

Linköping Studies in Arts and Science • No. 355

Beyond the Ivory Tower

A Comparison of
Patent Rights Regimes
in Sweden and Germany

Mark O. Sellenthin

Linköping Studies in Arts and Science No. 355

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Distributed by:

Department of Technology and Social Change

Linköpings universitet

SE-581 83 Linköping

Sweden

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Edition 1:1

ISBN: 91-85523-75-5

ISSN: 0282-9800

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Department of Technology and Social Change

Printed by: Utnitryck Linköping 2006.

Acknowledgements

In the course of this dissertation two empirical studies were conducted. In the first study representatives of technology transfer offices and similar organisations in Sweden and Germany were interviewed. The second study surveyed a large number of university researchers in both countries. I am indebted to all the interviewees and respondents that took the time to provide valuable information without which this book would not have been possible.

To write a PhD dissertation is not a lonely task. Although I am solely responsible for the whole text, there are a number of people who supported me in the last couple of years and who deserve a thank you. First of all, I have to thank my supervisor Prof. Göran Skogh, Department of Management and Economics, Linköping University who provided me with comments and support in the last two years of this thesis project. In addition to being a supervisor he was always a kind of informal mentor in the background who helped me a lot in my academic career. Furthermore, my second supervisor Prof. Staffan Laestadius, Division of Industrial Economics, Royal Institute of Technology (KTH) in Stockholm gave comments and valuable suggestions to me in a quite important phase of this venture. I owe a special thanks to Dr. Mats Bladh from my own department who was always a kind of informal supervisor during my years at Tema T. He read basically all of the texts that I produced during my time at the department, starting from the very first draft of the thesis – the “summer paper” – to the final version of it. Furthermore, I am thankful for the comments of my opponent at the final seminar, Dr. Christopher Palmberg, Research Institute of the Finnish Economy (ETLA) in Helsinki and the members of the committee of the final seminar, Prof. Magnus Klofsten, Prof. Hans Sjögren, both from the Department of Management and Economics at Linköping University and Dr. Mats Bladh for valuable comments. This thesis deals with quantitative analyses to a considerable extent, therefore, I am indebted to Prof. Stig Danielsson, Department of Mathematics, Linköping University, who read the statistical part and provided me with a lot of valuable comments and suggestions for improvement. I am thankful for the language correction by Gray Gatehouse. With regard to my questionnaire, I received a lot of support and guidance from my colleague Dr. Johanna Nählinder. Moreover, Prof. Charles Edquist, Division of Innovation, Lund University provided comments and support during the initial phase of this dissertation.

Doctoral students at the Department of Technology and Social Change are always admitted in “litters” and I received a lot of encouragement from my “litter” the D-01 cohort, in particular Robert Hrelja, Wiktorija Glad, Corinna Kruse and Vasilis Galis.

To write a doctoral dissertation is a huge task that requires plenty of administrative support. Eva Danielsson and Christina Lärkner provided this valuable support. Thank you!

Parts of the thesis were financially supported by the Swedish Institute for Growth Policy Studies (ITPS), which is gratefully acknowledged. The web-based survey was administered by Daniel Franzén, Franzén Consulting, whose help is gratefully acknowledged.

This thesis would not have been possible without the support of my family. I would like to thank my mother Heidi and my stepfather Horst who always encouraged me to go further in my academic career. Furthermore, my dissertation and the time as a PhD student was influenced a lot by the balance of my professional life and my family life. This balance would not have been possible without Antje and my children Tim, Linnéa and Florian to whom this book is dedicated.

Linköping, May 2006.

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Abbreviations

AB:	Aktiebolaget (Limited Company)
ArbNerfG:	Arbeitnehmererfindungsgesetz (Law about UTP)
AUTM:	Association of University Technology Managers
BMBF:	Bundesministerium für Bildung und Forschung (Federal Ministry of Education and Research)
CIS:	Community Innovation Survey
EPO:	European Patent Office
EXIST:	Existenzgründungen aus Hochschulen (University-based Start-ups Programme).
GBAORD:	Government Budget Appropriations or Outlays for R&D
GDP:	Gross Domestic Product
GERD:	Gross Domestic Expenditure on R&D
GmbH:	Gesellschaft mit beschränkter Haftung (Limited Company)
GUF:	General University Funds
HERD:	Expenditure on R&D in the Higher Education Sector
HSV:	Högskoleverket (Swedish Agency for Higher Education)
IPR:	Intellectual Property Rights
ISR:	Industry-Science Relations
KEIM e. V.:	Karlsruher Innovationsimpuls (Networking Initiative)
KTH:	Kungliga Tekniska Högskola (Royal Institute of Technology, Stockholm)
OECD:	Organisation for Economic Cooperation and Development
OTL:	Office of Technology Licensing
PRO:	Public Research Organisation
PVA:	Patent- und Verwertungsagentur (Patent and Exploitation Agency)

R&D:	Research & Experimental Development
RRV:	Riksrevisionsverket (Swedish National Audit Office)
SRS:	Simple Random Sampling
S&T:	Science and Technology
TBS:	Teknikbrostiftelse (Technology Bridging Foundation)
TTO:	Technology Transfer Office
UTP:	University Teachers' Privilege (“Hochschullehrerprivileg” in Germany, “Läraryrskännet” in Sweden)
VINNOVA:	Verket för Innovationssystem (Swedish Agency for Innovation Systems)

1. Introduction

The term “knowledge-based economy” is frequently used to describe the present form of capitalism in advanced countries. Universities and other research organisations have a prominent role in contemporary societies. Not surprisingly, “as key sites both for research into new fields and for the training of future researchers and skilled personnel, universities and other higher education institutions have found themselves inevitably drawn into the modern national policy arena” (OECD 1999, p. 9).

The role and perception of the university in our societies has changed considerably. The traditional university – often called the Humboldt university - has an educational ideal that links teaching to research. Commercial benefits to the surrounding society are not the focus of universities in this ideal. Traditionally, the university was regarded as “an autonomous community of teachers and students, where those by devoting themselves to science would develop their individual personalities. Devotion to science implied an orientation towards research, not only for the professors but also for the students. Teaching at its best would introduce the student to doing creative research” (Keck 1993, p. 118). Especially important is the focus on autonomy. These ideas developed by German idealist philosophy still prevail in many universities in Europe. Short-sighted benefits to the surrounding society should not steer the direction of research or teaching according to this idealist perception.

A sharp contrast to the traditional Humboldt model is the entrepreneurial university model. Braunerhjelm et al. (2003, p. 35, own translation) argue that an entrepreneurial university is an “informal alliance between research, privately and publicly funded links to the market, entrepreneurs and firms”. The primary characteristic of an entrepreneurial university is the open attitude towards interaction with society and to orient the direction, organisation, funding, and the conducting of research to the surrounding society’s benefits and values. The ideal is that this open attitude should be inherent in students and researchers alike. We should bear in mind that the entrepreneurial university’s primary focus is not on entrepreneurship in its educational programs or the establishment of spin-off companies by students or researchers. The ideal of the entrepreneurial university aims at establishing an open attitude towards interaction with society in general. When people talk about the ideal entrepreneurial university, they are usually talking about universities like Massachusetts Institute of Technology (MIT) or Stanford University. According to Deiacio et al.

(2002), already over hundred years ago, MIT chose to be a strong force in local and regional development instead of being an “ivory tower”. Today, MIT has established a lot of mechanisms that identify research questions from the surrounding environment. At the same time, the scientific excellence is unquestioned. Deiacco et al. (*ibid.*, p. 67) argue that a university like MIT that produces benefits for the surrounding society without reducing the scientific ambitions and integrity is called an entrepreneurial university.¹ Stanford University and MIT are frequently referred to as ideal types of entrepreneurial universities. Particular attention is often given to the licensing activities at Stanford. The Stanford model of patenting and commercialisation of research results has gained a lot of attention particular in Europe. Deiacco et al. (*ibid.*, p. 116) provide an overview of this model. One of their conclusions is that the expectations regarding licensing revenues are somewhat overstated. Most of the technology transfer offices (or offices of technology licensing OTL) at US universities are still not breaking even after 10 to 15 years of establishment. Those technology transfer offices that actually earn money with university patents usually get their returns from a very small number of patents. As Lita Nelsen, CEO of MIT’s Technology Licensing Office (TLO) put it “the direct economic impact of technology licensing on the universities themselves has been relatively small (a surprise to many who believed that royalties could compensate for declining federal support of research). Although a very few, and highly visible, “blockbuster” inventions have made tens of millions for universities, most university licensing offices barely break even” (Science 1998, Vol. 279, cited in Deiacco et al. 2002, p. 115). In contrast to the US, university licensing is a rather recent phenomenon in Europe.

Even if universities are increasingly regarded as “important engines of technological development and economic growth” (Klofsten & Jones-Evans 2000, p. 299), the share of governmental funds to universities has been stagnating in the advanced countries in the last two decades (Geuna 2001, p. 614). Universities are expected to interact more frequently with private industry and to adapt more to its needs. As a consequence, knowledge and technology transfer from university to industry is frequently regarded as a panacea to solve a number of economic problems. First, technology transfer is a means to exploit knowledge developed in universities and thus an important factor behind economic growth.² Second, technology transfer can

¹ A related topic is academic entrepreneurship which focuses more on the personal attributes of the researchers. Klofsten and Jones-Evans (2000) mention eight specific types of “academic entrepreneurship” including, for instance, contract research, consulting, external teaching, spin-offs, or patenting/licensing.

² There are a number of studies that confirm the link between university research and innovation/growth, see, for instance, Jaffe (1989), Mansfield (1995, 1998).

generate income for universities in the form of royalties and it can attract research funding from external sources such as private industry.

There are different means to transfer knowledge and technology to the surrounding society. A particular focus in the recent public discussion has been patenting and licensing of research results. Questions and issues about ownership in the research results become important. Especially concerning codified knowledge in the form of patents, the system of intellectual property rights (IPR) can be important. It determines in universities who owns the resource “academic knowledge” and influences the incentives to exploit research results. The ownership issue is important since only the party that owns the research results is legally allowed to transfer it to other parties. This includes the free dissemination of research results.

In some countries the inventions resulting from publicly-funded research are owned by the university scholars. This so-called “university teachers’ privilege”³ is frequently justified with the idealists’ principles of freedom of research and the desire for the independence of research from commercial interests. This idea is based on German idealist philosophy and in particular Wilhelm von Humboldt (Keck 1993).

In Germany, legislative action was taken in 2002 with a university reform. The university teachers’ privilege (“*Hochschullehrerprivileg*”) was abolished⁴ accompanied by support for the establishment of a network of patent and exploitation agencies (*Patent- und Verwertungsgesellschaft*, PVA). These measures are part of the exploitation offensive of the German Government that aims “to put scientific research results faster on the market” (BMBF 2001, p. 2). The main reasons for the abolishment of the university teachers’ privilege (UTP) were that patent output from universities was rather low, the universities did not benefit from exploitation earnings and the UTP counteracted the establishment of patenting and exploitation infrastructure. The German Federal Ministry of Education and Research (BMBF) has concluded that “considerable innovation potential thus goes unused at higher education institutions” (BMBF 2001, p. 4).

In Sweden, the university teachers’ privilege (“*Lärarundantaget*”) still exists. Since 1997, the universities have the “third mission” on their agenda. It means that universities, according to the law, have to fulfil three tasks: teaching, research and interac-

³ It is called privilege because the employer usually owns inventions originating in privately owned enterprises, and not the employee (the inventor).

⁴ §42,43 Arbeitnehmererfindungsgesetz (ArbNErfG).

tion with society in general.⁵ Technology transfer usually falls under the heading of the third mission – even if the third mission is much broader than that.

The public debate focuses a lot on IPRs in research results. The OECD (2002, p. 52) poses the question, “Is granting ownership to the researcher a good formula? In theory, it should increase researchers’ interest in commercialisation. However, putting all the responsibility for disclosing and protecting ownership on a single individual reduces the likelihood of patenting and subsequent licensing”. The European Commission views IPRs somewhat differently: “legislative issues (i.e. laws and legal regulations affecting ISR [industry-science relations]) are perceived by most national experts as having only small effects on the performance of ISR, in a positive or negative sense” (European Commission 2001, p. 336). Unfortunately, there is not much empirical evidence. This thesis contributes with an empirical analysis of the effects of patent rights regulation in universities in Sweden and Germany on the incentives to patent research results.

1.1 The context of the research

As already mentioned, the role of the university in society has changed considerably. In order to illustrate the importance of the patenting of university research and to locate this dissertation in a broader context, this section provides a brief overview of the changing perception of universities for innovation and competitiveness.

Geuna (1999) argues that we can basically distinguish between two major ideas or perceptions of the university since the end of the Second World War. Both perceptions are closely related to the two archetypes described above, namely the Humboldt university and the entrepreneurial university. The first perception of the university rests on the public good argument. Nelson (1959) and Arrow (1962) laid the foundation of the current economics of science. The major idea is that scientific knowledge is characterised as having the properties of non-excludability and non-rivalry in consumption. Both characteristics prevent the creator of scientific knowledge from fully appropriating the returns from investments in knowledge creation. Since the marginal costs of duplicating scientific knowledge are fairly low, scientific knowledge can be characterised as a public good. Thus, it cannot be expected that market forces are able to deliver the socially optimal level of investments in scientific research. This typical market failure argument calls for public investments in scientific research. Those public investments are typically justified by positive externalities that are associated with the production of scientific knowledge. The un-

⁵ §2 Högskolelagen (University laws): ”Högskolorna skall också samverka med det omgivande samhället och informera om sin verksamhet. Lag (1996:1392)”.

derlying assumption of this type of public support is that the transfer of scientific knowledge resembles a linear path. In the course of this conventional “linear model”, basic research leads to applied research and development, development leads to production and production leads finally to marketing. It is modelled as a smooth process down a one-way street (Kline and Rosenberg 1986). Although the linear model is frequently dismissed for its missing feedbacks, it is still used frequently in the public discussion about science and technology policy.⁶ Geuna (1999) argues that public funding under this regime rests on the notion that research output is difficult to measure and that the academic staff is in the best position to evaluate it. Furthermore, the autonomy of the university and its internal social organisation is regarded as the most appropriate means for managing university activities. The outcome of this notion is that public funding of university research is based on academic quality measured by academic researchers *ex ante*. This idea is pretty close to the ideal of the Humboldt university.

With regard to patent rights in research results, Mowery and Sampat (2005, p. 229) claim that “the Bayh-Dole Act is the ultimate expression of faith in the “linear model” of innovation – if basic research results can be purchased by would-be developers, commercial innovation will be accelerated.” The Bayh-Dole Act of 1980 permits universities and small businesses to obtain title to inventions funded by the federal government so as to license inventions (Bozeman 2000, p. 634). The Bayh-Dole Act is frequently used by universities and governments in Europe as a kind of role model to justify university patent rights in research results. After the introduction of the Bayh-Dole Act patenting and licensing at US universities increased heavily. However, Mowery et al. (2001) analysed the effects of Bayh-Dole and came to the conclusion that the Bayh-Dole Act cannot be regarded as the main reason behind increasing university licensing.

The second perception of the university rests on institutional analysis according to Geuna (1999). He claims that in the 1980s and 1990s institutional analysis gained increasing attention. A number of approaches analysed the role of universities with

⁶ According to Pavitt (2005, p. 93), “the range of interactions between firms and universities is considerable. At one extreme, there is something close to the so-called (but relatively rare) ‘linear model’. Here, fundamental research by a university scientist leads to a discovery, its practical importance is recognized by a business firm, which may collaborate with the university scientist in order to exploit it. This happens most often in science-based industries including the chemical, biotechnology, and pharmaceutical sectors, where the focus is on the discovery of interesting and useful synthetic molecules”. The so-called “linear model” of innovation is widely associated with Vannevar Bush and his famous “blueprint” for the US post-1945 R&D system, “Science: The Endless Frontier”.

regard to other actors in the innovation system.⁷ Those theoretical developments were spurred by the quest for relevance of university research to national needs and the pressure for accountability and cost reduction. The university is a complex governance structure and different stakeholders have different objectives. According to OECD (2003a, p. 7), “in addition to the scientific community, and the government as the main funder of the public research enterprise, the business sector and civil society in general have become more active stakeholders.” In particular, goals related to national competitiveness gain attention. “Governments’ main stakes are to seek greater efficiency in their research investment aimed at sustaining national capacities of knowledge production that can benefit society and provide spillovers in the economic sector” (ibid. p. 9). Even private industry is increasingly interested and involved in public research. “The business sector has become a more active stakeholder. Its increasing share in the funding of R&D performed in the public research institutions reflects its growing involvement in knowledge production” (ibid, p. 9). Governments increasingly intervene in the type and scope of university research. Increasing budget constraints led to a competitive approach to the funding of public research as argued by Geuna (1999).⁸ This increased the interest and need for ex post evaluation of university output by market factors etc. Universities are expected to interact with the surrounding society and they are evaluated by external parties and factors. The autonomy of the university is questioned and they are increasingly used as instruments for economic policy. Thus, the role of the university has changed from the fairly autonomous Humboldt archetype to the “interacting” archetype of the entrepreneurial university.

Most scholars of innovation disagree with the linear model that guided the perception and funding of universities in the 1960s. Beise and Stahl (1999, p. 398) argue that “science is only occasionally used in the innovation process and [it] interacts with technological progress (Kline and Rosenberg 1986)”. Thus, it can be argued that academic research is endogenous since academic scientists receive inspiration through collaboration with firms and select highly profitable technological fields where salaries are relatively high. This, in turn, can lead to more industrial support and funding of the researcher in the case of successful collaborative research projects. This is in line with Meyer-Krahmer and Schmoch (1998) who argue that often technology transfer is modelled in a linear way whereas in reality, knowledge and technology transfer is an interactive process. Interactive models of technology trans-

⁷ There are a number of systemic approaches that deal with the role of universities. See for instance, Edquist (1997), Etzkowitz & Klofsten (2005), Etzkowitz & Leydesdorff (2000).

⁸ Geuna (1999) calls this new approach to research funding the “contractual-oriented approach”. Key elements of this approach are that research results from public universities should spur local and national competitiveness. In order to select “useful” research, universities have to compete for resources. Selection criteria that are used are, apart from scientific quality, also the expected benefits for society.

fer seem to be more appropriate.⁹ Particularly important are interaction and feedback between the different stages and people associated with it.

With regard to transfer channels, Gibbons et al. (1994, p. 87) talk about a ‘watershed’ in the history of technology transfer in the universities in Western Europe and the US in the early 1980s. They mention that the traditional ways of technology transfer were the hiring of graduates, publication of research results, and consulting. But in the beginning of the 1980s a number of new channels of knowledge and technology transfer were developed such as university patent offices, liaison programmes, and industrial sponsorship of research groups. Pavitt (2005, p. 93) argues that “the provision of trained researchers, familiar with the latest research techniques and integrated in international research networks, is important to firms”. He argues that industrialists rank it as the greatest benefit provided by universities. Thus, between the extreme of direct applicability of university research results for commercial purposes and the indirect transfer mechanisms via graduates, there is a variety of other, often complementary, processes that link university research with industrial innovation. This includes mechanisms such as collaborative research and contract research funded by industry, university-based consultants, or exchanges of research personnel.

Technology transfer by means of patents and licences seems to be a particularly complex transfer mechanism. It requires the active participation of the inventor. Jensen and Thursby (2001) have shown that the vast majority of university inventions require further development. In a survey targeted at technology transfer offices at 62 US research universities, they found that only 12 percent of the university inventions were ready for commercial use. Furthermore, “over 75 percent of the inventions licensed were no more than a proof of concept (48 percent with no prototype available) or lab scale prototype (29 percent) at the time of license! Thus, an overwhelming majority of university inventions require further development once they are licensed” (ibid., p. 243). Jensen and Thursby’s survey shows that for 71 percent of the inventions licensed, successful commercialisation requires further cooperation by the inventor and the licensee. This clearly indicates the relevance of the chain-linked model of innovation since it can illustrate the feedback between the users and developers of new technology and its inventors. It is likely that university inventions encompass a large share of tacit knowledge which is difficult to codify

⁹ One of the best known models that incorporates feedback loops is the chain-linked model by Kline and Rosenberg (1986). In this model, the different stages of an innovation are potential market, invent and/or produce analytic design, detailed design and test, redesign and produce, and distribute and market. Those stages are linked with each other through feedback loops. But most important, in parallel to the different stages is a kind of knowledge base “fed” by research and modern science. This kind of scientific knowledge is not regarded as the initial step but is employed at all points along the different stages of innovation.

and even to articulate. This type of idiosyncratic knowledge is difficult to transfer. Consulting assignments by researchers can help in this context.

The broader developments with respect to the perception and funding of universities and the changes in the innovation process indicate that universities face a number of internal and external constraints. This is in line with Geuna (1999, p. 13) who characterises universities as "socio-economic organisations whose economic behaviour is influenced by external opportunities and constraints. Like other non-profit organisations, they have a multiplicity of objectives depending on the tasks they accomplish, the organisation they have, and their status as public or private institutions". Different competitive research-funding sources create diverse incentive structures. According to Geuna (2001, p. 623), "researchers and, in general, research organizations face different incentives and constraints depending on the source of the funds upon which they rely." The incentive structure in universities is important in order to understand and explain the behaviour of university researchers with respect to patenting and commercialisation of research results. Particularly important is the academic reward system and the funding of research.

Constraints of the Academic Reward System

The academic reward system constitutes a major factor that impacts on the incentives of academic researchers. One has to consider the motives of researchers to join the university instead of conducting research in corporate research laboratories. Dasgupta and David (1987, 1994) argue that the realms of science and technology are separated more by their social organization and reward structure than by the actual character of their work. Researchers at universities and in industry are "pre-committed" to different norms and rules of the game. For researchers in university, priority of discovery is the goal, and publication the means through which new knowledge is shared in timely fashion. In contrast, patents are important merits for the researcher in a corporate lab. Rewards are pecuniary and it seems that the incentive to divulge new information quickly is not as potent. Thus, publications in renowned scientific journals seem to be the means to respond to the academic reward system since publications lead to reputation and respect in the scientific community. Appointments to professorships rely mainly on scientific quality as measured by publications.

In relation to the reward system, employment security plays a crucial role in universities. Professors that hold a chair frequently receive long-term tenure and quite favourable pension conditions. High employment security could also mean that the scholars are independent from commercial interests. Since a tenured position is an important career goal for academics, they respond to the academic reward system to

climb the career ladder. Thus, it is likely that especially younger scholars devote their time to publishing research results since publications in renowned journals increase their chances to get a tenured position.

Funding

There are also other constraints in the internal governance structure of universities that might lead to predictable behaviour when it comes to patenting and commercialisation. One important constraint is the source of funding. We can distinguish between base funding and external funding. External funding means that the decision about funding is made outside the universities via research councils, governmental departments, private industry, foreign sources etc. Within external funding there are public and private sources of research funding. Direct government funds, e.g., research contracts and earmarked funds, and grants from the EU are also included. Base funding is given in a lump-sum to the university by the State and is mainly based on past expenditure levels. According to Geuna (2001, p. 610), this type of funding was the most prevalent until the early 1980s. Geuna has shown that the share of funding from private industry, foreign sources and foundations has increased in Europe during the last two decades. There is also a general trend towards project-based research that is funded by external sources such as research foundations and research councils. One consequence is a decrease of the share of base funding.

In countries with stagnating or decreasing base funds for university research, individual researchers have to raise funds from alternative sources. One way is to contact private enterprises and private or public funding agencies to get research funding. Thus, in times in which base funding by public authorities stagnates or even declines, funding by private enterprises and private or public foundations and councils is becoming more important. It seems also that private funding of public research is becoming more important since it suggests the solution of a number of problems at the same time. Mowery and Rosenberg (1993, p. 53) claim that one of the main challenges for industry is that its competitive advantage depends increasingly on the utilization of scientific research. But increasing costs of corporate R&D make it difficult for private enterprises to maintain own R&D labs. Contract research at public universities seems to be a solution to this problem. At the same time, universities and researchers face stagnating or decreasing base funds and appreciate industry-funded research as a means to overcome financial difficulties.

Relevant in this context is the IPR regime since some sources of funding (e.g., private enterprises, industrial consortia) make funding dependent on a transfer of property rights for the research results.

The university is a complex governance structure where different stakeholders (e.g., state, financiers, firms, researchers) pursue partly different goals. The previous discussion has shown that the incentives in universities are important. In addition, there are a number of public actors that support technology transfer which influences the incentives of researchers to commercialise research results as well. Jensen and Thursby (2001) have shown that the objectives of technology transfer office (TTO), administration, and researcher can be quite different from each other. The major objective for TTOs is revenue whereas sponsored research seems to be more important for researchers. This is in line with findings from Siegel et al. (2003) and Bercovitz et al. (2001) who illustrate that different objectives of the stakeholders involved in technology transfer can lead to serious conflicts and disincentives to disclose university inventions.

The supportive infrastructure plays an important role for the patenting and commercialisation of research results from universities. According to Goldfarb & Henrekson (2003, p. 640), “in order to understand the incentives created by intellectual property rights, it is imperative to understand the larger institutional context”. Bercovitz et al. (2001, p. 21) propose that “technology transfer activities, manifested as eliciting and processing invention disclosures, licensing university-created knowledge, seeking additional sponsorship of R&D projects or a combination of these three, are shaped by the resources, reporting relationships, autonomy, and/or incentives of technology transfer offices (TTOs).” Thus, the organisation of support is important. This includes private as well as public actors. Bercovitz et al. (2001) have found that organisational variables affect the relative productivity of university technology and licensing operations. They found that “faculty, particularly those in materials sciences, engineering and/or agricultural sciences, are reported to be accepting this trade-off valuing immediate support of ongoing research (and importantly, the funding of graduate students) over licensing returns” (ibid., p. 31). Thus, it seems that there is a trade-off between external funding and royalty income that could hinder commercialisation of research results. The organisation of support for patenting and licensing is thus of tremendous importance.

In sum, universities act in a changing environment. The innovation process and the demands on universities are changing as well as the funding and internal structure of universities. The perception of universities moved from autonomous “ivory towers” to vital elements of innovation systems. Most universities reacted to those changes by building up structures that support knowledge and technology transfer such as liaison offices and technology transfer offices. The underlying hope behind those

structures is that they create additional income for the university in times of stagnating or decreasing public funds. However, central to the success of knowledge and technology transfer is the individual researcher. Successful transfer requires active participation by the researcher. It is therefore central to understand the incentives that the researchers face. Those incentives are influenced by different factors, such as the academic reward system and the funding structure, but the organisation of support also plays a role. Furthermore, the question about patent rights in research results is a relevant one since it determines who is legally allowed to commercially exploit knowledge created at universities.

1.2 Purpose and overview of the book

The purpose of this thesis is to assess the impact of patent rights regulation in universities in Germany and Sweden.

The basic research question that will be addressed is:

What are the incentive effects of patent rights regimes in the university? In the case of Germany this means in particular: Does the abolishment of the university teachers' privilege decrease or increase incentives to patent? In the case of Sweden this means: Does the university teachers' privilege give positive or negative incentives to individual researchers to patent? In general, is patenting of university research more frequent in a regime where the researcher owns the results? Furthermore, this thesis investigates the role of technology transfer offices and other intermediaries in both countries in order to assess whether the TTOs etc. impact on the incentives of researchers to disclose inventions and to apply for patents.

As already mentioned, there are a number of different ways to transfer knowledge and results from university research. As Czarnitzki et al. (2000, p. 18) have shown, there are different mechanisms and means for knowledge and technology transfer, such as publications, collaborative research, educating students, and spin-offs.

This thesis assesses the impact of patent rights regulation and, as such, it focuses in particular on patents. It focuses thus on a rather small share of university research. Most of the research results can be published in scientific journals but the extent to which research results can be patented varies. Only tangible products can be pat-

ented which limits the analysis to university departments in which patenting is an option. Furthermore, the patenting procedure is quite time-consuming which decreases the importance of patents in industries with short product life-cycles. Since patenting is of limited importance in a number of scientific disciplines, this study is limited to researchers in the natural sciences, engineering sciences, and medical sciences in Sweden and Germany.

The thesis is structured in the following way: Chapter 2 presents the methodological approach of the thesis. The thesis combines qualitative and quantitative methods and a detailed account of the chosen methods is provided in that chapter. Chapter 3 provides the reader with background information about the role of universities and the structure of science systems in both countries. It elaborates on intellectual property rights and patenting. Furthermore, a description of the processes of patenting and commercialisation in both countries that builds upon the qualitative study is presented. The theoretical approach is presented in chapter 4. The theoretical approach focuses on incentives in universities and results in a theoretical model. The theoretical model is applied and tested in chapter 5. The quantitative analysis builds upon a survey of university professors in Sweden and Germany. The quantitative analysis provides a quite abstract and crude picture of patenting in both countries. In order to improve the quality of the results, the quantitative results are interpreted and enriched with the results of the qualitative interview study. Chapter 6 concludes.

