol, LU Innovation Innovationsbron etc.)

University colleagues from the same research group
Private Venture Capitalist/ Business Angels which might be interested in investing.
Other (please specify and rank it)

13. How did you cover the cost of your patent application? Please mark all the relevant options.

Formed a (spin-off) firm to cover the cost
Business Development and Support Organizations (e.g. Nutek)
Industrial partner in the research project covered the cost
Industrial firm, which was not a participant of the research project, covered the cost
Own individual resources (e.g. friends and family)
TTOs (e.g. Teknopol, Forskarpatent, Innovationsbron) covered the cost
Public research funds
Business Angels and/or Venture Capitalists
Other (please specify)

14. On a scale from 1 to 5 (1=not important, 5= extremely important), how important were the following factors for you to patent? Please mark all the relevant options. If a factor is not applicable for you, mark N.A.

	1	2	3	4	5
To solve research questions	☐	☐	☐	☐	☐
Materials & data and funds from industry	☐	☐	☐	☐	☐
For job satisfaction	☐	☐	☐	☐	☐
Local colleagues	☐	☐	☐	☐	☐
Credibility to attract money	☐	☐	☐	☐	☐
Industrial partners decision	☐	☐	☐	☐	☐
Financial & Business skills	☐	☐	☐	☐	☐
Keep industrial links	☐	☐	☐	☐	☐
Having industrial networks & reputation	☐	☐	☐	☐	☐
For Recognition & Reputation	☐	☐	☐	☐	☐
Research group decision	☐	☐	☐	☐	☐
Foreign colleagues	☐	☐	☐	☐	☐
Due to previous experience	☐	☐	☐	☐	☐
Political support & interest e.g. third task	☐	☐	☐	☐	☐
Univ. Administration interest & support-	☐	☐	☐	☐	☐
For publication possibilities	☐	☐	☐	☐	☐
Patenting is your legal right	☐	☐	☐	☐	☐
For Promotion	☐	☐	☐	☐	☐
Change Career/spin-off	☐	☐	☐	☐	☐
Personal income	☐	☐	☐	☐	☐
TTO support	☐	☐	☐	☐	☐
Other (please specify)					

If you directly or indirectly used any TTOs' services or assistance to apply for your patent, please answer the following questions 15-16. If you did not use any TTOs' services at all, please continue to question 17 onwards.

15. On a scale from 1 to 5 (1=not important, 5= extremely important), how important have the following factors been for you to choose to cooperate with a TTO? Please mark all the relevant options.

	1	2	3	4	5
TTOs covered the cost of patent application					
TTOs found a firm to buy/license the patent					
TTOs helped you to form your own firm					
There was no firm to cover the cost of patent application					
You did not have previous experience in patenting					
You wanted to have more time left to continue research, rather than engaging with the legal and financial issues of patenting					
You did not want to get involved in marketing/commercial (entrepreneurial) aspects of patenting					
Other (please specify & rank):					

16. Please describe your relations with the TTOs that were relevant for your patent application; e.g. <u>which TTOs</u> did you consult or contact; were you <u>satisfied</u> with the TTOs' services; would you have been able to achieve the same results <u>without</u> the help of TTOs, and so on.

If <u>you and/or a firm</u> are listed as the applicant(s) for the patent, please answer Questions 15-17, and continue to Part F onwards.
If a TTO is the only applicant for the patent, please pass over Questions17, and continue onwards.

17. On a scale from 1 to 5 (1=not important, 5= extremely important), how important have the following factors been for you to apply for the patent <u>yourself</u>? Please mark all the relevant options.

	1	2	3	4	5
To form your company					
There was no incentive to use TTOs (e.g. TTOs are incompetent)					
You did not know about the services available from TTOs					
There was no TTO at the time of your patent application					
You did not trust TTOs					
You did not need TTOs, since you had experience in patenting					
You did not need TTOs, since you had existing industrial connections (e.g. a firm interested in the research)					
Other (please specify & rank):					

18. On a scale from 1 to 5 (1=not important, 5= extremely important), indicate what were the main <u>advantages</u> of doing the patent application yourself. Please mark all the relevant options.

	1	2	3	4	5
Full ownership of the patent					

Higher financial benefits from the patent (i.e. royalty payments, licensee fees, equity shares etc.)
Less bureaucracy
Higher independence concerning what to do about the patent
Other (please specify & rank):

19. On a scale from 1 to 5 (1=not important, 5= extremely important), indicate what were the <u>disadvantages</u> of doing the patent application yourself. Please mark all the relevant options.