2. Methodology

2.1 *Methodological approach*

The methodology of the dissertation combines analyses on an organisational (i.e. university and technology transfer offices) and individual (i.e. university researcher) level and uses both qualitative and quantitative methods. The impacts of different patent rights regimes in universities on the incentives to patent research results are analysed by

- comparing two countries with different patent rights regimes in universities: Sweden and Germany;
- considering different organisational environments within one country, i.e. types of universities with regard to disciplinary orientation, the organisation and history of technology transfer, size, age etc.

The dissertation applies a comparative approach. According to Franz (2000), the study of experiences from other countries can be helpful in situations where economists have well-founded presumptions but where it is difficult to quantify the effects of legal changes due to counteracting effects. This is true particularly for changes in the institutional framework. This institutional benchmarking has increased in importance in the last decade. The initial step in benchmarking is the choice of countries according to Ochel (2004).

The countries under consideration are Sweden and Germany. Sweden is used for analysis because it still has the university teachers' privilege. Germany is chosen because it recently abolished the university teachers' privilege. This case will enable us to study the effects of a change of this legal institution on patenting and commercialisation paying special attention to the role of technology transfer offices (TTOs) in this changing environment. It has to be mentioned that benchmarking is particularly interesting for countries with similar characteristics, otherwise institutional learning is limited. Furthermore, functional equivalence has to be taken into account. Functional equivalence means that the same goals in two countries can be achieved with different institutions and organisations. This is particularly important with respect to the actors in the supportive infrastructure.

The second step in the benchmarking process is the choice of institutions. In our case, the patent rights regimes governing ownership in research results in both countries. They are part of the employment laws governing the relation between researcher and university. Finally, Ochel (2004) mentions enforcement as the third stage in the process of benchmarking. Enforcement of institutions is important since only institutions that are also enforced by the authorities are likely to show impact. It has to be mentioned that the analysis of enforcement is difficult. There is always a risk that respondents conceal their real intentions and behaviour since they may be acting against the law. Thus, questions assessing enforcement should be posed in a rather indirect way.

The effects of patent rights regulation in universities will be assessed on the organisational level as well as on that of individual researchers. The analysis on the level of individual university researchers (professors) aims at identifying the effects of patent rights regimes on individual behaviour with respect to patenting. Special attention is paid to the impacts of changes in the institutional and organisational environment for patenting and research commercialisation, such as changes in the patent rights regime (Germany) and changes in supportive infrastructure (TTOs). This analysis is quantitative and aims at estimating the parameters of an econometric model. The analysis yields a substantial amount of descriptive data about patenting at universities in general, hindrances to patenting, research funding, the academic reward system, support etc.

At the organisational level, i.e. universities and TTOs that represent universities, a qualitative approach is pursued. In-depth interviews with selected technology transfer offices at universities are used to analyse the impact of different organisational frameworks on patenting and commercialisation activities *within* a certain patent regime. Its focus is the role of technology transfer offices and other intermediaries. The interviews are used to describe the technology transfer process from the perspective of the university and its TTO. The responses in the interviews are furthermore used to interpret the results of the quantitative analysis.

The particular strength of this dissertation is the combination of qualitative and quantitative methods. The qualitative analyses offer a description of the processes of knowledge and technology transfer in a rich and detailed way whereas the quantitative analyses provide structural data and analyses covering a fairly large number of university researchers in both countries. According to Bryman (1997), the particular strength of qualitative methods is the focus on processes from the perspective of the actors, whereas quantitative methods focus on static analyses of structural patterns primarily from the perspective of the researcher. It can be argued that social scientists can have more confidence in their research results if those research results are "produced" through different methods. This is also the general logic behind triangu-

lation. According to Palmberg (2003, p. 36), “triangulation refers to the combination of different methodologies for securing different types of validity (i.e. methodology triangulation)”. Qualitative and quantitative methods are different methods to study the same research question. The quantitative survey was used to collect data from a large number of professors. In the course of the qualitative interview study, a limited number of professors were interviewed. This shows whether the general results from the quantitative analysis hold. In addition, economic reasons called for a survey of researchers instead of interviews since interviews are a rather expensive method of data collection with respect to travel costs and time. In sum, the qualitative study provides a rich variety of empirical data including anecdotic evidence. The quantitative study provides structural data covering a large number of respondents. Table 2-1 provides an overview of the general differences between qualitative and quantitative research approaches.

	Quantitative	Qualitative
(1) Role of qualitative research	preparatory	means for exploration of actors' interpretations
(2) Relationship between researcher and subject	distant	close
(3) Researcher's stance in relation to subject	outsider	insider
(4) Relationship between theory/concepts and research	confirmation	emergent
(5) Research strategy	structured	unstructured
(6) Scope of findings	nomothetic	ideographic
(7) Image of social reality	static and external to actor	processual and socially constructed by actor
(8) Nature of data	hard, reliable	rich, deep

Table 2-1: Differences between quantitative and qualitative research.

Source: Bryman (2000, p. 94). Printed by permission of Routledge Ltd.

Table 2-1 illustrates the longstanding debate about qualitative and quantitative methods. Basically, the interview study in this thesis provides rich and profound information about the process of patenting and the role of the actors in the infrastructure from their own perspective. Although qualitative research is characterised as unstructured with idiographic results, the aim of the qualitative study is to use the material from the interviews and additional studies of the actors in the infrastructure to provide a kind of overview or stylised model about the process of patenting and

commercialisation of university research in both countries which is valid not only for the eight universities studied but for a larger population of universities. A theoretical model (although preliminary in nature) was developed before the interviews were conducted. The relation between researcher and research subjects (i.e. the actors in the infrastructure, professors) was less close than in traditional ethnographic studies but not as distant as in the survey. With regard to the quantitative study, the type of information provided is 'hard' and reliable. The model tests causal relationships in a rather static way and the results can be generalized. The research strategy is structured and rather distant with regard to the relation between researcher and respondents. In sum, a combination of qualitative and quantitative approaches increases the credibility of the research results.

The whole dissertation project consists of two empirical studies. Detailed descriptions of the chosen methods can be found below.

2.2 Method of the qualitative study

This thesis investigates the role of technology transfer offices and other intermediaries in both countries in order to assess whether the TTOs etc. impact on the incentives of researchers to disclose inventions and to apply for patents.

A qualitative case study method was chosen since this approach fits the exploratory purpose of this study quite well and it "allows an investigation to retain the holistic and meaningful characteristics of real-life events" (Yin 1994, p. 3). Furthermore, this thesis analyses incentives of researchers in two different countries. Incentives are difficult to measure and qualitative evidence can be used in order to interpret and understand the results of the quantitative survey. In addition, the establishment of transfer infrastructure is quite recent in Germany and quantitative data is lacking to a considerable extent. Quantitative analyses require a larger sample. Sweden has only a small number of universities and rather few TTOs, thus, quantitative generalisations have limited value. Another reason for a qualitative study is the lack of patent data. Patent data is published at the earliest 18 months after the application was submitted to the patent office. The university teachers' privilege was abolished in Germany in 2002. That means that the first patent data after the abolishment was available in the beginning of 2004 covering the first half of 2002.¹⁰

¹⁰ According to Gering & Schmoch (2003, p. 80), "from a methodological point of view it is not possible to provide reliable statistics on university patents and licences in Germany. Until the abolishment of the university teachers' privilege the professors privately owned their inventions". Nevertheless, "it is possible to provide quite reliable statistics on inventions made by professors because in Germany the title "professor" is exclusively used for university professors, and they generally use it in official documents." (ibid, p. 80). Patent databases

According to Siegel et al. (2003), an interview-based study involves four methodological issues. First, issues concerning the sample selection have to be taken into account. Second, the nature of the interview questions plays an important role. Third, the researcher has to elaborate on the procedure for conducting the interviews. Fourth, the qualitative data analysis has to be addressed. The four issues will be discussed in turn.

First, a sample has to be selected. A relevant issue in this context is which persons are able to provide information that is important for answering the research question. Stakeholders from universities and independent intermediaries dealing with the patenting of research results were chosen. At universities, interviews with representatives from the university's technology transfer office (TTO) or university holding company and similar bodies were conducted. Representatives from independent intermediaries – in Germany PVAs (*Patent- und Verwertungsagentur PVA*) and in Sweden TBS (*Teknikbrostiftelser TBS*) – were interviewed. In most cases, the CEO was interviewed. In addition, interviews with researchers were conducted to get an idea about how they perceive infrastructure and the process of technology transfer. Interviews with stakeholders at four universities in Germany and four universities in Sweden were conducted. To ensure comparability, universities of technology and universities with strong technology faculties were chosen since patenting and commercialisation issues are most important and relevant in the natural sciences, engineering sciences and medical sciences.

The subjects chosen to identify the universities were civil engineering, electrical engineering and mechanical engineering. Nevertheless, the results are valid for other engineering subjects, and the natural and medical sciences as well, since the TTOs, holding companies, TBS and PVAs have a broad focus servicing invention disclosures and commercialisation for a broad range of scientific disciplines. In Germany, university rankings by the Centre for University Development were used to identify the German universities (Berghoff et al. 2002 & 2003). The RWTH Aachen was chosen since it is in the group of top universities in Germany in basically all of these subjects. The University of Technology Hamburg-Harburg (TUHH) was chosen because it is the youngest of all the universities of technology in Germany, founded in 1978, and it was the first German university that transformed its technology transfer office into an independent firm as a limited corporation. This served as a model

can therefore be searched for the title “professor” in the inventor category. Unfortunately, Swedish professors are not so keen on using their title as their German counterparts as a tentative search in patent databases confirmed. Thus, although it is possible to identify patents from single universities (see for instance the study of Linköping University by Schild 1999), it is too time-consuming to map patenting activities for all German and Swedish universities.

even for other universities. The university of Karlsruhe is the oldest university of technology in Germany and it has a strong reputation in engineering. The university of technology Berlin (TUB) has a strong record in electrical engineering. In Sweden, the two largest universities of technology, the Royal Institute of Technology (KTH) in Stockholm and Chalmers University of Technology in Gothenburg, were chosen. In addition, Linköping University was chosen because it is a quite young university with a strong technology faculty. Lund University was chosen since it has a quite long history of university-industry collaboration. Particularly important is Ideon, the first science park in Sweden, which was founded in 1983.

It is important to mention that universities fall under the responsibility of the federal states in Germany. The German universities are located in four different federal states and every federal state has its own PVA. In Sweden, every university region has its own TBS. The CEOs or directors of the different organisational units were interviewed. In total, 23 interviews were conducted.

Second, the theoretical framework was used to design an interview guide. At least two semi-structured interviews per case were conducted - one interview with a responsible person in the university (university holding company and similar bodies in Sweden, technology transfer office and similar bodies in Germany) and one interview with a responsible person (in most cases the CEO) in an intermediary organisation (technology bridging foundation in Sweden, patent and exploitation agency in Germany). Additional data was collected through Internet research and other sources. Interviewees were asked the same questions, although some questions were tailored to a particular group. The interviews were conducted in Swedish and German to avoid interpretation errors.¹¹ According to Siegel et al. (2003), the best approach for an exploratory study is to ask open-ended questions, such as “what is the role of your organisation” or “how could the situation be improved”. During the interviews, a “steering” or channelling of the answers was avoided.

Third, the procedure for conducting the interviews requires attention. The interviews were conducted in two ways. Most of the interviews were face-to-face interviews. In the literature it is claimed that this type of interview is the best way when conducting an inductive study on a controversial topic. Face-to-face interviews have a number of advantages.¹² It is possible to ask a number of complicated questions and it is possible to reduce obscurities through additional information. It is easier for the respondent to answer open questions and the trustworthiness of the answers increases due to the development of a personal relation during the interview. A number of disadvantages have to be taken into consideration. Face-to-face interviews are

¹¹ The author is fluent in German and Swedish.

¹² For the advantages and disadvantages of different types of data collection techniques, see Dahmström (2000).

rather expensive and time-consuming which limits the number of interviews that can be conducted in such a way. In addition, interviewer effects can occur since the personal relation can impact on the answers. There is a risk that the interviewees answer the questions in the way that they think the interviewer expects or “likes”.

The second type of data collection was telephone interviews to get complementary data. As with face-to-face interviews, a number of advantages favour telephone interviews. It is a quite fast and cheap way of data collection particularly in comparison with face-to-face interviews. Obscurities related to the questions can be sorted out. Telephone interviews have a number of shortcomings. It can be quite difficult to arrange a telephone interview. It is very difficult to establish a personal relation between interviewer and respondent. This can lead to refusals to take part in the study on the side of the interviewees.¹³ The time for telephone interviews is usually limited and it is difficult to ask complicated and sensitive questions. The environment can disturb the interview, in particular when interviewees answer other phone calls. There is a risk of less thought-out answers. Therefore, telephone interviews were primarily used to increase the amount of qualitative data and for verification of the results from the face-to-face interviews.

Fourth, there are a number of different stages of qualitative data analysis according to Miles & Huberman (1994): data reduction, data display, and conclusion drawing/verification. The different stages are intertwined and can be characterized as a continuous, iterative process. According to Miles & Huberman (1994, p. 10), “*data reduction* refers to the process of selecting, focussing, simplifying, abstracting, and transforming the data that appear in written-up field notes or transcriptions”. It is a part of the analysis and depends pretty much on the researcher’s judgement which data to include in the transcript and which data to exclude. Data reduction sharpens, sorts, focuses, discards and organizes data in such a way that conclusions can be drawn. In this study, most of the interviews were taped and transcribed roughly focusing on the essence of the content of the interview.¹⁴

The second stage in the analysis is *data display*. “Generically, a *display* is an organized, compressed assembly of information that permits conclusions drawing and action” (Miles & Huberman 1994, p. 11). The first type of data display in this study is the transcriptions of the interviews. This provides a first display of the (reduced) interview data. To summarize the data from the interviews and to display the data in a more comprehensive and accessible way, diagrams illustrating the relations between the different actors were developed. The interviewees’ responses about the process of patenting and commercialisation were transformed into stylized models.

¹³ In some instances, I was not able to conduct telephone interviews with people I wanted to include in the sample. Reasons were the interviewees’ lack of time or that they simply refused to take part in the study.

¹⁴ Some respondents did not like the interview to be recorded. Those wishes were respected.

As mentioned by Miles and Huberman, data display is an integral part of the analysis. It eases the drawing of conclusions.

The third stage is *conclusion drawing and verification*. Miles & Huberman (ibid., p. 11) claim that “from the start of data collection, the qualitative analyst is beginning to decide what things mean – is noting regularities, patterns, explanations, possible configurations, causal flows, and propositions.” Prior to the data collection, the theoretical model was developed. This theoretical model was used to develop the interview guide. During the interviews, specific follow-up questions were posed tailored to the specific circumstances of the cases. In the process of conclusion drawing and verification, conclusions are also verified as the analysis proceeds. The analysis of the transcriptions revealed a number of common issues that emerged in most of the interviews. Those common issues and topics are used to analyse and interpret the results of the quantitative survey.

It has to be mentioned that this study is not a detailed study of patenting at eight universities. The eight cases are only used to illustrate the process of patenting and commercialisation in two countries. Therefore, the analysis presents the most important results in two countries and not particularities of eight universities.¹⁵

2.3 Method of the quantitative study

Regulatory regimes of intellectual property rights (IPRs) represent incentives and barriers that affect decisions of individual researchers at universities. In order to analyse these effects, a survey of university researchers in Sweden and Germany was conducted. The survey reveals motives, incentives and barriers towards patenting and research commercialisation. Further questions cover the relation between publication, patenting, external funding and academic career. The role of patenting with respect to other technology transfer activities and the role of technology transfer offices is assessed. The survey was carried out as a standardised questionnaire distributed via the Internet.

This section describes the method employed in the survey. Three basic questions have to be answered when conducting a survey according to Dahmström (2000). The first question is what will be studied? It is about the subject of the study. What social phenomenon do we want to explain? It refers to the link between theoretical concepts and empirical measurement and results in the questionnaire as measurement instrument. The second question is who will be studied? The quantitative study focuses on university professors. Questions of interest are what kind of professors

¹⁵ A more detailed account of the eight universities studied can be found in Sellenthin (2004).

and researchers should be included in the survey and addresses issues related to the sampling frame. The third question is how the study will be conducted, which focuses on the sampling procedure, the process of data collection etc. In addition, issues concerning the quality and credibility of the survey responses are addressed.

2.3.1 The questionnaire as measurement instrument

The underlying logic of the survey study is that in a first step theoretical elaborations have to “deliver” the variables that are of interest with respect to the purpose of the study. The theoretical chapter of this dissertation discusses theories and concepts related to the research question. The outcome of the theoretical elaborations is a rather simple model about the patenting of university research (see figure 4-2). Furthermore, a few hypotheses are introduced in order to speculate about the relationships of a number of independent variables and the dependent variable “patenting”. A limited number of variables and factors were chosen as predictors of the patenting decision. A questionnaire was developed as a measurement instrument.

The validity and reliability of the survey are important. Ideally, the questions should directly measure what the researcher is interested in. Obviously, this is rarely the case in the social sciences. An important step in a survey study is therefore the operationalization of the theoretical concepts. The purpose of this study is to measure the impact of patent rights regimes on the incentives to patent research results. The aim is, therefore, to test whether the university teachers’ privilege or its absence matters for patenting activities. The university teachers’ privilege is only valid for inventions that can be patented. The dependent variable that is used in this survey is “patent application 2002-2004”. The university teachers’ privilege was abolished in Germany in the beginning of 2002. Thus, the German responses cover the situation without the UTP.¹⁶ There are reasons that make it difficult to assess the new regulation. One reason is old funding contracts where the IPRs are negotiated differently. Another problem could be that respondents are not well informed about the legal changes.

A number of independent variables have to be considered. The primary interest lies in the impact of the IPR regime. The comparative design (comparison Sweden-Germany) takes into account the different formal IPR regimes. In addition, the ques-

¹⁶ Since February 7 2002, the UTP is no longer valid in Germany. Thus, there is a small risk that researchers answered with regard to a patent application dating from January 2002 when the UTP was still valid, although this risk can reasonably be neglected. The data was collected in April and May 2005 including a reminder.

tionnaire includes questions about the perceived patent rights regime. Researchers were simply asked “who owns your research results?”. Theoretical considerations and empirical results from the qualitative study and other studies made clear that a number of additional independent variables have an impact on the dependent variable. Those variables include the structural factors, such as the funding system, the research orientation, and the reward system. In the survey, researchers were asked whether they received support from TTOs and other actors in the supportive infrastructure. It was asked whether researchers who did not get support at least knew the actors and the kind of support that they could expect. As such, variables that measure the functioning of the supporting infrastructure were included as independent variables in the survey.

Operationalisation in this case proceeds basically in three steps. The first step was the general theoretical model presented in the theoretical chapter of this dissertation. Second, the model was used to develop hypotheses about the strength and direction of the different factors. Third, a questionnaire was developed to test the different hypotheses. In general, the operationalisation moved from a very general model to a number of particular questions in the questionnaire. In particular, the questionnaire deserves more attention. Designing a standardized questionnaire is not an easy task. Converse and Presser (1986) present a number of possible mistakes and interpretation problems associated with standardized questionnaires. A standardized questionnaire is sent to a large population of potential respondents. Already the covering letter sent with the questionnaire has to be formulated very carefully in order to ensure a high response rate. The covering letter should inform about the study and the different questions in the questionnaire. It should address the potential respondents in such a way that they are willing to take the time to answer the questionnaire. The wording of the questions is another major source of failure in a survey study. Do the respondents understand the wording of the questions and the concepts associated with them? To check for interpretation errors and possible mistakes, the questionnaire was proof-read by a number of colleagues.¹⁷ In addition, a pilot survey was conducted and questions arising and comments by the respondents were taken into consideration when designing the final questionnaire. Another important question when designing a questionnaire is whether the respondents are able to answer the questions. Do they actually have access to the type of information demanded in the questionnaire? One example is questions about funding. The questions about funding are posed to leaders of research groups only, since it is likely that only those individuals possess this type of information. Furthermore, a rather differentiated questionnaire was used to account for differences in patenting activities. For instance, researchers who did not apply for a patent between 2002 and 2004

¹⁷ In particular, Johanna Nählinder did a great job and provided me with a lot of comments and suggestions for improvement. Furthermore, Staffan Laestadius gave feedback regarding the questionnaire. Francis Lee helped me with the English translation of the questionnaire. The questionnaire was available in Swedish, German, and English.

had to answer a substantially shorter version of the questionnaire than those researchers who did apply for a patent. This was possible because the data collection was web-based and some questions in the questionnaire were made dependent on how other previous questions were answered. To avoid confusion and fatigue, the respondents could only see those questions that they were supposed to answer on the screen.¹⁸ The questionnaire is shown in the appendix.

2.3.2 Sampling issues

The survey studies researchers at universities in Sweden and Germany. It focuses on senior researchers (*Hochschullehrer, lärare*) since only senior researchers own research results in a regime with university teachers' privilege.¹⁹ It focuses on universities and neglects university colleges and polytechnics (*Fachhochschulen, högskola*) because most of the publicly financed research is conducted at universities.²⁰ The survey includes senior researchers from departments where patenting is an option, such as the natural sciences, engineering and medical sciences. Two registers are used that include the population that is studied. The register of the German population is "Vademecum der Wissenschaft" (Vademecum 2003).²¹ In general, Vademecum contains e-mail addresses and classifications (e.g., size of department, subject classification) for all departments at German universities. The register for the Swedish population was "built" from homepages etc. There is no "Vademecum" database in Sweden.²²

¹⁸ For instance, researchers who did not apply for a patent 2002-2004 did not even see the questions for those who did apply for a patent since the questionnaire "jumped" over the patenting questions since the respondents chose "No, I did not apply for a patent".

¹⁹ Only senior researchers (*lärare*) own their research results according to the university teachers' privilege (*§ 1,2 Lagen om rätten till arbetstagares uppfinningar 1949*). Scholars include professors and lecturers (*docent, universitetslektor*).

²⁰ For instance, Beise and Stahl (1999) have shown that the R&D share of polytechnics in Germany is only about 5%.

²¹ Problems with Vademecum are that it only includes full professors who hold a chair. Thus, it does not include other researchers, for instance PhD candidates. Another problem is that in some cases the e-mail address of the secretary of the professor is included in Vademecum and not the personal e-mail address.

²² The Swedish register that was designed has shortcomings as well. For instance, the homepages of the departments could be wrong or not regularly updated. The register contains all Swedish universities and those university colleges that are allowed to graduate PhDs.

In sum, the survey is limited to senior researchers (primarily professors) at technical and medical faculties (the disciplines considered in the survey are the natural sciences, engineering and medical sciences, incl. pharmaceuticals) at universities in Sweden and Germany. The survey includes a sample of university researchers and not the total population. Thus, different sampling and estimation methods have to be considered.

As mentioned by Jacob (1984), sampling error can only be estimated when one is working with data collected through a random sample. The law of large numbers states that with a large number of samples, the mean of the sample means will equal the mean of the population. Furthermore, the central limit theorem states that if we draw numerous large samples, the means of those samples will approximate the bell-shaped curve of normal distribution. This means with simple random sampling (SRS) we can statistically infer parameters from our sample about the whole population. The error stemming from the inference from sample about population can be estimated by statistical techniques. In practice, the sample selection is more complex than simple random sampling. Each sampling design that deviates from SRS should include an elaboration about the design effect of the chosen design.

The questionnaire was sent to a stratified sample of university researchers (full professors) in natural science, engineering and medicine at research universities in Sweden and Germany.

The sampling elements are individual professors. The questionnaire collects data about their individual experiences and attitudes in relation to the patenting and commercialisation of research results. If the professors hold chairs or are leaders of research groups or institutes, structural features such as funding of their research group are assessed as well. The Swedish sampling frame contains the elements (professors) of the survey. In contrast, the German sampling frame contains primarily data from research groups etc. As such, the sampling frame does not contain the elements of the survey but it does contain clusters of elements since in many cases institutes or research groups consist of a number of professors. This has consequences for the sampling procedure.

A sampling procedure using stratification was used for the survey. According to Kalton (1983, p. 19), “the essence of stratification is the classification of the population into subpopulations, or strata, based on some supplementary information, and then the selection of separate samples from each of the strata”. Stratification is commonly used since the sample sizes in the strata can be controlled by the sampler, rather than being randomly determined by the sampling process. It is important that all strata are represented in the sample and it is advantageous if they are internally

homogenous in the survey variables. Stratification can also be achieved by systematic sampling. This is also called implicit stratification. "Implicit stratification involves listing the population by strata, then taking a systematic sample throughout the list" (Kalton 1983, p. 28). Systematic sampling is commonly used since it is very easy to apply. Systematic sampling means simply taking every k -th element after a random start. Like simple random sampling (SRS), systematic sampling gives each element in the population the same chance of being selected, however, it differs from SRS in that the probabilities of different sets of elements being included in the sample are not all equal. "For example, the probability of including both the i -th and $(i+k)$ -th element is $1/k$ in a systematic sample, whereas the probability of including both the i -th and $(i+k+1)$ -th is zero" (Lee et al 1989, p. 11). Those problems can be overcome by repeated systematic sampling. This means that several smaller systematic samples are selected going down the list several times with a new starting point in each pass instead of taking a systematic sample in one pass through the list. Another advantage of replicated sampling is that the variance of an estimate from all the subsamples can be estimated from the variability of the separate estimates from each subsample. Furthermore, repeated systematic sampling reduces the risk for periodicity in the sampling frame. Thus, for the Swedish sample a repeated systematic sampling procedure using stratification was used. The total sample was divided into eight subsamples.

The adjusted Swedish sample contains 1347 professors, of whom 390 are in the natural sciences, 489 are in the engineering sciences, and 468 in medicine. The Swedish sampling frame was built from scratch from the websites of the universities during autumn 2004. Missing elements in the frame can occur since not all universities update their websites continuously. According to the NU-database from the Swedish agency for higher education (HSV 2005) at Swedish universities there are in total 634 professors in the natural sciences (fulltime equivalents), 715.4 in the engineering sciences, and 793.1 in medicine. Thus, the sample used for the survey has a rather high coverage of the total population.

As already mentioned, the sampling frame for the German population is somewhat different. It contains clusters of elements (research groups). This requires a different sampling approach. Multistage cluster sampling was applied to the German population. In a first stage, clusters are selected from the primary sampling frame (Vademecum). For those selected clusters, in a second stage, the elements are selected by using a random selection procedure. The clusters were selected by a repeated systematic sampling procedure using stratification. According to Kalton (1983), the primary justification for cluster sampling is the economy it creates for sampling and data collection. It would have been too time-consuming and costly to find e-mail addresses for all German professors. Thus, cluster sampling was used to identify those clusters for which e-mail addresses were needed. As in the Swedish case, the German total sample was divided into eight sub-samples.

The adjusted German sample contains 3298 professors, of whom 1081 are in the natural sciences, 1070 in the engineering sciences, and 1147 in medicine.²³ According to Statistisches Bundesamt (2003), in Germany there are in total 7783 professors in natural science and mathematics, 3383 professors in medicine and veterinary medicine, and 8401 professors in engineering science. Thus, the German sample used for this survey has a rather low coverage.

Sampling error is a severe type of error. The usual aim of a survey study is to calculate estimates that are valid for the whole study population derived from a small sample of units of the population. In the case of census of the total population, there is no sampling error since the estimate (e.g., the statistical mean) of the sample is equal to the estimate of the census. The deviation of an estimate based on a sample in relation to an estimate based on the census is called the sampling error. Standard errors for a number of variables with regard to the complex survey design used are shown in table 8-1 in the appendix.²⁴

²³ A fairly large number of e-mail addresses included in the sampling frame were wrong and the request to participate in the study was instantly returned to the sender. The sample consists only of those researchers who actually received the questionnaire.

²⁴ Table 8-1 in the appendix presents the standard errors for the variables size of research group, share of base funding, share of industry funding, and share of researchers who applied for patents 2002 – 2004 (either themselves or by a third party). The mean for the whole survey and the means for the eight sub-samples are shown. Since replicated sampling was applied, the means of the sub-samples can be used to calculate the variance and standard errors based on the applied sampling design. The relation between standard error based on the applied sampling design and simple random sampling (SRS) shows increased (if relation is less than 1) or decreased (if relation is above 1) precision of the estimation of the mean. In Germany, the precision of the estimates is somewhat higher in the applied survey design as if SRS had been applied with the notable exception of the variable base funding. In Sweden, the precision of the survey estimates is somewhat lower than in the case of SRS. Stratification usually increases the precision of sample estimates. For a thorough discussion of survey sampling, see Kalton (1983).

2.3.3 Data collection

The data collection was web-based. Each researcher in the sample population received an introductory e-mail (covering letter) informing about the purpose and motivation of the study and an invitation to participate. Each researcher received an individual code that permitted the respondent to log into the web-site that contained the questionnaire. The respondents' answers were saved directly in a database.

A pilot study was conducted in February 2005 to test the validity and reliability of the questionnaire. The process of data collection was also tested. The pilot study used a somewhat different sampling population. It used university colleges instead of universities. A pilot study or pre-testing of the questionnaire is a vital element of a survey. According to Converse and Presser (1986, p. 54), a pilot study serves a number of purposes. A particularly important goal is testing items for an acceptable level of variation in the population. Furthermore, the meaning of the questions can be assessed through a pilot study. That means whether the meaning intended by the investigator is shared by the respondents. The researcher has to be aware that the meaning that is intended for the questions in the questionnaire is often not the meaning that the respondents apprehend. Task difficulty can be tested with a pilot study as well. This means whether the respondents can actually answer the question even if the question is absolutely clear. A pilot study can even assess respondents' interest and attention. A long questionnaire with a lot of questions can lead to fatigue or boredom effects. Similar to the problem of boredom is the flow and the naturalness of the whole questionnaire. A pilot study can be used to test the flow of questions and whether the questions are in the right or natural order. Another purpose of pre-testing is to test the skip patterns in the questionnaire. In our case of a web-based questionnaire, the pilot study must assess whether the "right" respondents answer their particular questions. Related to the problem of boredom effects is the time taken. The web-based pilot study measured how much time the respondents spent on each question. This enabled the instant assessment of the respondents' interest and overall attention.

In general, a web-based survey has a number of advantages and disadvantages according to Dahmström (2000). It is a rather cheap way of data collection. The answers of the respondents can be checked when they fill in the questionnaire. Finally, the data is registered directly in a database which reduces processing errors. Nevertheless, a number of disadvantages have to be taken into account. A web-based survey requires a database that contains all e-mail addresses. This caused some problems in Sweden since the Swedish data base had to be built first. For Germany, an address database was available (Vademecum 2003) but it contained a number of errors and wrong e-mail addresses as well. A considerable amount of time had to be

spent to correct for errors in the German database. A web-based survey has to take into account increased non-response because of technical problems. Furthermore, it is limited to respondents who have access to the Internet which can result in a “technical bias”. Not everybody is used to using the Internet although the share of Internet users is likely to be very high among the sample population which consists of natural scientists, engineers, and medical scientists. A web-based survey requires detailed planning and personal integrity has to be secured. The answers of the respondents were saved on a particularly ‘safe’ Internet server which was secured through a number of safety measures. The data collection was conducted by an external consulting firm.

The process of data collection has shown that web-based surveys have a number of properties. First, the response rate decreases heavily over time. The majority of respondents answer within a couple of minutes after receiving the introductory letter. The response rate is fairly low after some days. That means that web-based surveys are a rather fast way of collecting data. Second, how long the respondents needed to answer the questions can be exactly measured. This makes it possible to analyse whether they had difficulties with some questions. Third, wrong e-mail addresses are directly returned and how many people actually received the questionnaire can be assessed instantly. This reduces errors related to non-response. Finally, instant communication with the respondents is possible since the respondents can pose questions and give comments using e-mail. It seems that the barrier to posing questions and providing comments is lower for web-based surveys as compared to mail surveys.

2.3.4 Description of the responses/non-response analysis

In sum, the survey was confined to professors in three academic fields: the natural sciences, engineering sciences/technical sciences, and medicine. It deals with scientific fields that have the potential to create research results that can be patented. The unit of analysis chosen was the individual research professor. Systematic sampling using stratification was used. The questionnaire was distributed via the Internet. The sample includes all major research universities in Sweden and Germany. The questionnaire used in the study covers, besides background variables (e.g., age), structural variables (e.g., research funding, academic reward system), data on patenting and commercialisation, experience with different transfer channels, patent rights in research results. Table 2-2 provides a summary of the response rates.

The data covers 801 researchers in Sweden and Germany. The total response rate for both countries was 17%. The response rate in Sweden was almost 30% whereas the response rate in Germany was 12%.

	Responses	Sent out	Response rate
Total	801	4645	17.24
Germany			
Total	397	3298	12.04
Natural sciences (strata 1)	128	1081	11.84
Engineering sciences (strata 2)	153	1070	14.30
Medical sciences (strata 3)	116	1147	10.11
Sweden			
Total	404	1347	29.99
Natural sciences (strata 1)	117	390	30.00
Engineering sciences (strata 2)	160	489	32.72
Medical sciences (strata 3)	127	468	27.14

Table 2-2: Response rates.

Source: own survey.

Non-response is a serious problem in most survey studies. Since the response rate is particularly low in this study, a separate analysis of non-response was conducted. Non-response means that units were asked to participate in the survey but did not do so for different reasons. There are a number of different reasons for non-response. The study units could have been out of town, contact addresses could have been outdated, units could have simply refused to participate but there can even be technical reasons for not participating. The advantage of an Internet survey is that outdated addresses are easily identified since those e-mails were immediately returned. Non-response related to technical problems is always an issue with regard to Internet surveys. In our case, the study population was researchers at technical and medical faculties and the natural sciences. It is therefore rather unlikely that researchers in those fields have a negative attitude towards the Internet. Nevertheless, the low response rate could indicate potential respondents' concerns regarding personal integrity, security or Internet surveys in general. A number of potential respondents wrote e-mails that they were not willing to participate because of a high work-load. Others refused to participate because they had already taken part in similar studies. A serious reason for non-response is probably that the study units thought that the study does not concern them. The share of responding researchers is rather low

which could mean that a lot of researchers did not want to participate due to a lack of patenting experience or interest. The consequence of non-response is that it can distort the results. The response rates are rather low, particularly in Germany, which means that it is difficult to generalise the results to the whole population.

The differential response rate is likely to introduce a bias. Since the response rate is rather low it is important to speculate about the possible biases that non-response could introduce. The aim of non-response analysis is to analyse whether the answers and characteristics of those who responded to the questionnaire are different from those who did not answer the questionnaire. A non-response analysis provides information about possible biases in the data. Particularly important is whether the non-respondents are more or less patent-active than the respondents. In order to get an impression about the patenting of non-respondents, patent databases were searched.²⁵ The survey has shown that about 37% of the German respondents have granted patents. The figure for the Swedish respondents is about 29%. Granted patents can be searched in patent databases. Patent databases were searched for a sample of non-respondents. As could be expected, the non-respondents were considerably less patent-active than the respondents of the survey. Thus, the low response rate leads to seriously biased results since the patent-active researchers are over-represented in the survey.

Sandven and Smith (1998) have discussed biases introduced by differential response rates in the context of the Community Innovation Survey (CIS) in different European countries. The CIS assessed whether firms were innovative (introduced a new product or new services in the last two years). It has shown that countries with high response rates (in some of the participating countries, firms were actually forced by the authorities to take part in the survey) had a low share of innovating firms. In contrast, countries with low response rates had a large share of innovating firms. Sandven and Smith (1998) came to the conclusion that response rate and share of innovating firms are negatively correlated. Their hypothesis was that innovating firms are more likely to answer the questionnaire since they are motivated. Non-innovating firms are less inclined to answer the innovation survey since they probably do not feel motivated or convinced to participate in an innovation survey because they did not introduce an innovation. The same can be true for the survey of researchers in Sweden and Germany. Patent-active researchers might feel more addressed by the questionnaire than researchers who did not apply for patents. Thus, we might speculate that patent-active researchers are over-represented in the survey. The response rate of the engineering sciences is higher and the response rates for medical sciences are lower in both countries. This means that engineering sciences

²⁵ The online patent data base DEPATISnet (<http://depatisnet.dpma.de>) was used.

are somewhat over-represented in the survey. The survey responses were not weighted.²⁶

Table 2-3 shows the composition of the responses with respect to academic disciplines. It shows that in Germany, about 32% of the responses come from natural scientists, 39% from technical scientists, and 29% from medical scientists. The figures for Sweden are 30%, 39% and 31% respectively. The largest share of responses in both countries is from researchers active in the technical sciences/engineering. Responses from 18 different universities and university colleges in Sweden were collected. In Germany, researchers from 70 different universities participated in the survey. Almost 22% of the German respondents are conducting research at a university of technology whereas the same is true for about 19% of their Swedish counterparts.

In sum, the data is likely to be biased in a number of ways. The survey is biased towards patent-active researchers. Engineers are over-represented and medical scientists are under-represented. The response rate is considerably lower in Germany than in Sweden. Thus, the results have to be treated with caution.

²⁶ Weighting of the responses can be done in order to compensate for non-response. Nonetheless, the analysis was done unweighted since it is controversial whether weighting should be applied in complex survey designs. Most of the statistical tests can only be applied for unweighted data. See, for instance, Lohr (1999) for a discussion.

	Germany	Sweden
Natural Sciences	32.2	29.5
Physics	10.5	6.5
Chemistry	4.8	9.4
Biology	8.1	7.7
Geographical Sciences	8.8	5.9
Engineering Sciences	38.5	39.1
Computer Science/Information Technology (incl. Mathematics)	12.0	12.6
Technical Physics/Applied Physics	0.8	8.7
Electrical Engineering	10.3	5.9
Mechanical Engineering	9.1	8.4
Architecture/Civil Engineering	6.3	3.5
Medical Sciences	29.3	31.4
Human Medicine	8.8	27.2
Veterinary Science	1.3	----
Dentistry	4.8	----
Genetical Engineering, Molecular Biology, Micro Biology	11.1	2.0
Biotechnology	0.5	0.5
Pharmacy (incl. Pharmaceutical Technology, Pharmaceutical Biology and Pharmaceutical Chemistry).	2.8	1.7
Total	100.0	100.0

Table 2-3: Share of responses with respect to academic disciplines.

Source: own survey.

3. Background

This chapter provides the reader with a description of the context in which the patenting of university research takes place. A number of different statistics are presented to situate the dissertation in a broader context. First, the role of universities in cross-national comparison is shown. Second, the science systems and the support systems for patenting in Sweden and Germany are briefly summarised. Third, the infrastructure for patenting in Sweden and Germany is presented which builds upon the qualitative interview study. Fourth, regulation with regard to intellectual property rights is summarised to provide an overview of the legal context in which the patenting of university research takes place. Finally, a number of relevant previous studies are presented and reviewed.

3.1 The role of universities in cross-national comparison

In a report about university research in transition, the OECD (1999, p. 7) mentions a number of trends that have long-term implications for the organisation of university research:

- Declining government R&D finance
- Changing nature of government finance
- Increasing industry R&D finance
- Growing demand for economic relevance
- Increasing systemic linkages
- Growing research personnel concerns
- Internationalisation of university research
- A changing role.

A lot of developments that impact on universities are related to financial issues. Government R&D expenditures to universities have been reduced in a number of

OECD countries. Not only the size of the budgets has changed, also the nature of support has changed. Government funding is increasingly mission-oriented and contract-based. Funding is frequently made dependent on output and performance criteria. Competition for funding between researchers is increasing. Furthermore, private industry is funding an increasing share of research in universities. Universities are increasingly under pressure to deliver research that more directly benefits the innovation system of their national economies. Governments encourage linkages with firms, government facilities and other actors in supportive networks. Those trends certainly impact on the university and the reward system for researchers as well. It is likely that it even influences the incentives to commercialise research results. In addition, those trends impact on the linkages that universities and researchers maintain with firms, technology transfer offices and support intermediaries. Statistics for Sweden, Germany, the US and EU-15 are used to illustrate the recent developments.

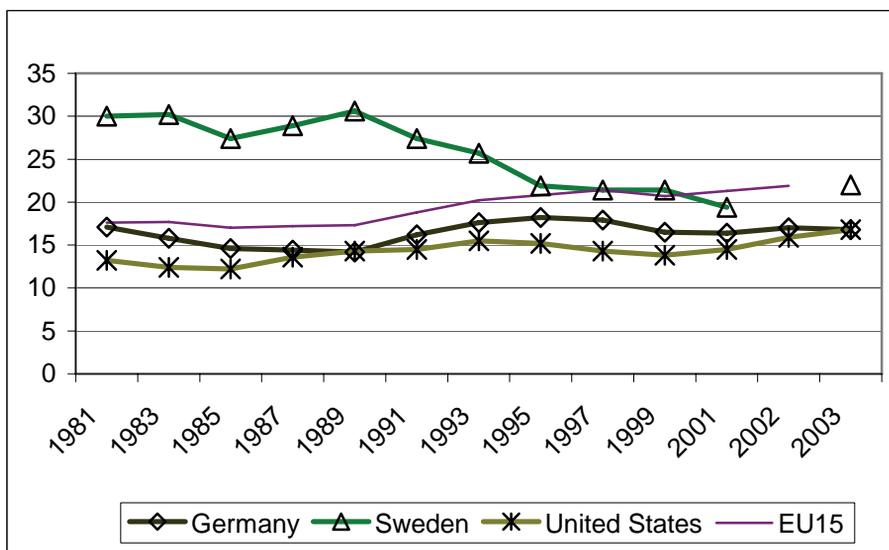


Figure 3-1: Percentage of GERD performed by higher education sector.
Source: Own calculations based on OECD (2005).

Figure 3-1 shows the percentage of Gross Domestic Expenditure on R&D (GERD) performed by the higher education sector. In other words, it shows the share of national R&D that is performed in the higher education sector as opposed to the business enterprise sector, the government sector and the private non-profit sector. The majority of national R&D efforts are carried out in the business enterprise sector. Nevertheless, figure 3-1 illustrates the importance of universities in the OECD

member countries. In Sweden, about 22% of national R&D performance was carried out in the higher education sector in 2003. The corresponding figure for Germany is 17% and for the US 17%.

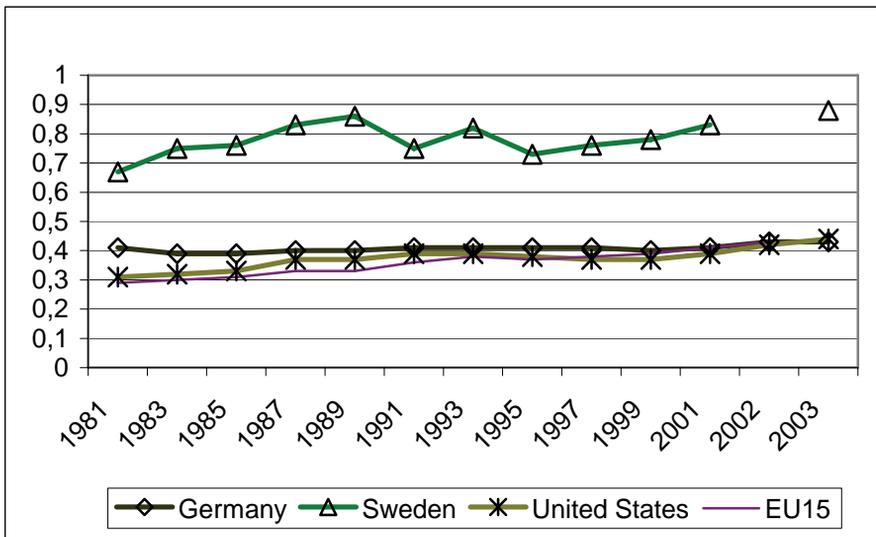


Figure 3-2: R&D performed by higher education sector as share of GDP.
 Source: Own calculations based on OECD (2005).

Figure 3-2 shows the relation of R&D performed in the higher education sector in relation to Gross Domestic Product (GDP). 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 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 the university has as performer of R&D.

Important for the incentives in universities are not only the changes in expenditures but also the sources of funding. The R&D performed in the larger higher education system can be analysed in relation to the different financial sources as classified by the OECD: 1.) government, subdivided into direct government funds (e.g., contracts and earmarked funds) and general university funds, 2.) business enterprises, 3.) abroad (including foreign companies and EU), 4.) private non-profit organisations, and 5.) higher education (own funds, e.g., from endowments). Government funding is the most important source of funding of universities.

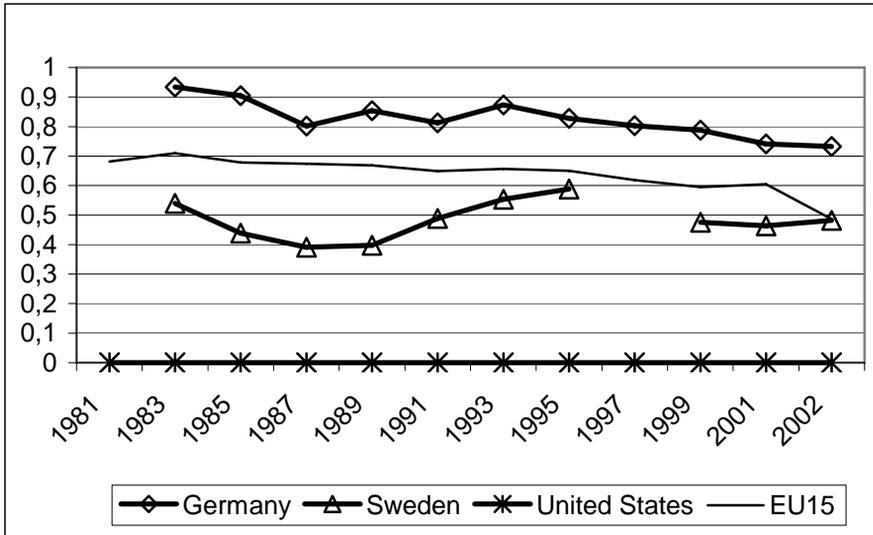


Figure 3-3: Percentage of HERD funded by general university funds.
 Source: Own calculations based on OECD (2005).

Government funding can be the responsibility of central governments (e.g., in Sweden) or the regional governments (e.g., Germany). Government funds to universities are funnelled through three different channels according to Geuna (2001): incremental funding, formula funding, and contractual funding. Incremental funding means that funds are allocated on the basis of past expenditure levels with incremental resources made available for the development of new activities. Until the 1980s, this funding mechanism was the most prevalent (Geuna 2001). With regard to formula funding, the budget of the university is determined by some form of assessment. One basis for funding can be the actual institutional expenditure per student enrolled or expected to be enrolled. These funds can be combined with general research funds according to a ratio of government funding for teaching compared with research. Research funds can also be determined by a formula system that makes the distribution of funds dependent on the basis of research record (e.g., number of scientific publications, number of finished dissertations). Contractual funding is applied via tender schemes. This means that research projects and goals are announced and interested researchers invest some time to write applications for funding. The ‘best’ applications are then selected and receive funding. This mechanism is introducing competition between researchers and research groups. In the case of limited funds and tightly specified targets, individual researchers and universities have to compete with one another for the resources. According to Geuna (2001, p. 610), recent years have seen an increasing reliance upon formula and contract funding. The governments make their funding increasingly dependent on per-

formance assessment and they support particular goals via tender schemes and contracts. The share of general university funds has substantially declined, while the share of direct government funds has increased, although not sufficiently to offset the decrease in the other components of government funding. Figure 3-3 shows the relation between civil government budget appropriations or outlays for R&D (GBAORD) for general university funds (GUF) and higher education expenditure on R&D. In other words, this is the share of R&D in universities funded by general university funds. It confirms that the share of general university funds in the higher education sector was declining or stagnating in most of the European countries during the 1990s. For the EU-15, it decreased from 68% in 1981 to 49% in 2002. In Germany, general university funding decreased from about 93% in 1983 to 73% in 2003. This share is even smaller in Sweden with about 48% of higher education expenditure funded by general university funds. In 1983 the share was 54%.

According to Geuna (2001), the declining share of government funding has been partly compensated for by a rise in the share of the other sources of funds. Particularly interesting in the context of commercialisation of research results from universities are industrial sources of funding.

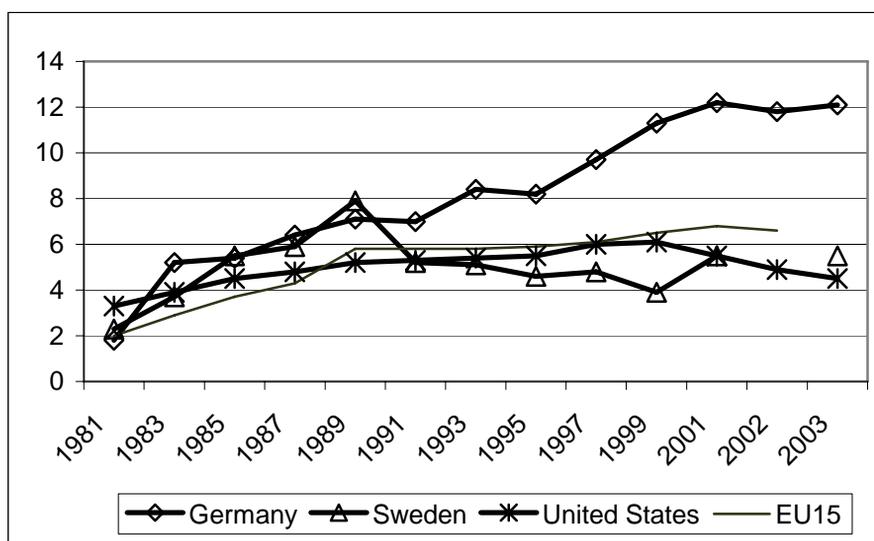


Figure 3-4: Percentage of HERD financed by industry.
Source: Own calculations based on OECD (2005).

Figure 3-4 shows the share of higher education R&D financed by industry for selected countries. In Germany, about 12% of R&D performed in the higher education sector was funded by industry in 2003. This is a remarkably high share. In the US,

only 4.5% of university R&D was financed by industry in 2003. The industry share of funding is somewhat higher in Sweden with 5.5% in 2003. The most remarkable increase happened in Germany from 1.8% in 1981 to 12.1% in 2003. The overall increase for the EU-countries (EU-15) was more moderate from 2% in 1981 to 6.6% in 2002.

3.2 Science and support systems in Sweden and Germany

The OECD statistics show a rather crude picture. A more detailed account of the organisation of public research in Sweden and Germany is provided below.

The system of academic research in Sweden consists mainly of universities; universities of technology and colleges (*högskolor*). Most of the research is conducted at public universities. About 82% of public R&D is spent in universities according to the European Commission (2001, p. 210). Research institutes that are not linked to or part of universities are of minor importance.²⁷ Recently, a number of national competence centres connected to universities were built up. These centres are financed by industry, the university, the Swedish Agency for Innovation Systems (VINNOVA) and the Swedish Energy Agency. According to VINNOVA (2003b, p. 1), “during a 10-year period (1995-2005) Swedish industry and the Swedish government are making a joint investment of Euro 550 million on research collaboration in 28 competence centres at 8 universities”. Industry pays about Euro 22 million/year, universities Euro 19 million/year, and VINNOVA and the Swedish Energy Agency Euro 19 million/year. On average 11 companies participate in each centre; 17 centres have applied for, or filed, 115 patents, 11 centres contributed to the start of 22 new companies. In these competence centres, university researchers and researchers from the financing enterprises conduct collaborative research. The patent rights for the research results are transferred to the collaborating firms. The university teachers’ privilege is not valid in these cases. This means that researchers that collaborate in these national competence centres do not own the research results.²⁸

²⁷ According to VINNOVA (2003, p. 13), this “Swedish model” for techno-scientific research goes back to the 1940s. The university is society’s central research resource because this is supposed to be the best way to connect research with education.

²⁸ In the competence centres, the parties involved (university institute, industrial partners, VINNOVA, Swedish Energy Agency) negotiated different terms concerning IPR. The university teachers’ privilege is only valid if there are no contractual agreements.

Governmental funding to universities in Sweden is allocated via direct (base) funding of universities (*fakultetsanslag*). In addition, there is the possibility to receive external funding via a number of research foundations (*forskningsstiftelser*), research councils (*forskningsråd*), governmental departments, the EU, private enterprises, etc. The funding of academic research has changed considerably. The importance of external funding increased from 42.6% of the total budget in 1993/94 to 53.1% in 2000 (Hällsten & Sandström 2002). In 2002, external funding accounted for about 55% of total research funding (HSV 2003). Universities that receive over 60% of total funding from external sources are not unusual.²⁹ Thus, research in Sweden is mainly conducted at public universities and the universities are increasingly dependent on external funding.

The Swedish research landscape has undergone major changes over the last decade. The funding system was changed which led to a reorganisation of the research council sector. Furthermore, a number of institutional changes were administered. As argued by Jacob et al. (2003, p. 1557), “both pillars were erected to reorient the research sector by prioritising research that could support the revitalisation of the Swedish innovation system and the creation of an infrastructure that could facilitate and support the commercialisation of university based research”. In addition, in 1997, the “third mission” or “third task” was introduced which means that universities have an obligation to interact with society in general. According to Jacob et al. (*ibid.*, p. 1557), “there seems to be a definite trend towards a reading that interprets the third task as being mainly about the commercialisation of academic research”. It has also to be mentioned that the introduction of the third mission did not lead to increased funding. Jacob et al. (*ibid.*, p. 1558) indicate that “the result is that many universities are facing a situation of functional overload”. In addition to the changes in the funding system, a number of support organisations were established. A number of technology bridging foundations (*Teknikbrostiftelser*) were founded to provide the universities with the assistance needed to make the linkage with the rest of society. Furthermore, university holding companies were established at each of the universities. Most of the policy measures were kind of “top-down” approaches aiming at increasing the commercialisation of university research. The primary instruments are the research funding system and the supportive infrastructure.

²⁹ External funding as share of total funding in 2000 (Jonsson & Sörlin 2002, p. 111): Chalmers University of Technology, Gothenburg (72%), Stockholm School of Economics (Handelshögskolan i Stockholm) (70%), Royal Institute of Technology, Stockholm (KTH) (64%), Linköping University (58%), Lund University (52%), Swedish University of Agricultural Sciences (SLU) (51%), Uppsala University (48%), Göteborg University (46%), Stockholm University (41%), and Umeå University (39%).

Germany has a diverse research landscape. Publicly financed research is conducted at universities, universities of technology, colleges or polytechnics (*Fachhochschulen*), and specialised research institutes (e.g., Fraunhofer institutes, Max-Planck institutes). About 44.9% of public R&D is spent at universities and about 7.1% of public R&D is spent at universities of technology (European Commission 2001, p. 130).

The study by Czarnitzki et al. (2000) investigated the interaction between science and industry in Germany. They analysed seven types of research institutes in Germany with respect to the preconditions that are needed for technology transfer and the extent to which transfer really took place. Table 3-1 below shows a number of figures for universities in Germany and Sweden. In addition, to illustrate the differences in structural features between specialised research institutes in Germany, data for Max-Planck institutes and Fraunhofer institutes are presented.

	MPG	FhG	Germany Univ/TU	Sweden Univ.
Research in natural sciences & engineering	91.2%	97.1%	38.8%	n.a.
Basic research orientation	88%	14%	57% / 38%	n.a.
Base funding	80%	25%	65%	46.9%
Industry funding (share of total budget)	2%	40%	7% / 11%	6.3%
Share of public R&D spent in universities			44.9%/7.1%	82%

Table 3-1: Some structural features of German and Swedish universities and institutes.

Source: The German data is modified from Czarnitzki et al. (2000), the Swedish data from Hällsten & Sandström (2002), Share of public R&D from the European Commission (2001). All figures refer to 2000.

Table 3-1 shows that German universities receive a larger share of their funding via base funding. It shows also that there are huge structural differences between the different R&D performers in Germany. The institutes of the Fraunhofer Society primarily conduct applied research, receive minor base funding and depend on industry funding to a considerable extent. In contrast, Max-Planck institutes predominantly conduct basic research funded by base funding. They receive minor industry funding. The universities in Germany are in between both extremes.

There are large differences regarding commercialisation efforts between traditional universities and universities of technology. Beise and Stahl (1999, p. 400) argue that “universities of social and natural science are known mostly for teaching and basic research without aiming at any commercialisation”. The situation is somewhat different with respect to universities of technology. Beise and Stahl (ibid, p. 400) claim that “technical universities have been formed since the last century to enforce inventions and technical applications of scientific findings but have subsequently focused on basic research (Keck 1993)”. In addition, there are legally independent external institutes (“An-Institute”) in the vicinity of universities. The head of an An-Institute is usually a professor of the university and an aim of those independent institutes is to gain administrative flexibility. An-Institutes operate under private law as private firms or registered associations. To a large extent, those An-Institutes are conducting applied research for private firms. An-Institutes conduct also commissioned research for public authorities and provide policy advisory services. They finance themselves almost entirely through external funding. Some An-Institutes also offer educational programmes. Polytechnics or university colleges focus primarily on education. Research is limited.

Since the abolishment of the university teachers’ privilege in 2002, German universities get assistance with regard to patenting and commercialisation from the recently established patent and exploitation agencies (PVA). There are 21 PVAs. PVAs negotiate the exploitation contracts between university and industry. The establishment of the PVAs was financed and supported by the federal government as part of the exploitation offensive.