	1	2	3	4	5
The cost of patenting was too high to cover individually					
Time losses (hassle of patent search and application)					
It was difficult to coordinate within the research group					
It was difficult to find firms to sell /license the patent					
It was difficult to form your spin-off company					
It was difficult to negotiate with industrial firms					
You could not sell/license the patent					
Other (please specify & rank):					

20. On a scale from 1 to 5 (1=not important, 5= extremely important), please indicate how important these factors were for you to apply for a patent. Please mark all the relevant options.

SUCCESS FACTORS	**1**	**2**	**3**	**4**	**5**
Access to financial resources to cover the cost of patenting					
Agreement among members of the research group					
Availability of time to pursue patenting process					
High degree of commercial/industrial interest/need regarding use of the patent, i.e. there was a big market demand					
Presence of a firm willing to buy/ license the patent					
Previous patenting experiences, or knowledge, (e.g. having education and/or work experience in a university where patenting is common).					
Previous relations with the applicant/licensee firm e.g. research contracts, consultancy etc.					
Support from the head of the department/ other colleagues					
Consensus with industrial partner, (e.g. royalty payments, fees, publishing					
Use of TTO services, (e.g. TTOs were assisting and helping to the cost of patent application).					
Other (please specify & rank):					

22. On a scale from 1 to 5 (1=not at all, 5=extremely serious), indicate how serious these following <u>problems</u> were for your patenting process. Please mark all the relevant options.

PROBLEMS	**1**	**2**	**3**	**4**	**5**
Conflict with industry on e.g. royalty payments, fees, publishing delays etc.					
Conflict within the research group (i.e. among co-inventors)					
Lack of experience in patenting					
Difficulties in finding a firm to apply for the patent, (e.g. industry was not interested in your patent).					

Disapproval from the university administration, (e.g. excessive bureaucracy and opposition to commercial activities).
Disapproval from the head of the department/ other colleagues, (e.g. open science mentality and opposition to commercial activities).
Limited time to spend on patenting, (e.g. teaching & other administrative tasks took so much time).
Limited financial resources to apply for a patent
There were other patents which were granted in a similar area
Low performance of TTO, (e.g. difficulties in finding the right TTO, TTO could not find the right industrial partner on time, TTO was not able to negotiate with the companies).
Other (please specify and rank):

23. What have been the <u>outcomes</u> of the patent? Please mark all the relevant options.
New product has been developed based on the patent
New process has been developed based on the patent
You have published research articles based on the patented research
The patent is highly cited in other patents
The patent is highly cited in scientific journals, (e.g. articles, publications, books etc.)
The patent has been sold/ licensed to a firm that you (and/or co-inventors) have had previous relations with *(e.g. knowledge exchange, consultancy, member of scientific advisory board etc.)*
The patent has been sold/licensed to an SME in Sweden
The patent has been sold/licensed to an existing large firm in Sweden
The patent is sold/licensed to a foreign firm in Sweden
The patent is sold/licensed to a foreign firm outside Sweden
A spin-off firm has been formed based on the patent
The spin-off firm based on the patent has been sold/merged with another company
The patent has not been sold/licensed yet, but you (and/or co-inventors) are trying to initiate a spin-off firm
The patent has not been sold/licensed yet, but you (and/or co-inventors or TTO) are trying to license (sell) it.
The patent is not in use at all. You (and/or co-inventors) have stopped working on the patent.
Other (please specify)

24. Have you <u>continued your relations</u> with the firm that now owns or uses the patent?
YES☐NO☐
25. If yes, <u>how</u> have you continued your relations with the firm? Please mark all the relevant options.
Ownership of spin-off company (having equity shares in the firm)
Consultancy to the firm that will develop and utilize the patent
Manager (member of managerial board) of the firm
Member of scientific advisory board of the firm
Initiation of joint research project with industry to develop the patent into products, etc.
Other (please specify)

26. On a scale from 1 to 5 (1=no impact, 5=very high impact), please indicate the <u>general impacts of the patent</u>. Please mark all the relevant options. If a factor is not applicable for you, mark N.A.