3.3 Infrastructure for patenting in Sweden and Germany

This section describes the public support infrastructure for patenting and commercialisation in Sweden and Germany. It provides a descriptive qualitative analysis of technology transfer processes in the form of stylised models.³⁰ The analysis presents the main actors in the infrastructure for patenting and commercialisation of university research in both countries. It builds upon the interviews and secondary material. In Germany, the process of patenting and commercialisation is prescribed by law to a considerable extent. In Sweden, because of the UTP, researchers can decide on a voluntary basis whether they want to involve supportive actors. Supportive actors include technology transfer offices at universities, technology bridging foundations, university holding companies, etc. A number of supportive actors were interviewed for this study. The reader has to be aware that the supportive actors in Sweden have only information about inventions that are commercialised with their support. Selection effects have to be considered. It is likely that the more successful – or more attractive to researchers – actors in the infrastructure possess more information than the less attractive ones. This has to be taken into consideration even with respect to different channels of technology transfer. It is possible in Sweden that a large number of patents are licensed directly to private firms without further notice or announcement to the public actors in the infrastructure. In contrast, actors in the commercialisation infrastructure in Germany are likely to have a broader picture since researchers have an obligation to disclose inventions and to take part in the commercialisation process as prescribed by law or as the university regulates it. Nevertheless, some inventions could be transferred unnoticed due to the lack of enforcement.

3.3.1 Infrastructure for commercialisation in Sweden

The university laws in Sweden were changed in 1997 to include the so-called “third mission”. The third mission means that universities have to interact with society in general. The aim is that the knowledge produced in universities should spill over to society. This includes popular lectures and publications aimed at a general audience. It also includes technology transfer and collaboration between universities and industry. With regard to publicly financed supporting infrastructure, the Swedish National Audit Office (RRV 2001, p. 18) mentions a number of organisations that support universities in their third mission efforts, including technology bridging foundations (*teknikbrostiftelser*, TBS), university holding companies, and science parks. Science parks are important for the establishment of new enterprises in gen-

³⁰ From a methodological point of view, this section contains parts of the qualitative analysis of the interviews.

eral. They do not focus particularly on patenting but promote academic spin-offs. Science parks frequently collaborate with the other public support actors, such as TBS and university holding companies.³¹ Thus, three major actors can be identified that are of relevance when it comes to the supporting infrastructure for patenting and commercialisation in Sweden: The university, their university holding companies, and technology bridging foundations. It is also important to mention that these organisations should not compete with private organisations (RRV 2001, p. 39). That means in practice that public organisations such as university holding companies or technology bridging foundations should support commercialisation and collaboration with private industry unless there are private actors that could replace their efforts. This is especially important when it comes to risk capital.

The university has, through the third mission, the obligation to create and sustain an effective process of interaction with the surrounding industry. The university can fulfil this mission through different means such as popular lectures, university fairs, “open university days” and the like. A number of interviewees mentioned that the universities do not receive additional funding to achieve the third mission. Universities receive funding for education and research but the third mission is usually not covered by financial resources. RRV (2001, p. 36) regards collaboration with industry as the most important part of the third mission.

Five holding companies were founded in 1994 and six in 1995. They received about 7 million € from the Swedish government. Their aim is “to own, sell and administer shares of wholly or partly-owned project and service companies whose purpose should be to pursue research and development aiming at commercial exploitation” (RRV 2001, p. 33, my translation). The university holding companies are owned by the universities and can be seen as the major instrument of the universities to achieve collaboration. The holding organisation separates this activity from the rest of the university. The university holding company becomes a professional organisation with a limited number of goals, in particular supporting the university’s third mission efforts. This includes provision of information and advice to scholars regarding patenting and commercialisation. Some holding companies are actively involved in commercialisation through the establishment of new enterprises. Since Chalmers University of Technology was changed into a foundation in 1994 it did not receive public money for a holding company. Nevertheless, Chalmers established a holding company already in 1985, Chalmers Innovation AB. Chalmers Innovation AB is a business incubator. The holding companies in Linköping and Lund provide basically information and advisory support to scholars. The holding company in Lund provides even seed capital. Financial support of commercialisation projects through the holding companies is rather limited as the interviews sug-

³¹ Technology bridging foundations are frequent financiers of business incubators and similar bodies in science parks.

gest. At the Royal Institute of Technology (KTH), the organisation of support changed recently. KTH Holding is still active but KTH Innovation collaborates with the holding company to increase commercial exploitation.

The technology bridging foundations (TBS) have a broader mandate. The seven TBS were founded in 1993. They received about 110 million € from the Swedish government. Their major aim is to “act for increasing contacts between university and industry in the whole country with the purpose of increasing the exploitation of universities’ knowledge and competence to increase growth in Swedish industry” (RRV 2001, p. 32, my translation). 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 university and industry, including collaborative research projects. Third, they should increase collaboration between small and large enterprises in the projects in which the TBS is involved. The four TBS that were studied in more detail have partly different roles. In Stockholm and Gothenburg, the TBS are not involved in operative business. Both TBS support the universities and finance infrastructure for patenting and commercialisation of university research. The TBS in Gothenburg offers scholarships for idea development and since 2002 it provides seed capital. The TBS in Stockholm supports other actors that work for commercialisation of research results such as business incubators etc. In contrast, the TBS in Lund is more operative. It provides a broad range of support through its different daughter companies. The TBS in Lund runs a business incubator, a patenting and licensing office, and a seed fund. In addition, they run a conditional loan fund. In Linköping, the TBS changed its organisational structure recently. TBS in Linköping is no longer operative but runs daughter companies that support the commercialisation of research results from the university. It runs a licensing office for health care innovations, a business incubator, and a seed capital company.

The interviews in Sweden indicate that support for the patenting and licensing of university inventions is underdeveloped at most universities. Some interviewees argue that the patenting and licensing of university inventions is not profitable in Sweden.

A stylised model of the process of patenting and commercialisation in Sweden

Four Swedish universities and their supporting infrastructure were studied in more detail. The following stylised model presents the common characteristics of the process of patenting and commercialisation of research results.

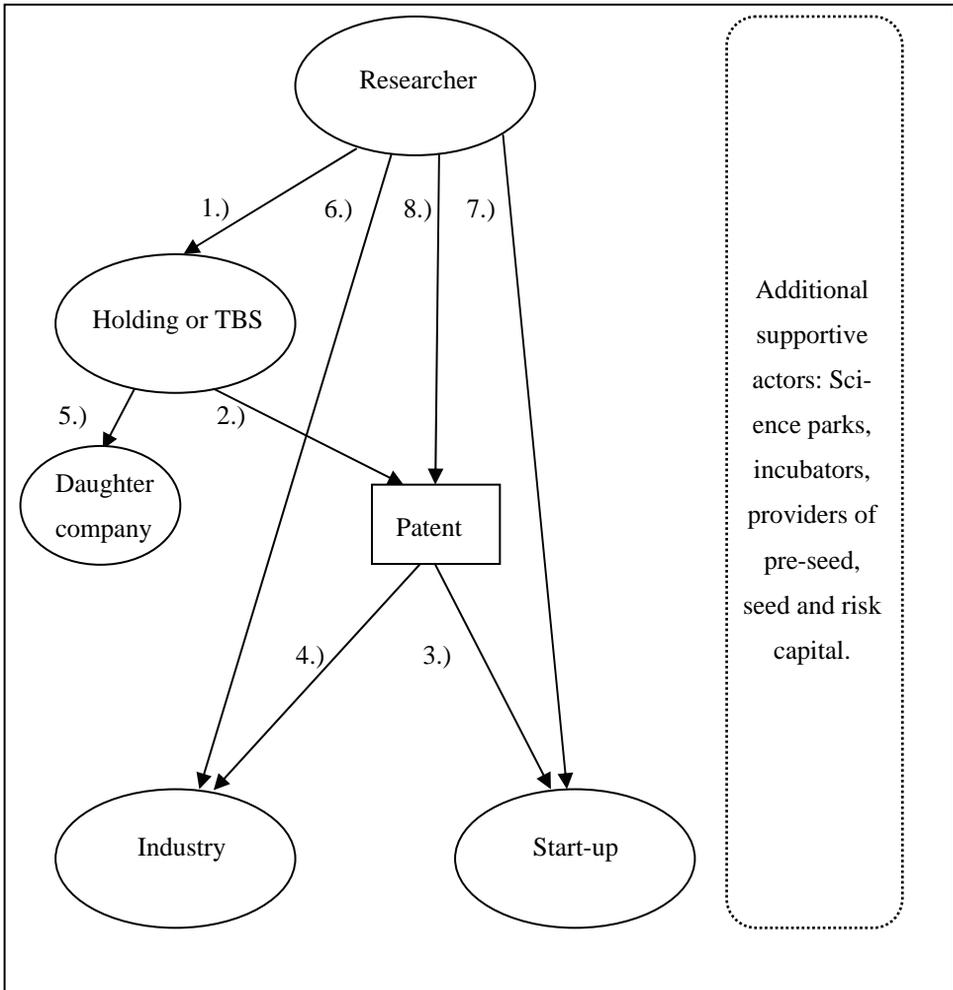


Figure 3-5: A stylised model of the process of patenting and commercialisation of research results in Sweden.

Source: own elaborations.

Since the researcher has full discretion about the utilisation of his research results, there is no single way of commercialisation. There are many different ways to commercialise university research. The supporting infrastructure accounts for this variety. One possibility would be free dissemination through publication of the research results. In the case of commercial exploitation, the scholar can contact the university holding company or the TBS (1.). In those regions where the TBS is more operative, as in Lund, the TBS and holding company are in a more competitive relationship. In regions where the TBS finances other actors (e.g., university holding company) only, as in Gothenburg, Linköping and Stockholm, the holding company is usually the first contact point. The holding company/TBS usually conducts the first commercial assessment. This can involve advice and information and arranging contacts with other supporting actors. The next step in the commercialisation process can be a patent application if the invention is patentable (2.). The patent application usually has to be financed by the inventor. In some regions (e.g., Gothenburg), there are financial funds available for the patent costs. Basically, all interviewees indicate that there is a lack of funding of the very first steps of commercialisation and that this is likely to act as an obstacle for scholars to patent and commercialise research results. After the patent is granted it can be used as an asset in a start-up or spin-off (3.) or can be sold or licensed to existing companies (4.). There is also the possibility that the holding company supports the entrepreneur and establishes a daughter company (project company) (5.). This option is even possible for commercial exploitation without patent. Those are the typical steps when the TBS/holding company are involved. Alternatively, the researcher can sell the invention directly to industry (6.) or establish a new enterprise independently (7.). The scholar can also apply for a patent independently (8.). The interviews suggest that the support for patenting and licensing is rather limited in Sweden although there are notable exceptions. The university patenting and licensing office in Lund (Forskarpatent i Syd) can provide the whole range of services around patenting and licensing if researchers transfer their patent rights to them. In this case, Forskarpatent covers all costs and pays a share of the royalties to the inventors. The other regions had similar patenting and licensing organisations but most of them had to close them down due to commercial failure. The process of finding a licensee is a difficult one and requires a lot of business competence and experience as argued by the interviewees.

Additional supportive actors such as business incubators and providers of seed capital are important. Most of the TBS in Sweden finance or run business incubators. Science parks seem to play an important role as well. Examples are Ideon in Lund and Mjärdevi Science Park in Linköping. In Sweden, there seems to be a particular network model that incorporates incubators, risk and seed capital and other public actors.

In general, success factors for patenting and commercialisation seem to be capital and business competence, according to the majority of the interviewees. The evalua-

tion of technology bridging foundations and university holding companies in Sweden by the Swedish National Audit Office (RRV 2001) and own empirical observations give the impression that technology bridging foundations and holding companies have been quite effective in building up infrastructures for the commercialisation of research results in general. Nevertheless, university patenting offices, such as Forskarpatent, were not as successful. Furthermore, basically all actors that support the patenting and commercialisation of university research are financed from public sources. Market solutions are missing except for the patent application itself (i.e. patent lawyers). Goldfarb and Henrekson (2003) studied the infrastructure in Sweden as well and came to the conclusion that the infrastructure was designed from the central government in a 'top-down' way.

3.3.2 Infrastructure for commercialisation in Germany

The infrastructure for commercialisation of university research in Germany was established only recently in combination with the abolishment of the university teachers' privilege. According to the Federal Ministry of Education and Research (BMBF 2001, p. 4), "the reform of the university teachers' privilege and the establishment of patenting and exploitation agencies are directly interlinked: After the reform of the university teachers' privilege more scientists will have an incentive to have their inventions patented and will thus achieve commercial exploitation. This will also ensure better use of capacities and thus ensure more economic work of the agencies".³²

There are 21 patent and exploitation agencies (*Patent- und Verwertungsagentur*, PVA). Every federal state (*Bundesland*) has its own PVA that is responsible for the universities in the state.³³ The role of the patent and exploitation agencies is to give advice to the university and the inventors who want to patent. They negotiate the exploitation contracts between university and private industry.

³² Unfortunately, the BMBF does not provide the reader with empirical evidence why scientists should have incentives to patent their research results after the abolishment of the UTP.

³³ Some federal states have different organisational arrangements with more than one PVA. With regard to the four universities studied in more detail, Provendis GmbH is responsible for all universities in North Rhine-Westphalia (NRW). NRW has about 18 million inhabitants. TLB GmbH is responsible for most of the universities in Baden-Württemberg. Baden-Württemberg has about 10.5 million inhabitants. With respect to patenting and commercial exploitation in Berlin, ipal GmbH is responsible for FU Berlin, Humboldt University Berlin, University of Applied Sciences Berlin, Technical University Berlin, FHTW University of Applied Sciences Berlin. Berlin has about 3.4 million inhabitants. Tutech GmbH is responsible for all universities in Hamburg. Hamburg has about 1.7 million inhabitants.

The federal government subsidizes via its Ministry of Education and Research (BMBF) the patenting costs of the PVAs. It offers financial support in the case of legal disputes. The BMBF paid 80% of the patenting costs in 2002 and 2003. For the years 2004 to the end of 2006, the BMBF still covers 50% of the patenting costs. Furthermore, the BMBF changed its funding policy with regard to technology transfer in the way that applications for research funding from the BMBF must include a clause about what happens with the research results (commercialisation plan). In addition, a number of flanking initiatives have to be taken into account. One important change in the administration of the universities is the move from cameralistic accountancy (public service accounting) towards commercial accounting with the introduction of a so-called “Globalhaushalt” (global budget). This gives the universities more autonomy to allocate the funds between the different departments inside the university. This means that universities are allowed to reward departments and researchers directly with respect to performance. The interviews suggest that this possibility will be used to foster technology transfer by allocating research funds based on performance criteria, e.g., patents. Another legal change is the reform of the employment law regarding researchers at universities (*Dienstrechtsreform*).³⁴ This reform opens the possibility for universities to attract researchers through wages that rise above the base salary. Previously, the base salary was fixed. To attract top-level researchers, the university can increase the wage above the base salary. Particularly at universities of technology, professors are frequently recruited from leadership positions in private industry.

A number of PVAs, such as Provendis GmbH and ipal GmbH were established quite recently.³⁵ In contrast, the PVAs in Hamburg (Tutech GmbH) and Karlsruhe (TLB GmbH) have longer experience with patenting and technology transfer.³⁶

In addition to PVAs, every university has its own technology transfer office (TTO) or similar body. They offer advice and guidance. The TTOs are usually the first contact points of the researchers. They check the formalities of the invention disclo-

³⁴ For an analysis of the reform, see Kräkel (2006)

³⁵ Provendis GmbH was established in 2001 as daughter company of Zenit GmbH which is a consulting company owned by the federal state of North Rhine-Westphalia (NRW), a bank consortium, and a business association. Zenit GmbH is responsible for most of the public aid programmes in NRW. Ipal GmbH was founded in 2001 and is owned by the universities in Berlin and Investitionsbank Berlin (a public bank responsible for executing the public aid programmes in Berlin).

³⁶ Tutech GmbH is owned by the technical university Hamburg-Harburg and was established in 1992. TLB GmbH emanated from a project at the University of Karlsruhe in 1987 and is owned by universities in Baden-Württemberg, the Fraunhofer Society and an industrial holding company.

tures and forward them to the PVAs. The PVAs are primarily responsible for the patenting and licensing process. PVAs are expected to finance themselves through royalty income in the long term. As already mentioned, until the end of 2006, the federal Ministry of Education and Research (BMBF) covers 50% of the costs of the services that the PVAs conduct for the universities (based on the sum of 2003) and it covers 50% of the costs occurring in relation to the patent application (Kienbaum 2006). Thus, the actors in the support infrastructure are primarily financed by public sources with grants from the federal government. This means that the German public infrastructure follows a kind of 'top-down' approach, as in the Swedish case.

In addition, there is a network initiative to support academic spin-offs (EXIST). EXIST ("*Existenzgründungen aus Hochschulen*") started in 1997 as a competition between different regional networks. It seeks "to improve the entrepreneurial culture at higher-education institutions and to increase the number of companies started up from academic establishments" (BMBF 2000, p. 4).³⁷ There is even a programme that provides seed capital for students and academic staff (EXIST-Seed). Furthermore, there is another network initiative (InnoNet) that aims at connecting research institutes with small and medium-sized enterprises.³⁸ In general, German R&D policy follows a network approach since the 1990s (Fier & Harhoff 2002).

³⁷ At least three different actors from a region had to collaborate, of which one actor had to be a higher education organisation. From 109 proposals for regional networks, 5 winner regions were selected and promoted with substantial financial resources. "Dresden exists" in Dresden and "KEIM" in Karlsruhe were honoured in 1999 by the EU as best thematic networks for the promotion of start-ups and growth of innovative businesses.

³⁸ In the InnoNet programme, small and medium-sized enterprises (SMEs) engage in collaborative research with research institutes. The SMEs finance 20% of the R&D expenditure of the research institute and receive the patent rights in the results. This kind of collaborative research is quite effective since not only codified knowledge in the form of patents is transferred but also tacit knowledge, which seems to be especially valuable when it comes to the application of research results. According to Belitz (2003), 37% of the research organisations in the InnoNet initiative were private research institutes (e.g., An-Institutes), about 33% universities, and about 25% Fraunhofer institutes.

A stylised model of the process of patenting and commercialisation in Germany

Four German universities and their supporting infrastructures were studied in more detail. The following stylised model presents the common characteristics of the process of patenting and commercialisation of research results. Of course, there are a variety of different actors in the different regions. Nevertheless, the German regulation prescribes partly the process of patenting.

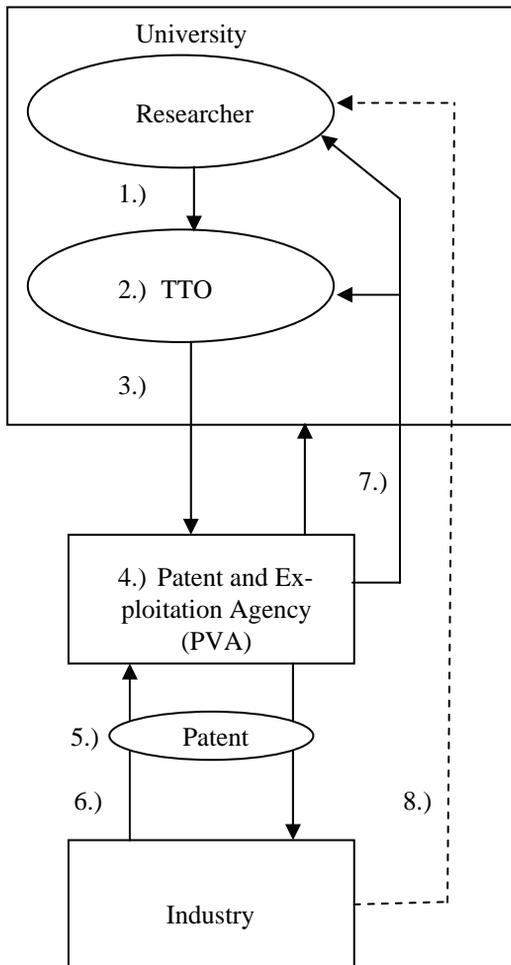


Figure 3-6: A stylised model of the process of patenting and commercialisation of research results in Germany.
Source: own elaborations.

The federal regulation governing employees' inventions (§ 42,43 *Arbeitnehmererfindungsgesetz, ArbNERfG*) prescribes some process elements and deadlines. The process of patenting and commercialisation of university research is similar in all cases and can be illustrated with figure 3-6.³⁹

- 1.) The researcher submits an invention disclosure to the TTO. Even if there is a legal obligation for the researcher to submit an invention disclosure, it is difficult to enforce this regulation. Evidence from the interviews in Germany suggests that some researchers lack knowledge about the new regulation. They still negotiate external funding contracts that include clauses about IPR transfer.⁴⁰ A huge bureaucracy would be needed to check all contracts.
- 2.) The TTO checks the invention disclosure with respect to formalities and completeness. It checks whether other parties (e.g., financing firms) already own the IPRs.
- 3.) The invention disclosure is forwarded to the PVA. The PVA and the universities usually negotiate service contracts, which means that there is an obligation to contract. That means the PVA has the mandate to patent and commercialise the invention disclosures of the universities in the federal state.
- 4.) The PVA assesses the invention with respect to property rights and technological and economic prospects, and provides a recommendation to the university whether they should claim the invention or not. When the university does not claim the invention, the inventor receives a clearance by the university. That means the inventor becomes the owner of the invention. The researcher also becomes the owner when the university does not come to a decision within four months after the invention disclosure was submitted.
- 5.) In the case of a claim by the university, the PVA protects the invention, usually through a patent application, and markets the invention, usually through licensing. The PVA bears a share of the costs and they cover their expenses by royalty income. A substantial share of the patenting costs and the costs of the services of the PVA are covered by the federal Ministry of Education and Research (BMBF). The PVA identifies licensees and negotiates licensing contracts.
- 6.) The licensee pays royalty fees to the PVA.

³⁹ This reflects the federal legislation in relation to the abolishment of the university teachers' privilege. Notably, it is also similar to the process of technology transfer at US American universities as presented in Carlsson & Fridh (2002).

⁴⁰ The situation is similar in the US even 20 years after the Bayh-Dole Act (see, e.g., Siegel et al. 2003).

- 7.) The PVA distributes the payments. The inventor receives 30% of the gross income. The surplus after covering of the costs is shared between the PVA and the university. The share of the PVA ranges between 30% and 50%. The university share usually flows back to the department of the inventor in the form of additional research funding, in some cases an administrative overhead of 5 to 10% is deducted.
- 8.) The interviews have indicated that a substantial number of inventions from universities are in a rather premature stage. Thus, further development of prototypes and similar is in many cases required. This can generate additional sponsored research.⁴¹

3.4 Focus on intellectual property rights and patenting

As mentioned in the previous section, the process of patenting and commercial exploitation is partly prescribed by law. The legal framework for intellectual property rights at public research organisations is determined by national legislation of intellectual property (e.g., copyright, national patent laws), international intellectual property rights regimes (e.g., international treaties such as TRIPS, EU directives), employment laws (e.g., ownership of inventions by individual researchers), research funding regulations, and contract law (OECD 2003b).

3.4.1 Patent laws & legislation

National legislation governing intellectual property includes patents, trademarks and copyrights and sets the terms for the kind of intellectual property that may be protected and the terms and length of protection according to OECD (2003b). According to Swedish and German patent laws, a patent is a bundle of intellectual property rights (IPRs), which is granted for a period of up to 20 years for an invention. The invention has to be new, industrially applicable and must involve an inventive step yielding sufficient advancement. The novelty criterion is particularly relevant in the case of university inventions since a publication forecloses a patent application.⁴² Patent documents disclose rich information about technical features, inventors, the

⁴¹ As already mentioned, Jensen and Thursby (2001) found that a substantial share of university inventions require further development which can generate additional external funding.

⁴² There is no “grace period” in Swedish and German patent laws. A publication forecloses a patent application since it violates the novelty condition (see BMBF 2002).

relation to other patents and publications, etc. According to the OECD (2004c, p. 35), “patent-based indicators reflect the inventive performance of countries, regions, firms, and other aspects of the dynamics of the innovation process (co-operation in innovation, internationalisation of technology, etc.)”. Patenting has increased in importance and the number of patents increased sharply in the last decade. More than 850 000 patent applications were filed in Europe, Japan and the US in 2002 as compared to around 600 000 in 1992 (OECD 2004c, p. 35). Particularly responsible for this increase are the technology fields biotechnology and ICT. The costs of patenting can be substantial. According to the European Patent Office (EPO, 1999), in 1999 the costs of an average European patent amounted to 29,800 €. This includes 10 years of protection in 8 member states. About 39% of these costs are related to translations. A national patent application is cheaper. In Germany, patent protection for the first 10 years costs about 1,950 € plus costs for legal advice which can amount to 4,000 € (BMBF Patent Server 2003). The costs for a national patent in Sweden are similar.

When using patents as a key indicator for commercially relevant invention activities at universities, one should be aware of several caveats.⁴³ The relevance of patenting as a measure of protection varies by discipline and field of technology. Patenting may sometimes be substituted by other protection mechanisms such as secrecy or complexity, and only a small proportion of all economically relevant inventions can be patented. Many patents are not used for protecting inventions but for strategic purposes.

3.4.2 International intellectual property regimes

There are a number of supra-national treaties and agreements that constrain national patent laws. Examples of international agreements are TRIPS and EU directives.

Granstrand (2005) characterises the history of the IPR system in terms of different eras. He talks about the non-patent/pre-patent era, the national patent era, the multi-national patent era, the international patent era, and the pro-patent era as summarized in table 3-2.

⁴³ See Griliches (1990) for a survey on patent statistics as economic indicators.

Era	Characteristics
<p>1. Non-patent era (Ancient cultures: Egypt, Greece, etc.)</p>	<p>Emergence of science separated from technology</p> <p>Emergence of cultural and industrial arts</p> <p>Secrecy and symbols emerging as recognized IP</p> <p>No patent-like rights or institutions for technical inventions</p>
<p>2. Pre-patent era (Middle Ages to Renaissance)</p>	<p>Emergence of universities</p> <p>Secrecy, copyright and symbols (artisan/trade marks/names) as dominant IP, also collectively organized</p> <p>Emerging schemes to grant privileges and remunerate disclosure</p> <p>Extensions of mining laws to inventions</p>
<p>3. National patent era (Late 15th-late18th cent.)</p>	<p>Breakthrough of natural sciences</p> <p>Local codifications of laws for patents (Venice 1474, England 1623, etc.), copyrights (Venice 1544, England 1709, etc.), etc.</p> <p>Regulation of privileges</p> <p>Conscious stimulation of technical progress at national level, linked to economic policies (e.g. mercantilistic)</p>
<p>4. Multinational patent era (Late 18th-late 19th cent.)</p>	<p>Emergence of modern nation states</p> <p>Industrialization</p> <p>Continued international diffusion of the patent system</p> <p>Local anti-patent movements</p> <p>Emerging international patent relations (e.g. disputes)</p>
<p>5. International patent era (Late 19th-late20th cent.)</p>	<p>Emerging industrial and military R&D</p> <p>International coordination of the patent</p>

	<p>system (Paris Convention 1883, WIPO, PCT, EPO, etc.)</p> <p>Separate IP regimes in socialist countries and LDCs</p>
<p>6. The pro-patent/pro-IP era (Late 20th cent.-?)</p>	<p>Intellectual capital surpasses physical capital for many entities</p> <p>Intensified international competition</p> <p>Global activism for IP from industrialized countries, especially from the US (leading to TRIPS and the WTO)</p> <p>Almost worldwide adoption of the patent system</p> <p>Increased international patenting</p>

Table 3-2: Eras in the history of patents and IP.

Source: Granstrand (2005, p. 268). Printed by permission of Oxford University Press.

Table 3-2 shows that as a response to the increasing importance of patents as a means to protect intellectual property, a number of international agreements and treaties have been signed. Two fundamental treaties are the Paris International Convention for the Protection of Industrial Property of 1883 (the “Paris Convention”) and the Berne Convention for the Protection of Literary and Artistic Works of 1886 (the “Berne Convention”). According to Granstrand (2005, p. 270), “the Paris Convention is based on two major principles: (a) Foreigners and foreign patent applications should receive the same treatment in a member state as domestic applicants and applications (non-discrimination); (b) a priority claim established in one member state should be recognized by all others, i.e. once an application for a patent is filed in a member state, the applicant can within twelve months file a patent application for the same invention in any other member state, which must regard the latter applications as being filed on the date of the original first application”. Those principles are still valid today. In 1967, the World Intellectual Property Organization (WIPO) which later became a United Nations agency was established. It also became involved in administering the Patent Cooperation Treaty (PCT) signed in 1970 and active until 1978. The PCT established an international clearing house enabling patent applications to take effect in some or all of the PCT member states. Another important development in international patent protection was the establishment of the European Patent Office (EPO) in Munich in 1977. It enables patent applications to be filed in some or all signatory nations. Please note that a patent issued by EPO is a bundle of national patent rights that are enforceable in accordance with the national law and court system in which the patent is filed. In 1975, a European Com-

munity Patent Convention was signed to establish a unified European patent that would be valid in all member states but this goal has not been achieved yet. In 1994, international harmonization was increased further with the TRIPS-agreement. The TRIPS-agreement links IP issues with international trade issues.⁴⁴

3.4.3 Employment laws and laws governing patent rights in university inventions

Employment laws can be used to determine whether individual researchers can own the output of their intellectual efforts. Usually, employment laws give title in inventions that are developed during the employees' professional occupation to the employer. Thus, in industrial research labs, the firm as employer generally owns the intellectual property rights in the inventions made by its employees. This is also true for non-university research institutes in Germany such as Fraunhofer institutes or Max-Planck institutes. University researchers are exempted in some jurisdictions such as Sweden.

In Sweden, the university teachers' privilege (*§ 1,2 Lagen om rätten till arbetstagares uppfinningar 1949*) gives the university teachers the patent rights for their research results. That means, the university researcher owns the right to publish the results in scientific publications, and he can apply for a patent to exploit the research results commercially but there are also a lot of other means to exploit research results, such as dissemination of results at conferences or consultancy assignments for private enterprises. The university scholar has full discretion about the means of knowledge dissemination. In the case of patenting, the researcher receives the entire benefits emanating from the patent but has to bear all costs as well. The Swedish regulation is dispositive (default rule), which means that the university teachers' privilege is only valid in the case of the absence of other contractual agreements.⁴⁵ According to Craswell (1999, p. 13), "a default rule, by definition, leaves parties free to specify some other rule to govern their relationship if they so choose". As already mentioned, in national competence centres, the researchers involved have to surrender their patent rights to the participating firms. Contractual agreements have priority over the UTP. It is important to mention that the university teachers' privilege is only valid for university teachers.⁴⁶

⁴⁴ For a discussion of TRIPS, see Granstrand (2005, p. 275).

⁴⁵ For more legal details, see SOU 2005:95 and SOU 1996:70.

⁴⁶ According to the university laws (Högskolelagen HL 3:2, 3:5), university teachers are professors and lecturers. Other university employees, e.g., PhD students, do not own the patent rights in their inventions.

In Germany, the university teachers' privilege was abolished in February 2002 (§ 42,43 *Arbeitnehmererfindungsgesetz, ArbNErfG*). In general, inventions made by university teachers are owned by the university. In the case of a patentable invention, the university teacher has to notify the university. The university has four months to decide whether to patent the invention or not. In the case of no decision after four months, the researcher retrieves the patent rights. In the case of a publication that would foreclose a patent application, the university teacher has to notify the university and has to withhold the publication for up to two months. The university is not allowed to forbid or change the content of the publication. The compensation for the researcher in the case of a patent application is 30% of the gross income. The costs associated with patenting and commercialisation are not subtracted. Patent and exploitation agencies (PVAs) assist universities in patenting and commercialisation. The new German regulation is valid for all university employees in contrast to the former university teachers' privilege that was only valid for university teachers.⁴⁷

In Germany and other countries, e.g., Australia, Austria, Belgium, Denmark, France, Ireland, Netherlands, Norway, the UK, and the USA the university owns the research results. The researchers own the inventions in Sweden and other countries, e.g., Italy (OECD 2003b). The UTP was abolished in Denmark in 1999. Italy introduced the UTP in universities in 2001. This indicates that there is no clear-cut answer which system – with or without UTP – is better.

3.4.4 Research funding regulation

According to OECD (2003b, p. 16), “at national level, there may be specific laws and rules that govern the ownership and use of intellectual property created by PROs according to source of research funding (e.g. the PRO's own funds, national or regional government funds)”. The source of funding of public research organisations (PROs) plays an important role with respect to patent rights in research output.

Some financiers of public research demand that IPRs are surrendered. This is frequent practice in the case of industry funding. There are also organisational arrangements where university researchers conduct collaborative research with industrial researchers where the university researchers are obliged to surrender their patent rights in the case of patentable inventions. In Sweden, this is the case in the Competence Centre Programme.

⁴⁷ The old university teachers' privilege was only valid for university teachers. This included professors, lecturers (“Dozent”), and associate professors (“wissenschaftliche Assistenten”).

3.4.5 Contract law

Closely linked to research funding regulation is contract law. As mentioned before, industry has become a more important stakeholder with respect to university research. Industrial funding of research and collaboration projects require the definition of patent rights in the outcomes of those research endeavours. The OECD (2003b) argues that many public research funding agencies, universities and public research labs apply standard form contracts that define patent rights. Some universities apply standard form contracts with regard to commissioned research from industry and research collaborations. One example of standard form contracts is the “Berliner Verträge” that were negotiated between the universities in Berlin and a number of large enterprises assisted by the patent and exploitation agency in Berlin. In commissioned research projects, the costs of patent applications are usually borne by the firm. In the case of a patent application, the university receives a lump sum (2500 € in the “Berliner Verträge”). When the invention is commercially exploited, the university receives additional income. This can take different forms ranging from lump sum payment (2500 €) to royalties. The university is responsible for paying the mandatory compensation to the inventors. There are similar arrangements with regard to collaborative research projects. Contract law is also important with respect to licensing etc.

Furthermore, the Swedish university teachers’ privilege is dispositive law which means that it is only valid by default. It is only valid if researchers and other parties have not agreed upon other alternative rules. Thus, contract law and individual agreements have priority over the UTP. This makes contract law particularly important.

3.5 Previous studies about IPR in universities

Governments and other public organisations have increasingly shifted their attention towards technology transfer from universities to industry. There are a number of reports and studies that analyse success factors and try to increase our understanding of the commercialisation of university research. This section of the thesis reviews briefly some of the studies that are relevant with respect to the purpose of this thesis. The thesis focuses on incentives in universities, therefore, primarily studies dealing

with incentive issues are included in this review. Studies dealing with technology transfer in general are omitted.⁴⁸

Particularly relevant for this dissertation is the study “Turning science into business: patenting and licensing at public research organisations” from the OECD (2003b). This study collected data about patenting, licensing and start-ups for a number of OECD countries through a survey. Unfortunately, no data was collected for Sweden and in Germany, only the public research organisations and not universities were included in the survey. However, the German contribution to the OECD study by Gering and Schmoch (2003) provided a valuable overview of patenting and licensing at German non-university research institutes. One of the major conclusions of the report is that there seems to be a trend among EU countries to focus on a change of employment laws in order to grant patent rights in the research results to the research organisation instead of the inventor. Their conclusions are that “ownership by institutions, as opposed to title by individual researchers, provides greater legal certainty for firms interested in exploiting research results, lowers transaction costs for partners and encourages more formal and efficient channels for knowledge and technology transfer” (OECD 2003b, p. 5). Nevertheless, they admit that knowledge about legal frameworks and rules is lacking and not well disseminated among researchers at universities and public research organisations (PROs). Furthermore, the OECD argues that even in those research organisations where the public research organisation already owns the research results incentives have been weak to patent and commercialise research results. For instance, in Germany the research results at PROs such as Max-Planck institutes or Fraunhofer institutes were always owned by the PRO and not the inventor. The OECD relates lacking incentives to public sector pay scales or fiscal rules that prevent PROs receiving royalty income. In Sweden, the wages of researchers are quite flexible and in Germany more flexibility was introduced recently. Another study by the OECD “University Research in Transition” (OECD 1999) was already mentioned. It studies the major trends that impact on universities. The report presents an extensive overview of the changing role of universities.

Another important study in the context of this dissertation was commissioned by the European Commission (2001). The aim of the study is to analyse the framework

⁴⁸ A number of general studies about patenting and technology transfer were studied but omitted in the text since they are not directly relevant for the purpose of this dissertation. Examples are Bozeman (2000), who reviews technology transfer at universities in general or the PatVal-EU-study. The PatVal-EU study was commissioned by the European Commission. The PatVal-EU study is based on a survey of European patents. The survey covers information about inventors of European patents, property rights and the economic value of patents and other aspects of the innovation process (see, e.g., Giuri and Mariani 2005).

conditions that are important in universities and PROs. The benchmarking efforts are based on data from the OECD, the Community Innovation Survey (CIS II), national statistics and assessments by national experts. The study included Germany and Sweden and concludes that industry-science relations (ISR) are largely determined by the structural features of a national innovation system. They highlight the importance of different types of ISR, such as collaborative research, personnel mobility, start-ups etc. A general conclusion of the report is that there is not a single best practice model of ISR on a country level. Good practice in shaping framework conditions for ISR includes taking the balance between technology transfer and other goals such as education and research into account, joint research programmes that promote direct collaboration between industry and university, a competition-based approach for allocating funding, the provision of supportive infrastructure that reduces transaction costs and information asymmetries in using IPRs. With respect to infrastructure, they draw attention to advisory support and pre-seed capital for start-ups and several awareness measures. Another way of strengthening ISR is to establish “transfer-specialised institutes” and to increase personnel mobility.

There are also a number of studies on the national level that focus on commercialisation of university research and the broader subject of knowledge and technology transfer.

One of the major investigations about the commercialisation of research results in Sweden was SOU (1996:70).⁴⁹ The goal of this study was to investigate how interaction between industry and university could be improved. One of the conclusions was that an abolishment of the university teachers’ privilege would not give the universities the patent rights in researchers’ inventions. They argue that universities are public authorities that should not deal with risky business such as commercial exploitation of inventions. Instead, they should improve the conditions so that research results can be commercialised. The strategy that is proposed includes that the university teachers’ privilege is not abolished, universities should not deal with risky business, universities should provide service to the researchers in relation to patenting and they should increase the awareness of researchers including that their research results can be patented and that publications foreclose a patent application. In

⁴⁹ For an overview about the different Swedish studies, see SOU (2005:95). Norway abolished the UTP in 2003. Gulbrandsen (2003) conducted a study of the effects of the legal reform based on interviews with researchers and administrative staff at universities. One of the main results is that the patenting and commercialisation is regarded to be very time- and capital-intensive by most of the interviewees. Furthermore, the interviews point at weaknesses in the support infrastructure. Only a small number of researchers commercialises at all. The most important “bottle-neck” with regard to patenting and commercialisation is the lack of pre-seed and seed capital, according to the interviewees.

addition, researchers should be obliged to notify the university about results that are exploitable, and the departments of the university should get a share of the income from commercial exploitation. They suggest also that research funding should be more oriented towards application. An important study of the infrastructure for patenting and commercialisation was conducted by the Swedish National Audit Office (RRV 2001). Some of the results have already been presented in previous sections. It is based on expert interviews and a web-based survey of researchers at Swedish universities. The report analyses the extent to which universities have built up supportive infrastructures after the introduction of the “third mission” in the university laws. RRV analysed the support efforts of universities, university holding companies and technology bridging foundations in all major university regions in Sweden. One conclusion was that the university holding companies were used as the major instruments of the universities to achieve collaboration. The technology bridging foundations were classified into three groups. The first group (Lund, Linköping, Uppsala) owns wholly or partly shares in a large number of enterprises, the second group (Luleå, Umeå) owns shares in a small number of enterprises, and the third group (Stockholm, Gothenburg) is not engaged in ownership. RRV (2001) came to the conclusion that the university holding companies and the TBS have distinct roles. The university holding company usually screens inventions in the university that have potential for commercialisation (they are usually contacted by the scholars). These inventions can be used as base to establish project companies. The seed capital comes in many cases from the TBS which invests in the start-up in return for shares. The evaluation by RRV gives the impression that technology bridging foundations and university holding companies have been quite effective in building up the infrastructure. Another important report in this context is VINNOVA (2003a). Its aim is to analyse how the commercialisation of research results from universities can be improved. The study reviews a number of previous studies and analyses the survey collected by RRV (2001). In addition, a number of expert interviews were conducted. Their conclusions point in a similar direction as SOU (1996:70). They do not suggest the abolishment of the UTP but propose that the university should receive a share of the commercialisation revenues possibly combined with an obligation of the researcher to notify the universities of the invention. Furthermore, VINNOVA suggests a number of other measures to increase technology transfer such as a network initiative linking universities with small and medium-sized enterprises, and they propose that universities should receive more financial resources to support commercialisation in general. There is also a quite recent public investigation about the UTP (SOU 2005:95). The inquiry suggests two alternative solutions. The first one leaves the UTP unchanged but obligates the inventor to notify the university in the case of a patentable invention. The university and the inventor could then negotiate about the rights in the invention. The second suggestion is the abolishment of the UTP. In this case, the investigation proposes that the inventor should receive a compensation of at least 30% of the income from commercialisation.

In Germany, knowledge and technology transfer from universities to private industry has received a lot of attention as well. One of the major studies about this issue is the study by Schmoch et al. (2000). It elaborates on the different mechanisms for knowledge and technology transfer at universities and public research organisations. The study analyses the infrastructure for patenting and commercialisation as well. A considerable amount of data was collected through a survey of universities and PROs. Some of the results of Schmoch et al. (2000) were published separately in Czarnitzki et al. (2000), which have already been discussed above in the background section of this dissertation. The study deals with the preconditions of technology transfer for universities and other research organisations. The study by Beise and Stahl (1999) analyses the effects of publicly funded research at universities on industrial innovations in Germany. They provide an overview of the German research landscape and results of a survey focusing on the importance of university research results for companies. Another study that analysed commercialisation of research results and the university teachers' privilege is Cohausz et al. (1998). It is based on expert interviews and a survey of researchers in Germany. One of their results is that the UTP has no significant effect on patenting and commercial exploitation of research results. Furthermore, the study highlights the importance of flanking efforts such as financial support of researchers through the state or the improvement of the commercialisation infrastructure.

Recently, the consulting firm Kienbaum GmbH evaluated the 21 German PVAs on behalf of the German Ministry of Research and Education (BMBF). Kienbaum (2006) evaluated all 21 PVAs in 2004 and the first three quarters of 2005. They used a web-based survey to assess the acceptance and success of PVAs. The survey was targeted at university administrations, university inventors and firms that exploited university research results from PVAs. In addition, Kienbaum conducted interviews with universities in Germany. The response rate was 52% for universities, 22% for university inventors and 32% for firms that exploited results through the PVAs. A major result related to the topic of this thesis is that a lot of universities and university inventors are actually avoiding the PVAs. The survey of universities revealed that there are still a number of researchers that are not willing to cooperate with the PVA and that are not willing or able to understand the abolishment of the university teachers' privilege. A number of universities do not acknowledge the advantages and benefits resulting from the services of PVAs either, and still give their researchers opportunities to exploit inventions by themselves or through other channels. The study by Kienbaum has also shown that only 12% of the universities involve PVAs in the acquisition of external funding whereas 74% do not involve the PVAs. Only 16% of the questioned universities claimed that they are willing to finance the PVA after the federal funding by the BMBF runs out in 2007. The survey of university inventors revealed that as many as 58% of the respondents were not convinced of the services of the PVA. The study shows that 10 to 20% of the university inventors are opposed to the PVAs and think that the foundation of PVAs as well as the abolishment of the UTP is superfluous and counterproductive. The outcome of the study

is basically a ranking of the different PVAs with respect to acquisition and patenting, exploitation, and customer satisfaction.

The patenting and licensing of university research has been an important topic in the US for quite a long time. Thus, there are a number of studies that analyse aspects related to patenting and licensing. Studies that are important in this context are, for instance, Bercovitz et al. (2001), Carlsson & Fridh (2002), Jensen & Thursby (2001), Mowery et al. (2001), Siegel et al. (2003). To review all those studies would go beyond the scope of this dissertation. The studies focus on university technology transfer at US universities. The institutional framework of US universities is quite different from Swedish and German universities which limits the usefulness for benchmarking and institutional learning. Nevertheless, important results of those empirical studies are (or have already been) presented when they are relevant for the purpose of this dissertation.

In sum, the results of previous research remain inconclusive with regard to the effects of patent rights regimes in universities. We simply do not know whether the university teachers' privilege fosters or hinders patenting of research results from universities. In addition, the commonly used theoretical approaches do not explicitly analyse the incentive structures in universities in a rigorous way. Thus, this thesis contributes with a quantitative analysis based on original survey data covering a large number of German and Swedish professors. In addition, it contributes with a qualitative analysis of technology transfer offices and the processes of transfer in both countries based on interview data.

4. Theoretical Framework

4.1 Incentives in employment contracts

The previous description of the background has shown that the role and funding of universities is changing. In order to understand the impact of those changes on the incentives of researchers to patent their inventions it is important to analyse the complex incentive structures they are facing. The research question raised in this dissertation deals with the incentive effects of patent rights regimes in universities. Thus, the complex incentive structures in universities have to be analysed.

As mentioned earlier, universities are increasingly orienting themselves towards commercially relevant research in order to overcome financial difficulties from stagnating public funding. University laws in Sweden and Germany alike include clauses that state that universities have knowledge and technology transfer as a task or goal besides the traditional tasks of teaching and research.⁵⁰ Thus, in order to accomplish the goal of technology transfer, the university has to delegate this task to its researchers.

From a theoretical perspective, incentives in universities are properly analysed by incentive theory. According to Brousseau and Glachant (2002, p. 9), “incentive theory (IT) starts from a canonical situation in which an under-informed party – called the “principal” – puts into place an incentive scheme to induce the informed party – the “agent” – to either disclose information (adverse-selection model) or to adopt behavior compatible with the interests of the principal (moral-hazard model)”. The key assumptions of incentive theory are quite close to traditional economic theory. They assume that economic agents are endowed with substantial rationality (so-called Savage rationality), the agents possess complete information concerning the structure of the issues that they are confronting and they have unlimited computational abilities. In addition, the agents have a complete and ordered preference set.

⁵⁰ In Germany, universities are under the responsibility of the federal states. Each federal state has its own university law. Nevertheless, the university laws of basically all federal states include technology transfer as a goal of the university, although some federal states included this clause only recently.

The consequence of those assumptions is that the economic agents are able to imagine the most efficient solutions and compute their expected values. Stable and complete preference functions lead to the choice of optimal solutions. Central to incentive theory is that the contracting parties do not have access to the same information on certain variables. This is a deviation from standard mainstream economics. In mainstream (neo-classical) economics, transaction costs are absent, which means that there are no costs with regard to monitoring and information gathering. The consequences, in particular with regard to property rights in research results, will be discussed throughout this chapter. Incentive theory will be used to illustrate the general problems in employment contracts followed by an elaboration about employment contracts in universities. Finally, the importance of transactions costs and property rights with respect to patenting and commercial exploitation will be highlighted. The theoretical arguments will be used to develop hypotheses that will be used in the empirical part of this dissertation.

Two types of models are used in incentive theory. Adverse selection models deal with information asymmetries before a contract is accepted and entered, whereas moral hazard models deal with information asymmetries after the contract is accepted. Brousseau and Glachant (*ibid*, p. 8) argue that “adverse selection, for example, is exemplified by a potential employer’s uncertainty concerning a job seeker’s level of competence, while moral hazard refers to uncertainty about the level of effort the latter will supply”.

The general problem in employment contracts in universities is related to asymmetric information. The effort of researchers is difficult to measure and to control. The output of researchers with regard to teaching, research and transfer is difficult to measure as well. Thus, the theoretical analysis of incentives in universities is primarily facing a moral hazard problem since one relevant dimension of the agent’s input is not observable by the principal. In addition, the effort of the agent cannot be deduced from observed output since the output of the agent depends not only on his effort but on other variables that are not under his control and that are not observable to the principal (e.g., co-workers’ efforts, randomness in the production process). Figure 4-1 illustrates the situation.⁵¹

⁵¹ For a formal presentation of principal-agent models see, for instance, Erlei et al. (1999). A formal mathematical exposition was omitted in this theoretical part since operationalization problems make it difficult to apply such a model for empirical testing. Nevertheless, the verbal and graphical exposition and argumentation illustrate the main issues of incentive structures in universities that are relevant for this dissertation.

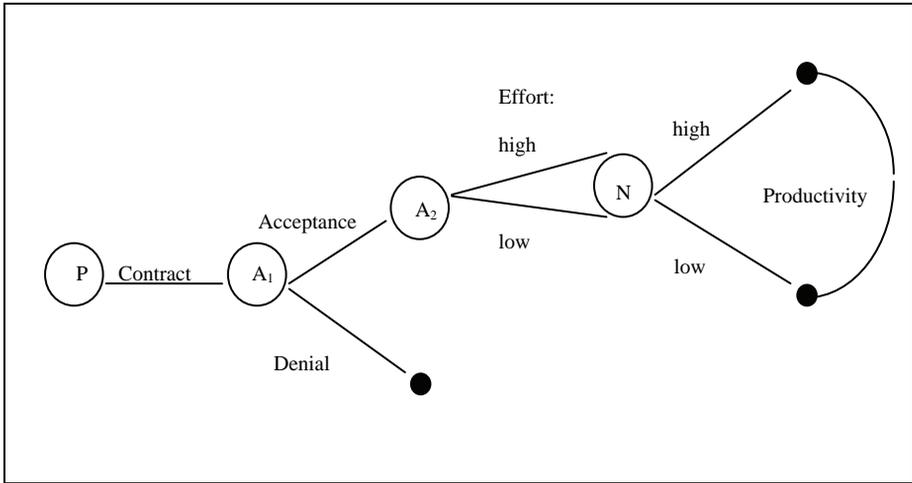


Figure 4-1: Graphical illustration of moral hazard in employment contracts. Source: Erlei et al. (1999, p. 112, my translation). Printed by permission of Schäffer-Poeschel Verlag GmbH.

In figure 4-1, the principal P (in our case the university) offers an employment contract to agent A (researcher). The agent can accept or reject the offer (A_1). In the case of acceptance, the agent chooses his level of effort (A_2). The principal cannot observe the chosen level of effort. Thus, there are information asymmetries in favour of the agent. The productivity and the output are not only determined by the effort of the agent but also by chance or luck. Thus, the “player nature” N determines partly whether the productivity is high or low. The principal receives the resulting output but he is not able to find out whether the output was produced by the effort of the agent or by favourable external conditions (luck or chance). This means also that the agent can justify low output with unfavourable external conditions.⁵²

The problem that has to be solved with regard to this moral hazard problem is that the principal has to install reward structures that provide incentives to the agent to exert a high level of effort. To provide optimal incentives to the agent, the payment scheme would be linear to the observed output. This would resemble an incentive contract. Incentive contracts give the agent a share of the value of his marginal

⁵² Non-observable actions are illustrated by multiple lines from the nodes. The end points are connected since the last action cannot be observed by all players.

product to provide incentives to increase effort. At one extreme, the agent receives the entire value of marginal product. Nevertheless, the use of such incentive contracts in universities is limited since the value of the marginal product does not entirely depend on the researcher's effort and it is difficult to define the product of research. In addition, incentive contracts cause costs in the case of risk-averse agents.⁵³ An example can clarify this argument. For a risk-neutral person a certain sum (say the person receives 10 € for sure) is valued equally as the outcome of a lottery with the same expected value (say the person could receive 100 € with a 10% probability, the expected value is, thus, $100 \cdot 0.1 = 10$ €). In contrast, a risk-averse person prefers a certain sum below the expected value instead of the outcome of the lottery (say the person prefers to receive 8 € for sure instead of the expected value of 10 € from the lottery). Thus, risk-averse persons are willing to pay a kind of insurance premium (2 € in the example) in order to insure themselves against the uncertain outcome of the lottery. Risk aversion is relevant in the case of incentive contracts since the researcher would receive a share of the value of his marginal product. Since the value of the marginal product is dependent on the researcher's effort, and variables that cannot be controlled by the researcher (chance or luck – the player nature – determine the outcome or benefits of research or patents to a considerable extent), the incentive contract resembles a kind of lottery. As already mentioned, in particular patenting is a risky business. Thus, risk-averse agents will not accept such an incentive contract. Risk-averse researchers will be willing to pay a risk premium to insure themselves against those risks. In other words, risk-averse agents will prefer a fixed wage.⁵⁴ The provider of this insurance can be the principal (university) since it can be assumed to be risk neutral because it is able to spread the risks over a large number of agents (researchers) (see e.g., Erlei et al. 1999). Thus, the university can provide a kind of insurance contract to the researcher by offering a fixed wage. An insurance contract provides a fixed wage to the agent and the principal bears the risk of fluctuations of the output. The disadvantage of a fixed wage is, however, that it provides no incentives to provide a high level of effort. Thus, there is a typical trade-off between insurance and incentive contracts.

In sum, the general situation is that the principal can offer either incentive contracts, insurance contracts or a mixture of both to the researchers. Gibbons (1998) calls this trade-off between incentives and insurance the classic agency model. The extent to which the agent receives the value of his marginal product is called bonus. If the

⁵³ Risk causes costs in the case of risk aversion (Cooter & Ulen 1996).

⁵⁴ The argumentation assumes that the entire outcome is affected by risk. This is not true with regard to patenting since only a small part of the researchers income is affected by risk. Thus, patenting and commercial exploitation resembles more a kind of "middle-class gambling" where the stakes are not that high for the researchers since they already have a fixed wage. Only the bonus is affected by risk not the entire income. It could also be argued that researchers are less risk-averse since not the entire income is affected.

agent receives the entire value of his marginal product the bonus is 1. This resembles a pure incentive contract. If the agent receives no bonus at all this can be called a pure insurance contract. According to Gibbons (1998, p. 116), “the efficient bonus rate is between zero and one, depending on factors such as the amount of risk in ε and the parties’ risk-aversions” (ε is the noise term in the production function). Thus, risk and the agent’s attitude towards risk are the primary determinants in this model. In relation to university research and transfer, it depends therefore on the inherent risks of research projects to deliver meaningful results (or commercially relevant results) and the risk aversion of the researchers. Still, the problem of monitoring and control has to be solved in some way.

4.2 Employment contracts in universities

The situation becomes more difficult in the case of more than one task at hand. The university has three different tasks that should be fulfilled simultaneously.⁵⁵ Thus, the employment contracts in universities should actually provide incentives to the agents to exert effort in teaching, research and transfer. This multiplicity of goals is typical for public bureaucracies. Tirole (1994, p. 1) argues “while private enterprises are in a first approximation instructed to maximize profits, government agencies generally pursue multiple goals”. He claims that the multidimensionality of goals is related to two general difficulties. First, several dimensions of performance are difficult to measure. Second, different goals within the same organisation raise the issue of their weights. In our context, one could ask which task is most important research, teaching or transfer?

A general lesson from multiple principal-agent situations where agents should exert effort in more than one dimension is that incentives have to be balanced in order to provide incentives to exert effort in all tasks, otherwise there is a risk that agents neglect the less-paid tasks. For instance, if the reward system builds entirely upon publications, it is likely that researchers publish and neglect the other tasks. Assume that the wages of professors were based entirely on the number of lecturing hours. This would provide incentives to teach as many hours as possible. The result would probably be that the teaching quality would decrease and research and the third mission would be omitted. This illustrates that the reward system has to be balanced in order to provide incentives to the researchers to exert effort in all tasks.⁵⁶ The

⁵⁵ Of course, the university has other goals as well, such as providing equal chances regardless of race, sex, religion etc. For simplification, only the three broader tasks of universities are discussed in this dissertation.

⁵⁶ The basic multiple principal-agent model was developed by Holmström & Milgrom (1991).

empirical study by Cockburn et al. (1999) can be used to illustrate this argument. One private industry where scientific publications (besides patents) are important for career advancement is the pharmaceutical industry. Cockburn et al (ibid.) have shown that in a study of researchers in the pharmaceutical industry, firms provided incentives for two tasks to be accomplished (patents and research papers) through the internal capital market and promotion policies. Researchers received more funding when they produced above-the-average output with respect to patents and they were promoted on the basis of scientific publications. Thus, the firms actually offered incentives on both dimensions.

To illustrate incentive problems that public bureaucracies are facing, Tirole (1994) argues that there are basically three ways to motivate self-interested economic agents. First, to install formal incentives. Second, the monitoring of work input and third, career concerns.⁵⁷

Formal incentives can be piece rate wages, bonuses, stock options and relative performance evaluation. All those incentives are based on verifiable performance measures. The classical economic model focuses on formal incentives. The model tells us that a firm hires workers until the wage paid is equal to the value of the worker's marginal product.⁵⁸ Wages are determined by supply and demand in the usual way. Workers are assumed to be highly flexible and the employment relations are typically governed by spot market employment contracts. Day labourers could be used as an illustrative example. The workers typically receive a kind of piece rate. Piece rate wages are similar to the ideal spot market contract that Macneil (1974, p. 738) characterises as "sharp in by clear agreement; sharp out by clear performance". The fully specified contract specifies quality, quantity, time and place of delivery, and the price. It is clearly specified ex ante and the performance is observable and verifiable by third parties ex post. This means that all contingencies are drafted in the contract and the legal system can clearly judge whether the contract was fulfilled after performance.

The work of professors is more difficult to specify than the contracts of day labourers. The work of researchers consists of doing research in areas where no previous knowledge exists. Thus, future discoveries and research results can obviously not be drafted in a contract. In addition, research especially in natural science, engineering and medicine is carried out in teams where it is difficult to measure the marginal

⁵⁷ Of course, researchers can be intrinsically motivated as well. In this case payment schemes focusing on extrinsic motivation can only lead to disturbing effects. See, for instance, the work of Frey (1997) in this context.