	1	2	3	4	5
Improved academic reputation					
Academic promotion					
Increased ability to publish more					
Increased ability to attract research funds, (e.g. patent generated funds for further research)					
Increased secrecy/delay of publications					
The patent contributed to research and teaching, (e.g. gained access to materials, data, equipment or research expertise of industry for free or at a reduced cost)					
Enlargement of the research group with new industrial researchers					
Increased relations with industry					
Formation of spin-off firm, (e.g. creation of job possibilities, alternative career paths)					
Provided job opportunities in industry					
Contributed to personal income					
The patent helped to solve an industrial problem/ or address societal needs					
You (or your research group) became role models for other researchers' patenting activities					
You (or your research group) learned more about patenting, and gained a better ability to apply for more patents					
Other (Please specify and rank)					

27. Please indicate the <u>economic implications</u> which the patent has generated <u>up to now</u> for you or for the firm where you have ownership. If an option is not applicable for you, mark N.A.

Consulting incomes SEK: **N.A.**
Total cost when the patent was filed (patent search, lfee, etc.)SEK:
Incomes when the patent is sold/licensedSEK:
Royalties when the patent is licensed SEK:
Equity sharesSEK:
Number of jobs created
Other (please specify):
Could we do a follow up interview with you? (if yes, please state the contact information below)
Would you like to have a copy of the final report of this study? (if yes, please state the contact information below)
Telephone:
E-mail:

Thank you very much for your time in completing this questionnaire.

If you need further information, or questions, please contact Devrim Göktepe at (+46) 046 222 39 30, (+46) 0736 35 59 35 or by mail to devrim.goktepe@innovation.lth.se

If you want you may specify your experiences, personal suggestions and comments on university patenting specifically please feel free to use extra pages)

Please save your file and send to academicinventors@innovation.lth.se

Appendix A4: Inventors Interview Guide

Interviews were done in English. It is neither the native language of the interviewer nor most of the interviewees. After completing the interview or sometimes during the interviews I summarized and /or paraphrased their statements, and asked them to correct me if there are any misunderstandings to prevent any misinterpretations afterward. On the other hand, since I have an intermediate level of Swedish Language, it was not problematic to understand some of the Swedish words that interviewees used.

Interview Guide with Serial Inventors

1. Background Information: Could you please briefly describe your research and its relations to your patenting activities?
2. Patenting activities during career development (both academic and industrial)
3. Motivations to patent. What are the reasons for being involved in patenting activities? Have you experienced changes over the years in your patenting activities?
4. Personal characteristics: To what extent your personal characteristics and background play a role in your patenting activities?
5. Please indicate how important were your personal qualities to your decision to patent?
6. Inventors' Role: How do you describe your role within your research group?
7. Could you describe your relations with the research group?
8. Could you describe your relations with university administration and technology transfer organizations?
9. Could you describe your relations with the surrounding industrial firms?
10. What were the main success factors behind your patenting activities?
11. What were the main challenges and problems you experienced in your patenting activities?
12. Could you give any examples of conflicts of interest within the research group, industrial partners etc. How was the dispute solved?
13. How do you balance your different activities at the university (teaching, research, patenting, administration etc.) other activities?
14. What do you think about the roles and influences of Institutions and Organizations for UITT (patenting)
    - 14.1. Teacher's Exception?
    - 14.2. TTOs?
    - 14.3. Third Task Law
15. What are your suggestions to increase academic patenting? (E.g. the best possible set-up of institutions and organizations for interaction with industry?)

Appendix A5: TTO Interview Guide

Interview Guide to Technology transfer Office Managers associated with LU and Ideon Science Park. [66]

I. Background Information

1. What are the main reasons (political initiations, practical needs) behind the establishment of TTO associated with Swedish Universities (or specifically Lund University)?

2. What are the organizational relations between the different TTO?

3. What roles do TTO play with regard to technology transfer (specifically patenting, licensing and spin-off company formation?

II. Nature of Technology Transfer

4. What are the strategies of identification of research results and inventions from the university setting?

5. How do TTO identify and transfer ideas from the university setting into industrial setting?

III. Efficiency of the activities of TTO

6. How we can increase the efficiency of patenting? (Or more specifically how can we increase the speed of transferring research results/ inventions into patents and to licensing/spin-offs from university to industry?) (Barriers/ challenges that TTO face)

IV. Cases and Outcomes of TTO activities

7. How do relations continue after patenting, licensing, and start-up company formation with the relevant actors?

8. What are the outstanding (successful) patenting, licensing, and start-up company formation cases that TTO have experienced?

9. What are the controversial/ conflictual cases?

V. Conclusive Remarks & Future Implications

10. What are the opinions of TTO to improve their own activity area?

What are the opinions of TTO to improve the technology transfer at universities in general?

[66] Within the scope of Chapter 8, I have not used all of the data from the interviews with TTO managers.