⁵⁸ For a discussion, see, for instance, Milgrom & Roberts (1992).

input of the team members. Nevertheless, formal incentives do play a role in the contracts of scholars with regard to teaching. Professors at universities in Germany have a fixed teaching load. The employment contracts prescribe a number of teaching hours that have to be fulfilled. Non-compliance is easy to monitor and to control. In Sweden, university employees receive a fixed payment for each teaching hour. Thus, with respect to teaching, employment contracts actually contain formal incentives and the fulfilment is easy to monitor and to control at low cost. Of course, we have to bear in mind that only the teaching quantity can be controlled but not the quality.⁵⁹

This leads to the second way to motivate economic agents in the form of monitoring as mentioned by Tirole (1994). Especially with regard to teaching, it is difficult to monitor teaching quality. In addition, according to Alchian and Demsetz's (1972) team theory, there is a measurement problem if work is carried out in teams. In universities, research is often carried out in teams and it is very difficult to measure the value of the marginal product of each researcher. There are a number of proxies or indicators. For research, a frequently used indicator is publications in scientific journals and citations. In this context it is important to mention that researchers frequently publish together with other researchers, which makes it difficult to assess the individual's performance. These are typical output indicators of research. For teaching, the number of teaching or lecturing hours is used to measure input. Input with respect to teaching hours can be measured but with regard to research this becomes more difficult. Researchers have no compulsory attendance or fixed working hours. A substantial share of researcher's work can be done at home (e.g., researchers can read or write articles at home). Furthermore, it is difficult – if not impossible – to define the product of research endeavours. In addition, the value of the marginal product of a researcher does not entirely depend on his effort. There are other factors, for instance simply luck, that have an impact on the research output of professors. Thus, we have a fundamental monitoring problem since the university cannot assess the value of the marginal product of its researchers in a meaningful way.

Career concerns inside and outside the organisation are the third way to motivate self-interested economic agents, according to Tirole (1994). He argues that “perhaps the main drive for civil servants and politicians is career concerns” (ibid., p. 7). Long-term contracts and wages based on seniority are frequently applied in public bureaucracies and universities. There are promotion rules that build upon subjective performance assessment every couple of years. A typical characteristic of wages in universities is that the wages of researchers in the first years of employment are below the value of the marginal product – however it is defined - whereas in the last

⁵⁹ Although there are approaches for measuring teaching quality, the common problem is that those indicators and proxies measure teaching quality only imperfectly.

years of employment, close to retirement, the wages are above the value of the marginal product. This provides incentives to the researchers to stay in the organisation. Lazear (1979) argues that the agency problem can be solved by paying workers less than the value of their marginal product when young and more than the value of their marginal product when they are old. Thus, researchers in the early phase of their careers anticipate the higher wages in the future and comply with the goals of the university and limit shirking by exerting a high level of effort. The university has to make sure that they are committed to this wage policy. Thus, it has to make sure that researchers are not laid off when their wages are above the value of their marginal product.⁶⁰ The reputation of universities works as kind of self-enforcing contract in this respect.

Wadensjö (1994) mentions three motives for long-term employment contracts. One important motive is risk reduction. The university insures the researcher against risks. Since the university employs a large number of different researchers it can decrease the risks associated with research through diversification. Research is in itself risky, since research effort does not always lead to meaningful research output in the form of knowledge, publications or patents. Furthermore, long-term wage contracts built upon seniority provide incentives to the principal and to the agent to invest in organisation-specific training. The qualification that is required to conduct research is highly specific. Researchers have to invest time and effort in order to get a PhD and to advance as senior researchers. Their human capital has considerably less value outside academia, although there are notable exceptions.⁶¹ The long-term contract enables the returns from those specific investments to be secured.⁶² Finally, long-term contracts are a way to monitor and control the researchers. Long-term contracts enable the principal to monitor the agent continuously. The agent can convince the principal that he abstains from shirking and exerts a high level of effort (bonding). The risk of shirking related to information asymmetries can be substantially reduced through long-term employment contracts based on seniority. Wages are dependent on promotion rules that depend on some form of assessment. Employees that stay in the organisation have proven that they abstain from shirking and exert a high level of effort. Subjective performance assessment can be based on the previously-mentioned performance indicators such as publications or citations.

⁶⁰ Professors appointed to a chair (*Lehrstuhl*) in Germany are employed as civil servants where the risk of getting laid off is low.

⁶¹ As mentioned, science-based firms such as pharmaceutical firms apply payment schemes that can be quite close to the reward system in universities.

⁶² For a discussion of asset specificity, see Williamson (1985).

4.3 Patent rights in research results

In a simplified way, we can argue that the wages of researchers are composed of a fixed salary and a flexible bonus. The fixed salary is usually dependent on personal factors such as qualification, age or rejected “calls” on professorships.⁶³ In addition, publications and the acquisition of external funding are likely to impact directly or indirectly on the fixed wage. The employment contracts of researchers also prescribe a fixed teaching load in Germany which is covered by the fixed wage. In addition, university researchers have the possibility to earn a bonus. This bonus can take different forms. This bonus can be additional income in the case of consulting assignments or patenting. The bonus with respect to patenting depends on the effort of the researcher with regard to patenting and chance or luck (or an error term). Chance or error is particularly relevant in the case of commercial exploitation since only a minority of patents cover costs. The extent to which researchers are able to earn a bonus is greatly affected by the patent rights regime in universities. The patent rights regime defines the extent to which researchers own their marginal output with respect to patenting.

The principal-agent setting models the decision of researchers with regard to the type of contract offered by the university as a take-it-or-leave-it-situation. It was argued that risk-averse agents would reject a pure incentive contract – for instance the initial allocation of patent rights in Sweden - since they favour a fixed income. Nevertheless, an insurance contract that provides a fixed wage to the agent would provide no incentives to exert effort. With regard to patenting, the patent rights in research results can provide incentives to exert effort if researchers are not overly risk averse. Thus, a principle consequence from incentive theory is that the initial allocation of patent rights matter for the incentives to exert effort. For our empirical case at hand this would mean that the different patent rights regimes in Sweden and Germany would lead to different incentives with respect to patenting and commercialisation.

Nevertheless, we have to bear in mind that the formal patent rights regimes in both countries resemble a kind of initial allocation with respect to patent rights only. The

⁶³ Qualification in the context of universities means that appointments frequently depend on formal qualification, for instance, a university degree is required to get an appointment as a PhD student or a PhD is required to become a senior researcher. In addition to the formal qualification (e.g., the academic title), other performance measures such as scientific publications are frequently used to assess the capability of potential candidates.

formal legal situation in both countries can be subject to bargaining between different parties. Patent rights in research results can be interpreted as a bundle of rights with different dimensions. In general, property rights resemble a bundle of rights that include the right to disposal and use, the residual right, the right to compensation, and freedom of contract (Faure and Skogh 2003, p. 62). The use and disposal right means that the owner of a resource can freely dispose of it as long as the use is not prohibited by other laws. The residual right includes the right to profit and the duty to cover losses. As mentioned by Faure and Skogh (ibid, p. 62), “the owner is, thereby, a risk-taker. The risk, and the chance of profit, gives the owner an incentive to maximize the utility or profit of the property.” The right to compensation safeguards that the owner of property can assert his rights upon infringement. This can be the case when the property is damaged. Freedom of contract means the right to transfer rights by contract and gift. Freedom of contract is a crucial precondition for a market economy since it enables voluntary agreements about transfers of property rights. Freedom of contract results in voluntary agreements that are beneficial to all parties involved. It safeguards that the owner of a resource receives all utility and profit associated with the property but in return he has to bear all costs. An efficient property rights regime internalizes all costs and benefits attached to the property. In that case, the owner as decision-maker conducts the trade-off between costs and benefits.⁶⁴

In the context of the patenting and commercialisation of university research, the initial allocation of patent rights in research results plays an important role.⁶⁵ In both countries, the researchers dispose of and use resources that are financed by other parties - for instance, the state, external private and public financiers - but the extent to which the researchers receive the benefits varies. In Sweden, the initial allocation of patent rights gives the professors the right to own their research results entirely.

⁶⁴ In reality, not all costs and benefits associated with property are internalized. External effects may distort the efficient pricing of resources. We can distinguish between positive and negative external effects. Positive external effects mean that benefits are not included in the pricing of the resource. Knowledge spill-overs are typically characterized as positive externality. The result is that the owner of the resource does not include those benefits in his cost-benefit analysis, which results in underinvestment in productive activities. The patent law is one way to internalize those positive externalities. The second case is negative externalities or negative external effects. This means that some costs are not included in the pricing of the property. Environmental problems such as pollution are typical examples of negative externalities. Since those external costs are not included in the calculations of the property owner, the decision-making process of the property owner is disturbed. This can result in an inefficiently high activity level related to the property right, e.g., industrial production that causes pollution.

⁶⁵ The term patent rights regime is used instead of property rights regimes since the university teachers' privilege covers patents only.

This patent right can be interpreted as a bonus with regard to patenting. Researchers can receive 100% of the gross income as bonus but have to bear the entire costs and risks. The UTP in Sweden is dispositive, which opens the possibility for contractual and bargaining solutions. In Germany, the initial allocation of patent rights gives the university the right to own the research results. The inventor receives 30% of the gross income as compensation and does not have to bear any costs and risks. The inventor has to notify the university in the case of a patentable invention. Thus, the initial allocation of patent rights is different in both countries. Nevertheless, the final allocation of patent rights can be different from the initial allocation since the freedom of contract - at least in the Swedish case - can lead to a transfer of patent rights to other parties.

The transfer of patent rights is highly affected by transaction costs. As argued by Cooter and Ulen (1996, p. 83), “when transaction costs are zero, an efficient use of resources results from private bargaining, regardless of the legal assignment of property rights”. This is the famous Coase theorem.⁶⁶ The theorem states basically two things. First, private bargaining will result in an efficient use of resources in the case of absent transaction costs. Second, related to the empirical case at hand, it means in a frictionless world without transaction costs, it simply does not matter whether the university or the researcher owns the patent rights in the research result since the resource – in our case the patent rights in research results – will always move to the party that values it the most. The focus is, therefore, on transaction costs since transaction costs impact on the transfer of patent rights. As a consequence, transaction costs together with the initial allocation of patent rights determine the incentives of researchers to patent and exploit research results. Cooter and Ulen claim that “when transaction costs are high enough to prevent bargaining, the efficient use of resources will depend upon how property rights are assigned” (ibid., p. 82). Thus, with respect to the purpose of this dissertation, it can be argued that the impact of patent rights regimes will be different in both countries if there are prohibitively high transaction costs that prevent bargaining.

In reality, there are transaction costs that possibly hinder the patent rights in research results from moving from university or researcher to the party who values it the most, namely private industry. Two types of costs can be distinguished in this context. First, the coordination of the different tasks in the university and the problem of accommodating the different interests of the university and its researchers causes costs. These costs of internal organisation in hierarchies are related to the principal-agent problem as discussed earlier. There are large information asymmetries that favour the researchers. It is difficult and costly to monitor researchers, and scholars

⁶⁶ The Coase theorem goes back to the seminal article by Coase (1960). It is frequently used as a reference point to illustrate the importance of transaction costs and property rights.

have a large discretion and liberty to use their results. Second, the transfer of patent rights in research results from university or researcher to private industry – through different means such as licensing or start-up – is costly as well. Those costs caused by using the market mechanism are frequently called “transaction costs”.⁶⁷

With regard to patent rights in research results, the bonus related to the third mission focuses particularly on patents. In addition, researchers can transfer their knowledge by different means such as consulting assignments, royalties from books, honoraria for lectures etc. That means in addition to the fixed wage, professors have the possibility to increase their wages through a number of third mission efforts. Research and teaching is difficult to measure and to monitor but it seems that effort with respect to the third mission is even more difficult to monitor. This is especially true in the case of patenting. Patenting and licensing is a highly risky process where only a small share of inventions generate profits. The consequence of the general agency model is that incentives are determined by the amount of risk inherent in the production of the marginal product and the risk aversion of researchers. Since the patenting and licensing of university research is associated with high risks, at least for Swedish professors, it is unclear whether the bonus in the form of patent rights is sufficient to set incentives to exert effort in the third mission. With regard to incentive theory and the general agency model, this could mean that researchers simply reject patenting as third mission and refuse to patent and commercialise their results, or avoid it.

Nevertheless, in the case of low transaction costs, a different result can occur. The formal legislation in both countries can be interpreted as the initial allocation of patent rights in research results. The Swedish UTP is a default rule which opens up for bargaining solutions. As already mentioned, there are a number of settings in which Swedish professors do not own their research results such as in the national competence centres. Thus, in those competence centres, the final allocation of patent rights is different from the initial allocation since the parties involved come to a bargaining solution. Universities in Sweden also have the possibility to abolish the UTP in negotiations with their researchers. In Germany, even though the researchers are obliged to notify the university in the case of a patentable invention, it is difficult and costly to enforce this regulation. This is related to the large information asymmetries in favour of the researchers. Thus, the initial allocation of patent rights in

⁶⁷ Transaction cost economics examines the “comparative costs of planning, adapting, and monitoring task completion under alternative governance structures” (Williamson 1985, p. 2). With respect to the market mechanism, these costs are usually called search costs, contract costs and the costs of contract enforcement. In general, Williamson (1985) distinguishes between market and human factors that impact on transaction costs. The market factors include uncertainty, frequency and asset specificity. Human factors consist of bounded rationality and opportunism.

research results in Germany gives the patent rights to the university but to what extent patent rights in research results are transferred by professors on an “informal” basis is difficult to estimate. A consequence of the Coase theorem is that low transaction costs favour bargaining and solutions that can be different from the initial allocation of patent rights. In the case of patenting and technology transfer, low transaction costs could be reasonably assumed in the case of experienced professors since they are likely to have contacts to private firms stemming from previous collaborations or consultancy assignments. In the case of low transaction costs, the initial allocation of the patent rights does not matter.

Therefore, incentive or agency theory comes to the conclusion that the initial allocation of patent rights matters, and as such we would expect differing patenting activities and behaviour in Sweden and Germany. This would mean that researchers take the initial allocation of patent rights as given and exert efforts with regard to patenting or avoid it entirely. In contrast, low transaction costs can lead to a different final allocation of patent rights which would mean that the initial allocation of patent rights has only limited impact. In this case, other things equal, we would expect similar patenting activities and behaviour in both countries. This would mean that researchers do not take the initial allocation of patent rights as given but bargain with other parties (e.g., financiers, university, TTOs) in order to transfer the patent rights.

Thus, the following tentative hypotheses can be used for empirical tests.

- Hypothesis 1: Patent rights in research results create positive incentives to patent research results.

Hypothesis 1 tests basically the different patent rights regimes. First, it tests whether patent rights owned by researchers create positive incentives to patent research results. The argumentation in this context is that researchers who own the patent rights in their results (Sweden) have positive incentives to patent and commercialise their inventions since they are entitled to the entire benefits. Second, it tests whether patent rights owned by the university (Germany) create positive incentives to patent research results. This scenario acknowledges risk aversion and the argumentation is that patent rights owned by universities reduce the risk of researchers and provide positive incentives to notify the university of patentable research results since German researchers receive a rather generous compensation without having to bear any risks. Finally, an alternative patent rights regime is patent rights in research results by firms. It was already mentioned that firms frequently finance public research. It is often in the financing company’s interest that the research results are protected by a patent application. Patent rights in the research results are frequently surrendered to

the financing enterprise in a number of organisational settings such as the national competence centres in Sweden. In addition, it is likely that firms predominantly finance applied research that can lead to commercial output as well. With regard to risk, it can be speculated that risk-averse researchers prefer to surrender their patent rights in return for a lump sum payment or external funding. To surrender patent rights to firms in return for a lump sum payment or external funding can be interpreted as transferring a risky and uncertain benefit into a certain fixed sum. Thus, the firm actually offers a kind of insurance contract with regard to patenting and commercial exploitation. The different patent rights regimes are tested separately in different regression models. Thus, the empirical analyses compare the impact of the different patent rights regimes.

In addition, a number of structural factors are likely to affect the incentives to patenting as argued in the following hypotheses.

- Hypothesis 2: The reward system of universities rewards patents, which creates positive incentives to apply for patents.

It was argued in chapter 3 that universities in both countries actually have the possibility to reward patents more directly. Patents can be used as criteria to allocate resources in the university and they can be used for assessment of the researchers for instance in the case of appointments to professorships. Thus, researchers that have proven to be active with regard to patenting and commercial exploitation have also greater chances to advance in academia.

It has already been discussed that the funding of universities is changing. Funding is also likely to impact on the incentives to patent and commercialise as argued by hypothesis 3 below.

- Hypothesis 3: Incentives to patent research results are relatively weak in research organisations with high base funding.

High base funding usually means that the researchers themselves have the freedom to decide about the research topics, which could mean that the researchers do not have to focus on commercial applicability which would result in weak incentives towards patenting and commercial exploitation. In contrast, it can be argued that in research organisations with low base funding, the incentives to patent and commercialise are stronger since high external (in particular private) funding can be assumed to spur commercially relevant research. In the case of privately commis-

sioned research, private industry is primarily willing to finance research that is beneficial to them in terms of exclusive patents etc. The type of funding is often related to the research orientation in terms of basic and applied research. It can be argued that basic research is related to base funding from the state.⁶⁸ In contrast, it could be suspected that applied research (which is assumed to be closer to the market) is often financed by external sources.⁶⁹ Thus, it can be speculated that researchers conducting primarily applied research have stronger incentives to patent research results than researchers conducting basic research, as argued by the following hypothesis.

- Hypothesis 4: Incentives to patent research results are relatively strong in applied research.

Finally, hypothesis 5 argues that the infrastructure for patenting and commercialisation has a positive impact on the incentives to patent research results.

- Hypothesis 5: Supporting infrastructure for patenting and commercial exploitation creates positive incentives to patent research results.

In Sweden, the scholar has the right to decide about the use of the research results. Nevertheless, there are agents that assist the researcher during the commercialisation efforts. These agents include technology bridging foundations and university holding companies. In this context, the fact that the university teachers' privilege is a dispositive law is important. Promising start-up companies can receive seed capital in return for shares in the enterprise. In the case of a patent application and an effort to commercialise research results, a daughter company can be established by the university holding company and the TBS can provide seed capital in the case of a promising project. University researchers that need seed capital and support from the TBS can sell part of their ownership rights. This gives incentives to TBSs to get involved in commercialisation efforts.

In Germany, patent and exploitation agencies (PVAs) play a role as mediators for the patenting and commercialisation of academic research since the universities and not the researchers own the patent rights. The new German regulation emphasises

⁶⁸ This argumentation follows the public good argument presented earlier in this dissertation.

⁶⁹ Nevertheless, it can be argued that the distinction between basic and applied research is becoming increasingly blurred, for instance in pharmaceutical research.

the role of PVAs for technology transfer. They act as mediators between the different parties. A specialised commercialisation infrastructure is beginning to build up around PVAs. Employees at PVAs are highly specialised in technology transfer. It seems that the new regulation increases networking between the different agents involved. Networking is of particular importance for the commercialisation of university research.

The supporting infrastructure is likely to impact positively on the incentives to patent and commercialise university research, since the supporting actors possibly reduce the risks associated with patenting and commercial exploitation. Especially for risk-averse researchers, the involvement of the public infrastructure can reduce risks and increase incentives to exert effort with regard to patenting and commercial exploitation.

In sum, the theoretical chapter has led to a number of factors or variables that impact on the incentives to patent university research results. The theoretical analysis of employment contracts of researchers has shown that the reward system in universities is of primary importance to impact on the incentives to exert effort in the three tasks. It is important to measure the role that different proxies and indicators have in the reward system. Patent rights in the research results are a bonus for third mission effort. The public infrastructure can possibly reduce the risks that a bonus materialises. A simplified model for subsequent measurement can be summarized as in figure 4-2.

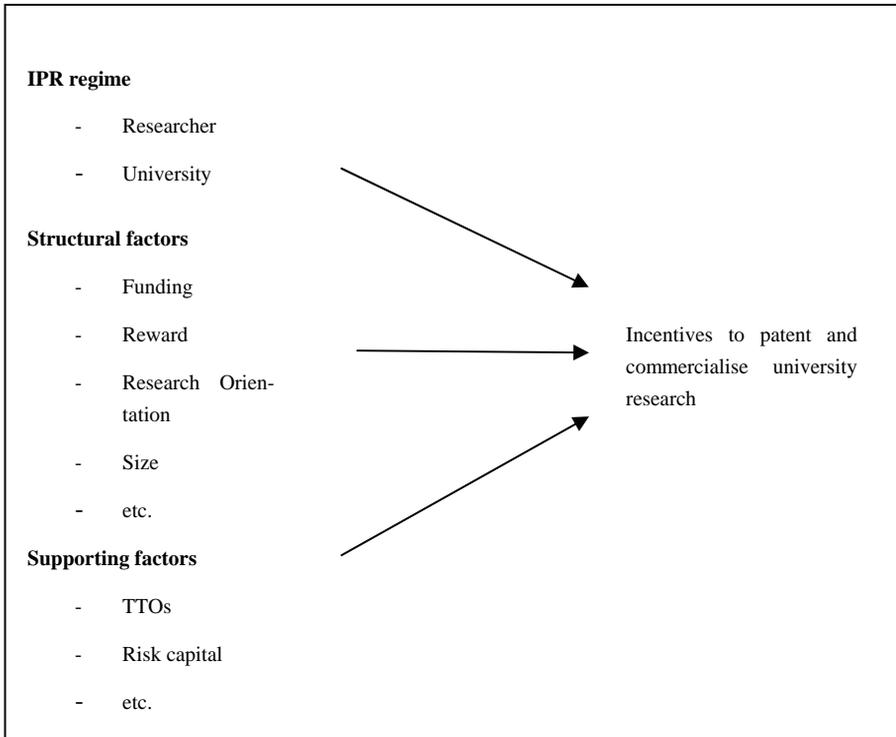


Figure 4-2: Factors impacting on the incentives to patent and commercialise research results.

Source: own elaborations previously published in Sellenthin (2003, p. 213). Published by permission of Peter Lang Verlag GmbH.

Figure 4-2 illustrates the three broader factors that are likely to impact on the incentives to patent and commercialise research results. The first factor is the IPR regime. It includes university-patent rights in research results, researcher-patent rights in research results and other solutions, for instance, when firms own the patent rights in the research results. The second factor is the structural factors including the sources of funding, the reward system, and the research orientation. The third factor is the supporting factors including the existence of technology transfer offices, risk capital, etc.

5. Analysis

The theoretical chapter has resulted in a model that will be applied in order to estimate the incentive effects of patent rights regimes in Sweden and Germany. Different hypotheses were developed that relate variables to the theoretical dimensions and factors. The analysis proceeds in the following steps: In 5.1, descriptive statistics provide an overview of the survey data. The first half presents general background statistics whereas the second half presents descriptive statistics for the three broader factors of the theoretical model. The estimates for a number of regression models are presented in 5.2. The regression models show a rather abstract picture about the incentives of university researchers to apply for patents. This abstract picture will be enriched and interpreted by the results of the qualitative interview study in 5.3.

5.1 Descriptive statistics

5.1.1 Background statistics

In the beginning of this analytical chapter, some basic descriptive statistics are presented to provide the reader with an overview of the survey. Table 5-1 shows some background data about the researchers in the survey.

	Germany	Sweden
Age	51.83	54.95
Experience in academia in years	22.60	27.33
Experience as professor in years	12.62	9.15
Share of professors responsible for a research group (%)	92.40	86.10
Size of research group (research staff incl PhD candidates in fulltime equivalents)	10.39	9.46
Share of female researchers (%)	9.3	9.8

Table 5-1: Basic personal characteristics of the respondents in the survey.

Source: own calculations.

On average, German researchers in the sample are about 52 years old and their Swedish counterparts about 55 years old. The researchers are quite experienced with about 23 years of experience in academia in Germany and about 27 years in Sweden. The vast majority of researchers in the sample are responsible for research groups, institutes, chairs etc. For the researchers responsible for research groups, a number of structural variables were assessed, such as size of research group and funding. The average size of research group is 10.4 in Germany and 9.5 in Sweden. The size of the research group measures the scientific staff including PhD students in full-time equivalents. The share of female researchers in the sample is about 9.3% in Germany and 9.8% in Sweden. This shows that the natural sciences, engineering sciences and the medical sciences are male-dominated research fields.

	Germany	Sweden
Share of patent-active researchers 2002 - 2004 in total (%)	27.7	23.8
Researchers, who have applied for a patent 2002-2004 themselves (%)	15.6	12.6
Another party has applied for a patent 2002-2004 (%)	12.1	11.1
TTO/Uni/Holding	25.5	6.8 (*)
PVA/TBS	2.1	0.0
Firm	59.6	79.5(*)
No patent, but intention to get the invention patented by themselves (%)	3.0	4.5
No patent, but another party has the intention to patent the invention (%)	5.8	2.5(*)
No patent, but commercial potential (%)	27.0	27.5
Research results cannot be patented (%)	36.5	41.8
Share of researchers who have patents (only granted patents) (%)	37.2	28.5 (**)
Number of patents	5.1	3.6
Share of researchers with five or more patents (%)	28.6	25.2
Number of observations (n)	397	404

Table 5-2: Descriptive statistics about patenting.

Note: Differences between both countries were tested by a chi-square test.

(†): sig. 10%, (): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.*

Source: own calculations.

The data about patents in table 5-2 show that about 28% of the responding researchers in Germany applied for a patent – either themselves or another party - between 2002 and 2004. The corresponding figure for Sweden is 24%. The differences between both countries are not statistically significant as measured by a chi-square test.⁷⁰ Table 5-2 shows that 16% of the responding German researchers themselves applied for a patent between 2002 and 2004 and 12% got their research results patented by a third party. In Sweden, about 13% of the respondents applied for a patent between 2002 and 2004 themselves, whereas 11% got their research results patented by a third party. These results are remarkable. After the abolishment of the UTP in Germany, one might expect the majority of patent applications to be handled by third parties, for instance the PVA or the university. Still, the majority of responses of the patent-active researchers indicated that they themselves patented their results. The question covered patent applications between 2002 and 2004, in other words when the UTP was already abolished in Germany. The majority of researchers who indicated that a third party applied for a patent for their research results got it patented by firms. In Germany, the university applied for 26% of those cases, where a third party handled the patent application. In Sweden, this share is significantly lower (6.8%) and includes the university holding companies.

A rather large proportion of researchers in the sample indicated that they or a third party did not apply for a patent although their results had commercial potential. This figure suggests that there is a rather large potential of research results that are not commercialised although researchers regard them as promising. A large share of researchers claimed that their research results cannot be patented. The data about previous granted patents is also quite interesting. Researchers were asked whether they hold granted patents. Note that the previous question covered patents applied for. A granted patent was already assessed by the patent authorities. According to the European Patent Office, it takes about 44 months to get a patent granted after the application was submitted. The Swedish Patent and Registration Office mentions three years. Table 5-2 shows that 37% of the German respondents have granted patents. This figure is significantly lower in Sweden where about 29% answered that they already have granted patents.

Thus, the survey results suggest that German researchers are slightly more patent-active than their Swedish counterparts although we have to be careful in interpreting differences between the two countries due to different response rates and possible biases. The average number of patents granted is 5.1 in Germany and 3.6 in Sweden. The share of researchers with five and more patents is 29% in Germany and 25% in Sweden.

⁷⁰ The chi-square tests applied in this chapter test the differences between Sweden and Germany.

	Germany	Sweden
Total	27.7	23.8
Natural Sciences	22.7	21.4
Physics	26.2	15.4
Chemistry	31.6	34.2
Biology	18.8	22.6
Geographical Sciences	17.1	4.2
Engineering Sciences	27.5	22.5
Computer Science/Information Technology (incl. Mathematics)	10.4	17.6
Technical Physics/Applied Physics	66.7	31.4
Electrical Engineering	46.3	50.0
Mechanical Engineering	30.6	11.8
Architecture/Civil Engineering	20.0	0.0
Medical Sciences	33.6	27.6
Human Medicine	22.9	26.4
Veterinary Science	40.0	----
Dentistry	26.3	----
Genetical Engineering	38.6	12.5
Biotechnology	0.0	100.0
Pharmacy (incl. Pharmaceutical Technology, Pharmaceutical Biology and Pharmaceutical Chemistry).	63.6	42.9
Universities	26.8	22.6
Universities of Technology	31.0	28.6
Share of Universities of Technology (in survey)	21.9	19.1

Table 5-3: Share of patenting researchers by discipline.

Source: own calculations.

Table 5-3 provides a more disaggregated view on patenting. It shows the share of respondents who applied – either themselves or through another party – for a patent between 2002 and 2004 by disciplines. It reveals the differences in patenting activity by disciplines. Patent protection in pharmaceutical research, electrical engineering and chemistry seems particularly important, but the figures in the table should be interpreted with caution since the number of responses in each discipline is rather small.

It is also interesting to learn more about those researchers who did not apply for a patent between 2002 and 2004. Obstacles and hindrances to patenting are quite interesting from a policy perspective. The analysis of hindrances to patenting can be quite fruitful in order to understand the situation of researchers better. Those researchers who did not apply for a patent between 2002 and 2004 were asked why they did not. The reasons are provided in table 5-4.

	Germany	Sweden
Hindrances to patenting: Why did you not apply for a patent? (%)		
I do not own the patent rights.	1.3	1.5
I lack knowledge about patenting.	11.4	11.2
Patenting process is too time-consuming.	19.9	16.9
Too risky to apply for a patent.	1.3	3.4
Too costly to apply for a patent.	16.1	15.0
I do not want my research results to be used in that way.	6.8	15.7(**)
The degree of inventive ingenuity is not high enough. Further development needed.	17.8	17.6
My research results cannot be patented.	56.8	53.6
Because of the attitude towards patenting at my institution.	2.1	0.7
Number of observations (n)	236	267

Table 5-4: Hindrances to patenting.

Note: Differences between both countries were tested by a chi-square test. (†): sig. 10%, (): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.*

Source: own calculations.

The lack of patent rights in the research results does not seem to be a hindrance to the respondents. About 11% of the researchers in the survey regard lacking knowledge as an important hindrance to patenting. A rather large group of researchers (20% in Germany, 17% in Sweden) indicate that the patenting process is too time-consuming. A small minority claims that the risks were a hindrance. The empirical material shows that 16% of the German respondents and 15% of the Swedish respondents claim that they did not apply for a patent because it was regarded as too costly. Ethical considerations can also play a role with respect to patenting and commercialisation. Almost 16% of the Swedish respondents do not want their research results to be used in that way. The corresponding figure for Germany is significantly lower.⁷¹ Another interesting finding is that a fairly large number of researchers did not apply for a patent because their results needed further development before a patent application could be filed (about 18% in both countries). The major reason why researchers did not apply for a patent was that their results simply cannot be patented. Only a rather small share of university results can be patented. Results that cannot be patented include a large share of basic research, software, algorithms etc.

The previous results have shown that about one fourth of the respondents in Sweden and Germany applied for patents between 2002 and 2004. Thus, patenting is probably not the most important channel of knowledge and technology transfer. There are a lot of different channels of interaction between university researchers and industry. Researchers in both countries were asked about their personal experiences from collaboration with firms. Table 5-5 shows the results.

Only a minority of researchers does not have any experience at all of industrial collaboration. The vast majority of researchers in both countries have some form of experience from collaboration or commissioned research. The training of skilled personnel is a major objective of universities. The graduates of university programmes are ready to be employed in industrial firms. This educational function is often regarded as the most important impact of universities with respect to knowledge and technology transfer. A number of universities offer particular courses and lectures tailor-made to industrial firms that should increase the knowledge of the firms' employees. It seems that lectures and training is a rather prominent way of knowledge transfer in Sweden since almost 60% of the respondents have some experience with this transfer channel as opposed to 18% in Germany. Particularly interesting in the context of this dissertation is that about 20% of the respondents in both countries have some kind of experience with respect to joint patent applications with firms. Joint patent application means that university researchers and industrial researchers together apply for a patent. In those joint efforts, the firms are usually

⁷¹ It is unlikely that those researchers can be induced to patent and commercialise their results through IPR regimes or improved support.

the applicants holding the patent rights. Another important channel of knowledge and technology transfer is consulting. A rather large share of respondents in both countries had consulting assignments between 2002 and 2004.

	Germany	Sweden
Personal experience from collaboration with firms (%)		
No experience.	8.3	10.5
Research collaboration and cooperation.	64.5	63.9
Commissioned research/problem solving for a company.	61.4	51.1(**)
Lectures or training for a company.	17.6	59.9(***)
Joint patent application.	20.5	19.8
More general activities to get in contact.	21.0	36.1(***)
Share of researchers with consulting assignments 2002 - 2004 (%)	45.8	43.5
Number of observations (n)	386	399

Table 5-5: Personal experience from collaboration with firms.

Note: Differences between both countries were tested by a chi-square test.

(†): sig. 10%, (): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.*

Source: own calculations.

In sum, the descriptive analysis of the survey data reveals a number of interesting facts. First of all, researchers in both countries are similarly patent-active although we have to be careful in interpreting the differences due to possible biases. About one fourth of all researchers did apply for a patent between 2002 and 2004. The majority of patent-active researchers applied for patents themselves. Slightly more than one fourth of the researchers answered that they did not apply for a patent although their results were regarded as having commercial potential. The survey has also shown that a large share of research results is not patentable. Patenting varies considerably between the academic disciplines. The vast majority of researchers have experience with regard to collaboration with firms. Thus, the descriptive results of the survey do not give the impression that researchers in Sweden and Germany live in any kind of 'ivory tower' isolated from commercial interests.

5.1.2 Descriptive statistics about the model factors

5.1.2.1 Structural factors

The academic reward system is likely to have an impact on the incentives to patent and commercialise research results. A number of questions covered the academic reward system. The descriptive statistics are presented below in table 5-6.

	Germany	Sweden
Publications are important for academic career	96.4	98.8(*)
Publications impact on salary in the long run	29.3	58.2(***)
Patents are important for academic career	20.7	13.4(**)
Patents important to attract external funding	26.6	31.7
Patents impact on salary in the long run	13.1	12.7
External funding is important for academic career	90.6	94.7(*)
External funding impacts on salary in the long run	34.4	72.5(***)

Table 5-6: The academic reward system.

Note: Differences between both countries were tested by a chi-square test.

(†): sig. 10%, (): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.*

Source: own calculations.

The figures show the share of researchers agreeing to statements that are related to the academic reward system. The questions related to the reward system asked whether publications, patents and external funding are important for a career in academia. In addition, it was asked whether publications, patents and external funding have an impact on the salary in the long run. Respondents could answer on a Likert scale from 1 (disagree totally) to 7 (agree totally). They could also abstain from answering and answer “I don’t know”. Table 5-6 presents the mean for those

researchers who agreed that there is a relation between publications, patents and external funding and career/salary.⁷² There is large agreement in both countries with the statement that publications are important for an academic career. In Germany, 96% of the respondents agree with that statement and 99% in Sweden. Less than 30% of the German researchers think that publications impact on their salary in the long run whereas almost 60% of the Swedish researchers identify a relation between publications and long-run salary. The differences are statistically significant. Patents are not regarded as important for an academic career in Sweden and Germany. A mere 21% in Germany and 13% in Sweden regard patents as important for a career in academia. A minority in both countries conceives patents as important instruments to attract external funding.

According to the researchers in the survey, patents do not have an impact on the long-run salary. Only 13% of the respondents in both countries see such a connection. The questionnaire assessed also the importance of external funding. The vast majority of researchers in both countries regard external funding as important for the academic career. About 91% in Germany and 95% in Sweden hold that opinion. The agreement is large across all research fields. About one third of the German researchers see a relation between external funding and their salary. In contrast, a large majority of Swedish researchers indicate a connection between external funding and salary in the long run. The differences are statistically significant. The impact of external funding on the salary seems to be larger in the natural and engineering sciences than in medical sciences.

The survey responses with regard to the academic reward system in both countries show a number of similarities but also large differences. The academic reward system in both countries favours publications and external funding. Both have an impact on a career in academia as claimed by the majority of respondents in both countries. Particularly interesting are the differences with respect to salary. Swedish researchers regard publications and external funding to be important for their salary in the long run whereas the vast majority of German researchers do not see such a connection. This hints at different salary systems in both countries. It seems that the Swedish academic salary system is more flexible and rewards publications and external funding in a more direct way as opposed to the German system of academic salaries. The German reward system used to be quite inflexible. Nevertheless, it was changed in 2002 and nowadays the universities have more freedom to increase salaries above the minimum level but as the survey results suggest, this is not common practice, yet.⁷³

⁷² Thus, it measures the share of researchers that indicated 5 to 7 on a Likert scale.

⁷³ Notably, there are large differences between the whole sample and those researchers who actually did apply for patents between 2002 and 2004. In Germany, 60.2% of those research-

In the theoretical chapter it was argued that the source of funding is likely to impact on the incentives to patent and commercialise research results. The descriptive statistics related to funding can be found in table 5-7 below.⁷⁴

	Germany				Sweden			
Share of total funding (%)	Total	Nat.	Eng.	Med.	Total	Nat.	Eng.	Med.
Base funding (7)	41	35	47	39	33	39	31	31
Industry funding (10)	12	7	15	13	11	4	15	12
Basic research (24)	34	47	17	42	35	50	26	32

Table 5-7: The funding of research in Sweden and Germany.

Source: own calculations.

When looking at table 5-7, it becomes obvious that base funding is higher in Germany than in Sweden. Although there are large differences with respect to the field of research. The engineering sciences in Sweden receive about 31% of their research funding in the form of base funding, whereas in Germany this share is substantially larger with about 47%. The share of industry funding is quite similar in both countries with 12% in Germany and 11% in Sweden. As one could expect, the share of industrially funded research is larger in engineering than in the natural sciences. The natural sciences are more strongly oriented towards basic research, whereas the engineering sciences are oriented towards applied research. The medical sciences are somewhat in between these extreme positions.

5.1.2.2 Supportive infrastructure

The survey of researchers assessed the infrastructure for patenting and commercialisation. Researchers who got their results patented between 2002 and 2004 were asked specific questions about the type of services provided by the actors in the

ers who actually applied for patents claimed that one of their motives to apply for a patent was to attract research funding. In Sweden, this is true for 56.3% of the respondents who applied for a patent in the period 2002 to 2004 (either by themselves or by a third party).

⁷⁴ Professors holding chairs and leaders of research groups, institutes and so on were asked to indicate the shares of funding from different sources.

vicinity of universities.⁷⁵ They got the possibility to assess and evaluate the different actors as well. Researchers who did not apply for patents were asked whether they know the actors and services provided by the transfer infrastructure and whether they are interested in getting support from them in general. Obviously, the data received by the patent-active researchers⁷⁶ is more detailed and rich than from those researchers who did not apply for a patent between 2002 and 2004.

In the German survey, 56% (58/103) of the patenting researchers got support from the public infrastructure. A minority of 32% (80/249) of the non-patenting researchers said that they know the actors in the public infrastructure and that they are interested in getting support from them. This result is interesting. It was argued that university inventors in Germany are obliged to disclose their inventions to the university's technology transfer office. Nevertheless, only 56% of the patent-active researchers in 2002-2004 got support from the public infrastructure. The responses in the Swedish survey are similar. About 40% (36/90) of the patenting researchers got support from the public infrastructure. A mere 17% (48/285) of the non-patenting researchers said that they know the actors in the public infrastructure and that they are interested in getting support from them. This result shows that as many as 40% of the patent-active researchers in Sweden contacted the actors in the public infrastructure and received support although Swedish university inventors are not obliged to use the public infrastructure.

Some characteristics of the infrastructure for patenting and commercialisation of university research are presented in table 5-8 below. It shows that a large share of the researchers who got their results patented in 2002 to 2004 received support in some way. In Germany, researchers have to submit their invention disclosures to the TTO of the university. When the university decides to claim the invention, the PVA takes over the patenting and commercialisation process, usually in close collaboration with the inventor. About 47% of the patent-active researchers in Germany received support from their university's TTO and about 23% received support from the PVA. This indicates that the university's TTO is the primary contact point in most cases. About 23% of the patent-active researchers received no support at all and about 13% received support from firms.

⁷⁵ The survey contained a number of questions about the public infrastructure. German respondents could evaluate the services of TTO and PVA. Swedish respondents had the possibility to evaluate the university holding company and the TBS. In addition, respondents in both countries could indicate and evaluate the support from other sources.

⁷⁶ "Patent-active" and "patenting researchers" refer to those respondents who applied for patents between 2002 and 2004, either themselves or through third parties.

	Germany	Sweden
TTO	46.6	21.1(***)
Independent TTO/Univ. Holding	6.8	17.7(*)
PVA/TBS	23.3	18.9
Firm	12.7	23.3(†)
No support	23.3	24.4
Number of observations (n)	103	90

Table 5-8: Actors that provided support in Sweden and Germany.

Note: Differences between both countries were tested by a chi-square test.

(†): sig. 10%, (): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.*

Source: own calculations.

The picture in Sweden is somewhat different. The researchers own their invention and they have full discretion about its use. Thus, they are not required to disclose their invention to the university or any other actor. Nevertheless, in Sweden about 21% of the patent-active researchers received support from the university's TTO. About 18% of the patent-active researchers received support from their university's holding company, and about 19% got help from the technology bridging foundation (TBS). The patent-active researchers in the Swedish sample frequently received support from both the TTO and the university holding company. In total, about 33% of the patent-active researchers in Sweden received support from either the TTO or the university holding company. About 24% of the researchers who either themselves or by other parties got their research results patented between 2002 and 2004 received no support at all, and about 23% received support from firms. Swedish respondents received significantly more support from firms than their German colleagues.

Table 5-9 below shows the type of support that the researchers in both countries received from the public infrastructure.

	Germany	Sweden
Support with regard to... (in %)		
patent application	48.2	22.9(***)
licensing	16.4	4.2(**)
market analysis & business plan	3.6	7.3
financial support	5.5	19.8(**)
competence development	0	3.1(†)
marketing	5.5	4.2
administrative support (e.g., rooms)	4.5	8.3
brokerage	4.5	3.1
Number of observations (n)	110	96

Table 5-9: Type of support from the public infrastructure.

Note: Differences between both countries were tested by a chi-square test.

(†): sig. 10%, (): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.*

Source: own calculations.

Table 5-9 indicates that the infrastructure for support in Germany has a different role than in Sweden. The public actors in Germany support primarily patent applications and licensing agreements. About 48% of the researchers in Germany who got support received it with respect to patent application and 16% got help with licensing. Only about 6% received financial support. The actors in the public infrastructure rarely provide support with regard to market analysis, competence development or marketing. The situation is different in Sweden. Swedish public actors provide help with respect to patent applications as well, but to a significantly lesser extent. About 23% of the users of the public infrastructure received help with the patent application and only 4% with respect to licensing. Swedish respondents received significantly more support with respect to finance than their German colleagues. Swedish researchers received more support with respect to competence development, market analysis and administrative support than their German counterparts although the differences were not statistically significant. Thus, the statistical results hint at different means to commercialise university inventions. The German infra-

structure supports primarily patenting and licensing. The Swedish infrastructure provides financial support and advice as well.⁷⁷

Researchers who received public support were asked to evaluate it. Table 5-10 shows the results.

Share of researchers who were...	Germany	Sweden
not satisfied at all with the support (1-3).	32.1	34.3
ambivalent regarding support (4).	12.5	20.0
satisfied with the support (5-7).	55.4	45.7
Number of observations (n)	56	35

Table 5-10: Assessment of the public infrastructure by the researchers.

Note: Differences between both countries were tested by a chi-square test.

(†): sig. 10%, (): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.*

Source: own calculations.

Table 5-10 shows that a majority (55%) of the German users of the public infrastructure were also satisfied with it. About 32% of the researchers who received support from the public infrastructure were not satisfied at all with the services and 13% of the researchers were ambivalent. The picture is similar in Sweden.⁷⁸

⁷⁷ Studies by the OECD show large differences with regard to access to venture capital. According to OECD (2004b, p. 5), “the venture capital market for the very early R&D-based phase of start-ups has almost entirely dried out in Germany”. In contrast, the OECD evaluates Sweden rather positively with regard to access to venture capital around universities. Access to venture capital is importance since “relative to GDP, venture capital investment is quite small, but it is a major source of funding for new technology-based firms. It plays a crucial role in promoting the radical innovations often developed by such firms” (OECD 2003c, p. 46). According to OECD (2003c), the investment in venture capital as percentage of GDP in the years 1998-2001 was in Germany 0.052% for the early stages and 0.075% for the expansion phase. This share was substantially larger in Sweden with 0.077% for the early stages and 0.130 for expansion. The figures for the EU were 0.044 for the early stages and 0.093 for expansion. In contrast, for the US about 0.163% of GDP was invested in early stages of firm development and 0.330% in expansion. Thus, it seems that university researchers in Sweden get access to financial resources more easily in the course of patenting and commercialisation.

⁷⁸ Please note that the differences between Sweden and Germany are not statistically significant and the number of observations is low.

5.1.2.3 Patent rights regimes

All researchers were asked “who owns the patent rights in your research results?”.⁷⁹ The question was not limited to patent-active researchers and it was posed at the very end of the questionnaire.⁸⁰ Thus, the question measures the perceived patent rights regime. Table 5-11 presents the results.

Who owns the patent rights in your research results?	Germany	Sweden
Myself	17.4	44.3(***)
The university	26.0	4.4(***)
A financier of my research	9.9	5.7(*)
A company	22.8	19.8
I don't know	9.7	10.7
Abstain	36.2	26.6(**)
Number of observations (n)	373	384

Table 5-11: Perceived patent rights regimes.

Note: Differences between both countries were tested by a chi-square test.

(†): sig. 10%, (*): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.

Source: own calculations.

There are obvious differences between both countries. In Sweden, about 44% of the respondents regard the research results as their own property. The same is true for only about 17% of the German respondents. About 26% of the respondents in Germany regard the university as the owner of their research results, whereas only about 4% are of this opinion in Sweden. Those statistically significant differences reflect the differences in the formal patent rights regimes in both countries. Companies frequently own the patent rights in research results of university researchers in both

⁷⁹ A similar question about ownership in IPR was also included in the OECD questionnaire (OECD 2003b).

⁸⁰ Obviously, the general form of the question opens the possibility of misinterpretation by respondents. The question was put at the end of the questionnaire and addressed all respondents in order to provide an assessment of the patent rights situation perceived by the respondents. Multiple answers were possible.

countries as the survey results suggest. Only about 10% of the respondents in both countries lack knowledge about the patent rights situation with respect to their research results. As much as 36% of the respondents in Germany and 27% in Sweden abstained from answering the question. This indicates that questions about patent rights are quite sensitive since such a large number of respondents refused to answer.

With respect to patent-active researchers in Germany, about 41% (41/101) of the researchers who got their results patented in 2002 to 2004 claimed that they themselves owned their research results. About 47% (47/101) claimed the university owns their results and about 44% (44/101) regarded a firm as the owner of their patent rights. In contrast, about 9% (24/272) of the non-patenting professors claimed that they themselves own the patent rights in their research results. About 18% (50/272) thought that the university is the owner of the patent rights and about 15% (41/272) claimed that a firm owns the patent rights in their research results. In the Swedish survey, about 64% (60/94) of the researchers who got their results patented between 2002 and 2004 claimed that they themselves own the patent rights in their research results. About 2% (2/94) claimed the university owns their results and about 57% (54/94) regarded a firm as the owner of their patent rights. In contrast, about 38% (110/290) of the non-patenting professors claimed that they themselves own the patent rights in their research results. About 5% (15/290) thought that the university is the owner of the patent rights and about 7% (22/290) claimed that a firm owns the patent rights in their research results.

5.2 The regression models

This section specifies and tests a number of regression models. Based on the theoretical framework illustrated by figure 4-2, the aim is to estimate the impact of a number of independent variables on the dependent variable “Applied for patent 2002 – 2004”. It shows the variables that influence the decision to apply for a patent. The theoretical model is the building block of the functional specification of the econometric model. The theoretical model derived that patent rights in research results can be interpreted as a bonus in the employment contracts of researchers. The bonus installs incentives to seek patent protection. Thus, the dependent variable can be whether researchers got their results patented between 2002 and 2004. The dependent variable in this case is nominal. The aim of the econometric model is to estimate the expected value of the dependent variable $E(Y_i) = \mu_i$.⁸¹ The ordinary linear model which reminds the reader of a linear regression model is thus

$$E(Y) = \mu = \sum_{k=1}^K \beta_k x_k.$$

We introduce the variable η in order to create a more generalizable model which links the function $\sum_k \beta_k x_k$ to μ .

In general, a generalized linear model can be specified that includes the linear predictor η produced by x_1, x_2, \dots, x_k . Regardless of the type of model, the set of explanatory variables always linearly produce η , which is a predictor of Y . The relation between the predictor η and the independent variables x is given by

$$\eta = \sum_{k=1}^K \beta_k x_k.$$

However, the relation between μ and η remains to be specified. According to Liao (1994), the link between μ and η distinguishes one member of the family of generalized linear models from another. The link function is basically determined by the distribution of the random component in Y , namely ε . In our case, where the de-

⁸¹ This section draws heavily on Liao (1994).

pendent variable resembles two outcomes (applied for a patent 2002 – 2004: yes or no), a logit model can be specified.⁸² Thus, the link function is

$$\eta = \log[\mu/(1 - \mu)].$$

In sum, the logistic regression model applied in this chapter has the following form:

$$\log \left[\frac{P(y=1)}{1 - P(y=1)} \right] = \sum_{k=1}^K \beta_k x_k.$$

With respect to the variables used, the quantitative analysis applies a simple logistic regression model:⁸³

$$\log \left[\frac{P(y=1)}{1 - P(y=1)} \right] = \text{CONST} + \beta_1 \text{IPR} + \beta_2 \text{STRUCTURE} + \beta_3 \text{SUPPORT}^{84}$$

where $y=1$ means “application for patent 2002-2004”: yes.

The estimation for each independent variable results in an odd ratio. The odd ratio measures the chances (or odds) that a researcher got his results patented. The dependent variable “Patent” separates the researchers in two groups: those who got their results patented between 2002 and 2004 and those who did not apply for patents. The odd ratio estimates the propensity or likelihood that the independent variable in question increases the odds or propensity that a patent was applied for. In general, the odd ratio is frequently applied to estimate the risk or chance of a par-

⁸² According to Liao (1994, p. 12), “sometimes in the literature the distinction between the two names of *logit models* and *logistic regression* is based on whether continuous explanatory variables are included in the set of x variables. Some researchers call models with categorical x variables logit models and models with mixed categorical and continuous x variables logistic regression models. Others make no such distinction”.

⁸³ See Reese (2000) for an introduction to logistic regression analysis.

⁸⁴ The single variables under the headings IPR, STRUCTURE and SUPPORT are included in the regressions.

ticular outcome if a certain factor is present. It is a relative measure that tells us how much more likely it is that someone who is exposed to the factor under study will develop the outcome as compare to someone who is not exposed. It is a way to present probabilities. The odds of an event happening is the probability that the event will happen divided by the probability that it will not happen (Westergren et al. 2001, p. 268). An odd ratio above 1 indicates that the propensity to patent increases when the independent variable in question appears whereas an odd ratio below 1 decreases the propensity to patent. The dependent variable is the propensity of university professors (or their universities) to patent research results. A number of independent variables are used to explain the propensity to patent research results. The general hypothesis is that the likelihood to patent is affected by the patent rights regime, structural factors, and supporting factors. In addition, a number of variables related to personal attributes, such as commercial experience of the researchers, are included. The following table 5-12 shows the variables used in the regression models, the measurement scale and the odd ratios that can be expected from the theoretical reasoning.

<u>Label</u>	<u>Description</u>	<u>Used as indicator for:</u>	<u>Scale</u>	<u>Ex-pected odd ratios</u>
Patent	Measures whether the respondent got research results patented between 2002 and 2004 either by himself or by third parties.	Incentives to apply for patents.	nominal	
	<i>IPR Regime (IPR):</i>			
Researcher-IPR	All researchers were asked "who owns the patent rights in your research results?" and the response was "myself".	Patent rights in research results	nominal	>1 (?)
Uni-IPR	All researchers were asked "who owns the patent rights in your research results?" and the response was "the university".	Patent rights in research results	nominal	>1 (?)
Firm-IPR	All researchers were asked "who owns the patent rights in your research results?" and the response was "a firm".	Patent rights in research results	nominal	>1 (?)
Country	Dummy variable for country (Germany=1)	Country differences	nominal	?

	Structural factors (STRUCTURE):			
Share of base funding	Leaders of research groups were asked about the funding structure of their research group.	Base funding.	metric	<1
Share of industry funding	Leaders of research groups were asked about the funding structure of their research group.	Industry funding.	metric	>1
Share of external funding	Leaders of research groups were asked about the funding structure of their research group.	External funding.	metric	>1
Patents are important for career	All researchers were asked about the importance of patents for the academic career.	Importance of patents to improve academic career.	nominal	>1
Patents are important for ext funding	All researchers were asked about the importance of patents to attract external funding.	Importance of patents to attract external funding.	nominal	>1
Patents impact on my salary	All researchers were asked about the importance of patents for long-run salary.	Importance of patents to increase salary.	nominal	>1
Basic re-search	All researchers were asked about the type of research they carry out primarily.	Basic research.	nominal	<1
Applied research	All researchers were asked about the type of research they carry out primarily.	Applied research.	nominal	>1
Natural sciences	Researchers in the natural sciences.	Research field.	nominal	<1
Technical sciences	Researchers in the technical sciences/engineering.	Research field.	nominal	>1
Medical sciences	Researchers in the medical sciences.	Research field.	nominal	>1
Size	Size of research group in full-time equivalents including PhD students.	R&D input	metric	>1
Previous patents	Measures whether respondents hold granted patents.	Experience with the patenting system	nominal	>1
Joint patent	Measures whether respondents	Experience of indus-	nominal	>1

	have personal experience of joint patent applications with firms.	trial collaboration with firms leading to patents.		
	Supporting factors (SUPPORT):			
Support	Measures whether researchers who applied for patents in 2002 to 2004 received support from the public infrastructure. Researchers who did not apply for patents were asked whether they know the actors and services provided by the transfer infrastructure and whether they are interested in getting support from them in general.	Importance of supportive infrastructure	nominal	>1

Table 5-12: Variables used in the regression models.

The dependent variable “Patent” measures whether researchers applied for patents between 2002 and 2004. It is coded 1 (patent: yes) if the researcher got his results patented either himself or by a third party and 0 (patent: no) if no patent was applied for. Thus, it covers patent applications by third parties such as universities, PVAs, TTOs etc. as well. The variables under the heading “IPR Regime” are related to patent rights. A country dummy was introduced in order to account for the differences in the formal legislation. In Sweden, the researcher owns his results and in Germany the university owns the results. Besides the formal patent legislation, IPR Regime also includes the perceived IPR regime taking into account contractual solutions. Contractual solutions include IPR transfer to enterprises that fund university research or if researchers transfer their patent rights to firms in return for a lump sum payment. Researchers were asked “who owns the patent rights in your research results?” and it can be distinguished between “Researcher-IPR”, “Uni-IPR”, and “Firm-IPR”. “Researcher-IPR” means that respondents answered that they themselves own their IPR. “Uni-IPR” means that respondents perceived the university as owner of their IPR. Finally, “Firm-IPR” means that respondents regarded firms as owners of their patent rights in their results. Structural factors include the academic reward system, the funding of research, size of research group, the research orientation and research field. The regression models estimated the impact of different funding sources on patenting. In particular, they estimated the impact of base funding, industry funding, and external funding on patenting. The leaders of research groups and similar people were asked about the sources of funding of their research groups and the shares of different sources were used for the regressions. The impact of the academic reward system was assessed by asking a few questions regarding the impact of publications, patents and external funding on the academic career and salary. The responses covering patents were used for the regression models. Thus, it

was estimated whether those researchers who hold the opinion that patents are important for their academic career show a higher likelihood of applying for patents. Similarly, the responses about the importance of patents to attract external funding and the impact of patents on the salary were used to estimate the dependent variable "Patent". Researchers participating in the survey were asked about their primary research orientation. The resulting variables "Applied research" and "Basic research" were used to estimate patenting. As already mentioned in the section about sampling, the survey was separated into three different research fields (strata). Those research fields, "Natural sciences", "Technical sciences", and "Medical sciences" were used in order to estimate patenting. The variable "Size" measures the size of research groups in full-time equivalents in order to assess whether size impacts on the decision to apply for patents. In addition, the variables "Previous patents" and "Joint patent" were used in the survey. "Previous patents" measures whether respondents hold granted patents which can be used as a proxy for experience of the patenting system. The variable "Joint patent" measures whether respondents have personal experience of joint patent applications with firms and is an indicator for experience of industrial collaboration and the patenting system.

Supporting factors measure whether researchers received support from the public actors in the infrastructure. Researchers who got their results patented between 2002 and 2004 were asked whether they received support from the public infrastructure. Researchers who did not apply for patents between 2002 and 2004 were asked whether they know the kind of services that the public infrastructure offers and whether they are interested in getting support from them.

5.2.1 Analysis of the total survey

A number of different models were specified and tested for statistical significance. Table 5-13 shows a selection of models.

Table 5-13 (1/3)	Model 1	Model 2	Model 3	Model 4	Model 5
Variables	Odd ratio	Odd ratio	Odd ratio	Odd ratio	Odd ratio
Size	0.981(*)	0.967 (***)	0.984 (†)		0.981 (*)
Previous patents	21.097(***)		11.852 (***)	12.060 (***)	12.626 (***)
Support	2.357(***)	2.911 (***)	2.519 (***)	2.610 (***)	2.588 (***)
Researcher-IPR					
Uni-IPR					
Firm-IPR					
Joint patent			3.617 (***)	3.744 (***)	3.659 (***)
Basic research			0.643 (†)	0.634 (†)	
Applied research	1.652(†)	2.225 (***)			
Share of base funding			1.007		
Share of industry funding					0.983 (**)
Share of external funding				0.992	
Patents => career					
Patents =>ext funding					
Patents => salary					
Natural sciences					1.452
Technical sciences					
Medical sciences					
Country (Germany=1)					
N (observations)	629	641	597	601	597
Model Chi-square (d.f.)	276.318 (4)	67.003 (3)	273.266 (6)	274.077 (5)	275.863 (6)
Significance	0.000	0.000	0.000	0.000	0.000
Correctly classified cases (%)	83.9	73.0	84.4	84.4	84.8
Nagelkerke R-square	0.509	0.142	0.526	0.525	0.530

Table 5-13 (2/3)	Model 6	Model 7	Model 8	Model 9	Model 10
Variables	Odd ratio				
Size	0.982 (*)	0.983 (†)	0.984 (†)		
Previous patents	12.446 (***)	11.866 (***)	10.539 (***)	11.653 (***)	12.123 (***)
Support	2.612 (***)	2.583 (***)	2.506 (***)	2.452 (***)	2.509 (***)
Researcher-IPR					
Uni-IPR					
Firm-IPR					
Joint patent	3.596 (***)	3.554 (***)	3.479 (***)	3.567 (***)	3.575 (***)
Basic research	0.601 (†)	0.713	0.669	0.601 (†)	0.482 (**)
Applied research					
Share of base funding					
Share of industry funding	0.986 (*)	0.987 (†)	0.989		
Share of external funding					
Patents => career			1.252		
Patents => ext funding					
Patents => salary				2.191 (*)	2.149 (*)
Natural sciences					
Technical sciences	0.524 (*)				0.536 (*)
Medical sciences		1.279			
Country (Germany=1)					
N (observations)	597	597	534	595	595
Model Chi-square (d.f.)	281.039 (7)	276.133 (7)	243.101 (7)	272.088 (5)	277.778 (6)
Significance	0.000	0.000	0.000	0.000	0.000
Correctly classified cases (%)	85.3	84.4	83.5	83.9	84.4
Nagelkerke R-square	0.538	0.530	0.513	0.522	0.531

Table 5-13 (3/3)	Model 11	Model 12	Model 13	Model 14	Model 15
Variables	Odd ratio	Odd ratio	Odd ratio	Odd ratio	Odd ratio
Size	0.982 (†)	0.980 (†)		0.979 (*)	0.980 (*)
Previous patents	12.276 (***)	10.905 (***)	11.647 (***)	11.398 (***)	9.897 (***)
Support	2.610 (***)	2.450 (***)	2.309 (***)	2.177 (**)	2.638 (***)
Researcher-IPR		1.409	1.579 (†)		
Uni-IPR				2.151 (*)	
Firm-IPR					2.095 (*)
Joint patent	3.588 (***)	3.344 (***)	3.750 (***)	3.616 (***)	2.715 (***)
Basic research		0.725		0.725	0.727
Applied research					
Share of base funding					
Share of industry funding	0.985 (*)	0.987 (†)		0.988 (†)	0.990
Share of external funding					
Patents => career					
Patents => ext funding					
Patents => salary					
Natural sciences					
Technical sciences					
Medical sciences					
Country (Germany=1)	0.932	1.028			
N (observations)	597	577	684	577	577
Model Chi-square (d.f.)	274.145 (6)	270.455 (8)	304.804 (4)	274.269 (7)	274.731 (7)
Significance	0.000	0.000	0.000	0.000	0.000
Correctly classified cases (%)	84.8	85.1	84.4	82.8	84.7
Nagelkerke R-square	0.527	0.533	0.524	0.539	0.540

Table 5-13: Regression models for the total survey.

(†): sig. 10% (*): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.

Source: own calculations.

Model 1 estimates the impact of size, previous patents, support and applied research on the decision to apply for patents between 2002 and 2004. The odd ratio measures how the propensity to patent - as measured by patent applications between 2002 and 2004 - changes when the independent variables change. The dependent variable "Patent" separates the researchers in two groups: those who got their results patented between 2002 and 2004 and those who did not apply for patents. The odd ratio measures the chances (or odds) that a researcher got his results patented. For instance, the odd ratio for size is 0.981 which indicates that an increase in size changes the chances to apply for patents from 1:1 to 0.981:1. Thus, the variable size is of limited value to foresee and predict patenting. In contrast, an odd ratio of 21.097 in the case of the variable previous patents changes the propensity to patent from 1:1 to 21.097:1. Thus, the variable previous patents has strong predictive value for the dependent variable "Patent". The impact of the public support infrastructure is also positive and statistically significant.⁸⁵ As expected, the applied research orientation impacts positively on the propensity to apply for patents. The first model classifies about 84% of the cases correctly and is able to explain about 51% of the total variance.

In model 2, the first model was slightly modified. Previous patents were excluded, which tremendously changes the results. The impact of the other independent variables is quite similar as in the first model but only about 14% of the total variance can be explained by model 2. This indicates the importance of previous experience with the patenting system. Researchers who already hold granted patents are more likely to apply for patents in the future.

In the third model, the applied research orientation is substituted by basic research orientation. The result is that basic research impacts negatively on patenting as one would expect, since the propensity to patent changes to 0.643:1. In addition, the variable experience of joint patent applications with firms was introduced which further increases the likelihood to apply for patents. The argumentation with regard to experience of joint patent applications with firms is similar to the argumentation about previous patents. Both variables measure experience with the patenting system and both variables have a positive impact on the propensity to patent between 2002 and 2004. As argued in the theoretical chapter of this dissertation, the source of funding is likely to impact on the incentives to patent and commercialise research results. The leaders of research groups, institutes, chairs etc. were asked about the sources of funding of their research group. Different models were tested to assess the impact of the different funding sources on patenting. It seems that the source of

⁸⁵ The test statistics for significance are based on a Wald-test. (†): sig. 10%, (*): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.

funding has a rather minor impact on the propensity to patent. The odd ratios for different variables are close to 1 which indicates limited explicative power.

The different variables referring to the academic reward system were also tested for statistical significance. One variable was statistically significant. Researchers who claimed that patents have an impact on their salary in the long run were also more likely to apply for a patent between 2002 and 2004. This variable has a statistically significant impact (2.191 in model 9) on the propensity to patent.

The field of research is another variable that impacts on the propensity to patent. Research fields in which patents are frequently used to protect intellectual property are more likely to patent than other research fields. The survey was confined to researchers in the natural sciences, engineering sciences and medical sciences. Patents are used to protect inventions in all three strata but the extent varies. Thus, three different models were tested using the three strata as independent variables. The natural sciences and medical sciences have a positive impact on patenting whereas technical sciences have a negative impact on the decision to patent although only the impact of the technical sciences is statistically significant.

Finally, the impact of patent rights regimes was tested on the propensity to patent. The country dummy was used to explain differences with respect to formal regulation since we compare different formal regulations in two different countries. As shown by models 11 and 12, the country dummy is close to 1 and not statistically significant. This indicates that the country dummy is not able to explain patenting. The descriptive statistics have already shown that patenting behaviour is quite similar in both countries. The regression results for the perceived patent rights regimes are more interesting. Model 13 shows that researchers who indicate that they own their patent rights themselves are more inclined to apply for patents. Model 14 shows that university patent rights in research results favour patenting and model 15 shows that firm patent rights in research results have a positive impact on patenting as well. The odd ratios for Uni-IPR and Firm-IPR are larger than for Researcher-IPR. The estimates for the three different patent rights regimes are all statistically significant. Thus, in order to highlight country differences, the survey was analysed separately for each country as well.

5.2.2 Analysis of the German survey

As for the total survey, a number of different models were specified and tested for statistical significance. Table 5-14 shows a selection of models that fit the German survey.

	Germany					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variables	Odd ratio					
Size	0.947 (**)	0.946 (**)	0.951 (*)	0.953 (**)	0.957 (*)	0.955 (*)
Previous patents	8.104 (***)	8.167 (***)	9.088 (***)	8.606 (***)	9.077 (***)	9.948 (***)
Support	2.828 (**)	2.827 (**)	2.183 (*)	2.858 (**)	2.282 (*)	2.326 (*)
Researcher-IPR	1.998 (†)	1.967		2.018 (†)		
Uni-IPR			3.050 (**)		2.893 (**)	3.234 (**)
Firm-IPR						
Joint patent	3.137 (**)	3.099 (**)	3.615 (**)	2.699 (*)	3.391 (**)	3.866 (**)
Basic research		0.448 (*)	0.466 (*)		0.509 (†)	0.367 (*)
Applied research	2.169 (*)					
Share of industry funding				0.985 (†)		
Patents => salary					2.531 (†)	
Technical sciences						0.471 (†)
N (observations)	301	301	301	286	260	301
Model Chi-square (d.f.) =	147.123 (6)	147.731 (6)	153.474 (6)	131.403 (6)	131.684 (7)	157.292 (7)
Significance =	0.000	0.000	0.000	0.000	0.000	0.000
Correctly classified cases (%)	84.4	84.4	82.7	83.9	80.8	83.4
Nagelkerke R-square	0.544	0.544	0.562	0.517	0.548	0.572

Table 5-14: Regression models for the German survey.

(†): sig. 10%, (*): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.

Source: own calculations.

The analysis begins with a very general model and estimates whether the independent variables previous patents, size of research group, support, applied research orientation, and previous experience of joint patent applications can explain the propensity of German researchers to get their research results patented between 2002 and 2004. Furthermore, it was tested whether patent rights in research results by the researchers themselves mattered for patenting. Model 1 in table 5-14 shows the results of the regression model. Size of research group is statistically significant but the effect is slightly negative as shown by an odd ratio below 1. Previous patents have a strong impact on the decision to patent (8.104). The propensity to patent increases from 1:1 to 8.104:1 if the researcher holds previous patents. That means researchers who already hold granted patents are more likely to apply for patents. The same is true for experience of joint patent applications with firms. This is a quite strong and statistically significant predictor of patenting (3.137). Support has a positive impact as well (2.828). Researchers who got support or researchers who assessed the supportive infrastructure in a positive way are more likely to apply for a patent. As one might expect, researchers who conduct applied research are more likely to apply for a patent (2.169). Particularly interesting is the patent rights question. The model shows that researchers who indicated that they themselves own the patent rights in their research results also had a higher propensity to apply for patents between 2002 and 2004 (1.998).

In model 2, applied research orientation was substituted by basic research orientation. As one might expect, basic research orientation has a negative impact on patenting (0.448). In the previous model, applied research orientation increased the propensity to patent to 2.169:1, whereas basic research orientation changes the propensity to patent to 0.448:1. This effect is statistically significant but model 2 also shows that patent rights in research results by researchers decrease in statistical significance.

In model 3, the model is somewhat modified. The variable university-patent rights instead of researcher-patent rights was included in the model. The result of model 3 is remarkable. It shows that even those respondents who indicated that the university owns their patent rights were more likely to get their results patented between 2002 and 2004. The odd ratio was even larger (3.050) than in case of researcher-patent rights. These results show that in Germany basically both types of perceived patent rights regimes seem to have a positive impact on the propensity to patent.

Different models were tested to assess the impact of the different funding sources on patenting. The only statistically significant effect can be found in model 4 where industry funding has a small negative impact on patenting although statistically significant, the effect is really small since the odd ratio is close to 1 (0.985).

Different variables regarding the academic reward system were also tested for statistical significance. The parameter estimate for one variable was statistically significant. Model 5 shows that researchers who claimed that patents have an impact on their salary in the long run were also more likely to apply for a patent between 2002 and 2004. This estimate is statistically significant and has a rather strong impact on patenting (2.531).

The field of research is another variable that impacts on the propensity to patent. The natural sciences and medical sciences have a positive impact on patenting whereas the technical sciences have a negative impact on the decision to patent although only the impact of the technical sciences is statistically significant. Model 6 shows that researchers in the technical sciences are less likely to apply for patents as indicated by an odd ratio below 1 (0.471).

In sum, model 6 shows the best fit of all models as measured by Nagelkerkes pseudo R-square. The model is able to classify about 83% of the cases correctly and it can explain about 57% of the variance of the dependent variable as measured by Nagelkerkes pseudo-R-square.

5.2.3 Analysis of the Swedish survey

As in the German case, the Swedish responses were used to test a number of simple logistic regression models that vary the different independent variables delivered by the theoretical reasoning. Finally, a model is presented that fits the data quite well. Table 5-15 shows the regression results for the Swedish survey.

	Sweden					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Variables	Odd ratio					
Size	0.990					
Previous patents	13.339 (***)	8.716 (***)	10.058 (***)	9.413 (***)	8.587 (***)	10.798 (***)
Support	1.915 (†)	2.257 (*)	2.389 (*)	2.075 (†)	2.263 (*)	2.224 (†)
Researcher-IPR	1.362					
Uni-IPR						
Firm-IPR		4.830 (***)	4.157 (***)	3.962 (***)	4.033 (***)	4.146 (***)
Joint patent	3.962 (**)	2.857 (*)	2.705 (*)	3.059 (**)	2.945 (*)	2.675 (*)
Basic research		0.836				
Applied research	1.236					
Share of base funding			1.022 (*)			1.022 (*)
Patents => career				2.766 (*)		
Patents => ext funding					2.617 (*)	
Technical sciences						0.600
N (observations)	303	353	292	308	282	292
Model Chi-square (d.f.) =	144.251 (6)	171.120 (5)	157.074 (5)	158.857 (5)	146.000 (5)	158.646 (6)
Significance =	0.000	0.000	0.000	0.000	0.000	0.000
Correctly classified cases (%)	85.8	86.4	87.3	86.7	86.2	88.4
Nagelkerke R-square	0.551	0.577	0.604	0.586	0.580	0.608

Table 5-15: Regression models for the Swedish survey.

(†): sig. 10%, (*): sig. 5%, (**): sig. 1%, (***): sig. 0.1%.

Source: own calculations.

The first model measures the impact of size, previous patents, support, applied research, and joint patent on the decision to patent. In addition, it estimates the impact of researcher patent rights (“Researcher-IPR”) on the likelihood to patent. The results are somewhat different from the German case. The estimates for size and applied research orientation are not statistically significant in the Swedish survey, as shown in model 1. Ownership of patent rights by researchers themselves has a positive impact on patenting although not statistically significant. Support has a positive and statistically significant impact on the propensity to patent (1.915). Personal experience with the patent system is quite important. Researchers who already hold granted patents are likely to apply for more patents, as the large odd ratio of 13.339 suggests. Thus, the propensity that a respondent is patent-active (as measured by the dependent variable “Patent”) increases from 1:1 to about 13:1 in the case of granted patents. Researchers who have experience of joint patent applications with firms are more likely to apply for patents (3.962).

Basic research orientation has a negative impact on patenting as an odd ratio below 1 indicates (0.836), although not statistically significant as shown in model 2. Support has a positive impact on patenting and the odd ratio has increased in comparison to the first model (2.257). Experience of joint patent applications with firms has a strong impact on the propensity to patent in basically all models. The same is true for previous patents. Researchers who previously applied for patents are more likely to do so in the future as well. This is a very strong predictor in all models.

Ownership of patent rights by firms has a positive impact on patenting. For instance, the propensity to patent as measured by patent applications between 2002 and 2004 increases to about 4:1 in case of firm-patent rights (models 3 to 6). Thus, it seems that researchers who surrender their patent rights in their research results to private firms are more likely to apply for patents. This result is interesting, especially with regard to funding. The impacts of the different sources of funding on the propensity to patent were tested as well. Base funding has a small positive effect as measured by an odd ratio of 1.022. The other sources of funding were also tested but none was statistically significant. As in the German case, this result is counterintuitive.

The academic reward system can play an important role for the decision to patent. Model 4 shows that researchers who claimed that patents are important for their academic career are more likely to apply for patents (2.766). Patents are not only directly important for the academic career, they can also be used to attract external funding. Those researchers who agreed with this statement also showed a higher propensity to apply for patents, as measured by a large odd ratio (2.617).

The impact of the research fields was tested as well. It shows that the natural sciences and medical sciences have a positive impact on patenting although not statistically significant. In model 6 it is shown that the technical sciences have a negative impact on patenting although not statistically significant. The sixth model has the best overall fit as measured by Nagelkerkes pseudo R-square. It is able to explain about 61% of the variance of the dependent variable and 88% of the cases are correctly classified.

5.2.4 Summary of the regression results

In sum, particularly important predictors of the propensity to patent – as measured by patent applications between 2002 and 2004 – are previous patents, joint patent applications with firms, support from the public infrastructure, and research orientation (basic/applied). In addition, those researchers who claimed that patents impact on their salary have a larger propensity to patent. Country differences are rather small. Nevertheless, in Sweden those researchers who indicated that firms own their patent rights and those who claimed that patents are important for their academic career were more likely to apply for patents. Furthermore, those researchers who argued that patents are important to attract external funding have a higher propensity to patent. In Germany, researchers who indicated that the university owns the patent rights had a higher propensity to patent as compared to researchers who claimed that they themselves own the patent rights.

Figure 5-1 illustrates the results of the regression analyses and shows the strength of the relations between independent variables and dependent variable as measured by the odd ratios. The figure includes the statistically significant results only.

The regression analysis has estimated the impact of a number of independent variables on the dependent variable “Patent”. The data was collected by using a survey. When working with survey data the analyst is often confronted with the problem of multi-collinearity. This means that not only the independent variables are correlated with the dependent variable but that the independent variables are correlated with each other as well. The consequence of multi-collinearity is that we are not able to be sure whether the variance of the dependent variable is really brought about by the independent variable x_1 or by the independent variable x_2 in the case of strong correlation between x_1 and x_2 .

IPR regime	Total	Sweden	Germany
Researcher	1.6		2.0
University	2.2		3.2
Firm	2.1	4.1	
Structural factors			
Funding			
- Industry	1.0		1.0
- Base		1.0	
Reward			
- Patents => career		2.8	
- Patents => ext. funding		2.6	
- Patents => salary	2.2		2.5
Research Orientation			
- Applied research	1.7		2.2
- Basic research	0.6		0.4
Research field			
- Technical sciences	0.5		0.5
Size	1.0		1.0
Personal characteristics			
- Previous patents	9.9	10.8	10.0
- Joint patents	2.7	2.7	3.9
Supporting factors			
Public support	2.6	2.2	2.3

Incentives to patent and
commercialise university
research

Figure 5-1: Overview: the results of the regression analyses.

Note: Only the odd ratios of the statistically significant results are presented.

Source: own calculations.

In order to assess the dependencies, a chi-square analysis was conducted. The results can be found in the appendix. The main results that are relevant for the interpretation of the regression results are provided below. The chi-square analysis shows that there are a number of dependencies between the variables. Most of the dependencies are easily explained. The relation between research orientation and scientific disciplines shows that engineering is positively associated with applied research and negatively with basic research. This reflects that scientists in the technical sciences are primarily oriented towards applied research, as could be expected. The regression analysis has shown that support is a strong predictor of the propensity to patent. The chi-square analysis shows that support is strongly related to Uni-IPR and country. Researchers who indicated that the university owns their IPR (most of them are German) frequently used the public support infrastructure. This makes sense since German researchers are actually obliged to consult the public infrastructure since the university owns the patent rights. The variable joint patent applications with firms is also a strong predictor of the propensity to patent. The chi-square analysis reveals that it is strongly associated with Firm-IPR and previous patents. This could indicate that researchers whose patent rights are owned by private firms often file patent applications together with those firms. As one would expect, the questions regarding patent rights are correlated with the country dummy. The majority of researchers who claimed that they own their patent rights themselves are actually conducting research in Sweden whereas the majority of the researchers indicating that the university owns their patent rights are working in Germany. Together with the descriptive evidence provided earlier, this shows that although some researchers in Germany still regard the patent rights in research results as their own property, the majority of researchers perceive the university as the owner. Particularly interesting is the variable previous patents which is a particularly strong predictor of the propensity to patent between 2002 and 2004. Researchers were asked whether they have granted patents. It is important to emphasize that this variable is very distinct from the dependent variable "Patent" which covers patents applied for between 2002 and 2004 only. The patenting process is quite time-consuming and it takes between three and four years from the submission of a patent application to a granted patent.⁸⁶ The variable previous patents is closely related to most of the variables. It shows basically the same dependencies as the dependent variable "Patent". About 65% (166/257) of the researchers who have granted patents have applied for patents between 2002 and 2004 as well. Only 17% (35/206) of the researchers who applied for patents between 2002 and 2004 do not hold granted patents. Although the time span needed for the patenting process does preclude that both variables actually measure the same "thing", it shows that previous patents are closely related to future patent applications.

⁸⁶ Thus, the risk of tautology is minimal. The independent variable "Previous patents" is not congruent with the dependent variable "Patent".

5.3 Discussion and qualitative results

The thesis deals with incentives in universities. Incentives are difficult to measure. In the quantitative analysis, patent applications between 2002 and 2004 were used as a proxy for incentives to patent research results. One could argue that in the case of no patent application, the incentives were simply too weak, whereas a patent application indicates that the researcher in question actually had strong incentives to apply for a patent. Thus, a rather crude indicator for incentives to patent was applied in the quantitative part. In order to provide a more detailed account of incentives and patenting, the results of the interview study are used to interpret and enrich the quantitative results.⁸⁷ The interviews focused on employees at, and representatives for TTOs, PVAs, TBSs and a small number of professors. Thus, we have to bear in mind that the responses mirror primarily the opinions of TTOs and similar support actors.⁸⁸ The analysis and discussion below is based on the theoretical framework as presented in figure 4-2.

5.3.1 The impact of structural factors

The survey has shown that structural factors have an impact on patenting and commercialisation activities. The research orientation plays a major role in explaining patenting as the survey results suggest. Researchers active in applied research are more likely to apply for patents than their colleagues with a basic research orientation. This is true for the total survey and for the German survey. In Sweden, the research orientation is not statistically significant. As one might expect, the research field has a strong impact on the possibilities to patent. Patenting is a frequent option in fields like pharmacy but less frequent in other fields, such as the geographical sciences. Thus, the structural factors that characterise research departments such as applied research orientation and research fields where patenting is frequently used to protect intellectual property can already explain a great deal of patenting behaviour. With regard to hypothesis 4 we can conclude that in Germany incentives to patent

⁸⁷ A detailed description of the chosen methodological approach can be found in chapter 2.

⁸⁸ In general, the reader has to be aware of selection effects in Sweden. In Germany, researchers are obliged to consult and contact the TTOs in the case of a patentable invention, even in cases where results are externally funded. In Sweden, the TBS and holding companies have no information about external funding and IPRs since the researcher has full discretion about the use of his IPRs. Thus, the Swedish participants in the interview study only possess information about patenting and commercialisation in those cases where the scholars involve them on a voluntary basis.

research results are strong in applied research and weak in basic research. In Sweden, the hypothesis cannot be confirmed by the empirical data.

Important for the decision and propensity to patent is the academic reward system. The descriptive statistics in both countries illustrate the dominant role of publications with regard to career concerns. External funding also has a very strong impact on the academic career. Notably, only the Swedish respondents claim that publications and external funding impact on salary as well. These results indicate that the salaries of Swedish researchers are in part dependent on publications and external funding. In Germany, both measures are very important for the academic career but not for the salary. It seems that the employment contracts governing the relation between university and researchers in Germany do not assess publications and external funding in order to determine the salary and the bonus. Patents are less important in the reward system of universities, especially in Germany as the survey results indicate, but this could change as claimed by one German respondent working for a PVA.⁸⁹

“This is going to change in the appointment committees [for professorships]. A patent is increasingly becoming accepted as an assessed publication.”

At some German universities, there are plans to incorporate patents as performance criteria for the allocation of funds in the university. A number of universities introduced global budgeting which gives the universities more freedom and autonomy to dispose of their resources. Thus, universities get the possibility to shift priorities and resources between the departments. Patents are becoming important for researchers at the university as well. The new salary structure for professors in Germany enables the universities to reward more productive researchers. This means, for instance, that universities can pay higher salaries to researchers that apply for and hold patents. Previously, the wage structure for researchers was quite inflexible. Although the interviews in Germany suggest increasing impacts of patents on academic careers, the quantitative results show that this insight has not become evident to the researchers yet.

Nevertheless, those researchers who actually got their results patented between 2002 and 2004 had a different opinion. In Germany, those researchers who claimed that patents impact on their long run salary also showed a higher propensity to patent. In Sweden, those researchers who claimed that patents are important for their academic

⁸⁹ Citations of interviews presented in this section are translated since the interviews were conducted in Swedish and German.

career and that patents are important to attract external funding were more likely to apply for patents between 2002 and 2004. Thus, patents seem to have a rather indirect impact. These results suggest that patents are not directly used to reward efforts in research or the third mission. The employment contracts seem to reward publications and external funding. Both measures impact on academic careers and to a lesser extent on the salaries of researchers. Patents are rarely used to assess the performance of researchers, as the survey results imply. Thus, with regard to hypothesis 2 the empirical results are somewhat mixed. The descriptive analysis does not confirm the hypothesis that the reward system rewards patents. Nevertheless, the regression results have shown that researchers who regard patents as important in the reward system had a larger propensity to patent.

Researchers and universities alike have a strong interest in external funding in both countries. Researchers in Sweden who claimed that patents are important to attract external funding showed a greater propensity to get their results patented. Patents can be important as an indicator of research competence to acquire external funding.⁹⁰ A spokesman for a Swedish TBS formulated it in the following way:

“A researcher can be known to be a good businessman in addition to being a good researcher. If he has achieved that, it is clear that he can get funds from industry as well. It plays a certain role. But it is more that he is commercially oriented and the patent is the consequence of that. If you are a more traditional researcher and have one or more patents, then it does not really matter.”

In addition, empirical evidence from the interviews suggests that there is no conflict between publication and patent. The new German regulation allows a publication to be delayed for up to two months. Most of the respondents do not regard the new regulation as a hindrance to academic publications. Usually, the researchers can publish even faster since the PVAs work quite fast with the patent applications. Patents and publications can be regarded as complementary, at least in technical subjects.

From the description of the background and the theoretical argumentation it could be expected that external funding impacts on the incentives of researchers to patent research results. The financial benefits from the patenting and licensing of research

⁹⁰ A similar argument was presented by Gering and Schmoch (2003) who state that a major reason to seek patent protection for Fraunhofer institutes is to attract research grants and contracts.

results are frequently regarded as a possible compensation for decreasing public funds. This argument requires some clarification. Often, technology transfer is viewed as a one-way street where researchers invent something that is patented and licensed to a private firm. This view is typically associated with the linear model of the innovation process as presented earlier.⁹¹ The revenues of this deal flow back to the university and the inventor and the deal is over. Technology transfer is far more complicated. The descriptive statistics have shown that a lot of respondents believe that their results do not have enough inventive ingenuity and that more development would be needed in order to get a patent. The interviews in both countries, as well as other studies (e.g., Jensen & Thursby 2001), have shown that firms frequently license a technology even before the technology is really developed or before even a prototype is available. University inventions often require further development which frequently requires the involvement of the inventor.

The involvement of the inventor can take place with the involvement of the university – e.g., through externally funded R&D projects – or without the university – e.g., through consulting assignments of researchers. The survey in Sweden and Germany has revealed that consulting assignments are frequently used as a means of transfer. About 44% of the Swedish respondents and 46% of German respondents had consulting assignments between 2002 and 2004. It can be reasonably suspected that consulting assignments are a kind of extra bonus for researchers.⁹²

The study of the German infrastructure for patenting and commercialisation has shown that PVAs are in a critical position in this context. The PVA in Hamburg is responsible for the management of all projects that involve commissioned research from private industry at the university of technology of Hamburg-Harburg. They are also involved in the acquisition of funding for prototype building. Thus, the PVA does not only try to sell licences but also to acquire external funding. The PVA receives a small overhead for this service. The PVA in Karlsruhe has nothing to do with the acquisition of external funds. Nevertheless, it assists when cooperation partners are sought for building prototypes. The same is true in Aachen, where the acquisition of external funding is only a by-product in the course of efforts to find

⁹¹ As already mentioned, the Bayh-Dole Act in the US is viewed by Mowery and Sampat (2005) as an example of this linear view of the innovation process.

⁹² Goldfarb and Henrekson (2003, p. 643) argue in their paper about commercialisation policies at Swedish and US American universities that consulting is a frequently used mechanism for transfer. They define consulting arrangements as a mechanism “whereby the researcher either spends a limited amount of time working for the firm and/or takes up a position on one of the firm’s boards” (ibid., p. 643). Furthermore, “academics are often compensated quite generously for such activities” (ibid., p. 643). Goldfarb and Henrekson (ibid., p. 642) hint at the study by Jensen and Thursby (2001) and claim that “survey results suggest that the form of inventor involvement most preferred by academics is research grants”.

licensees. In Berlin, the acquisition of external funding is not one of the tasks of the PVA. Nevertheless, cooperation contracts between the university and industrial firms are negotiated as a by-product in the course of commercialisation efforts. A number of interviewees argue that a general problem is that most of the inventions from universities are in the rather premature phase of an idea. It is very difficult to sell an idea and if they can sell the idea in an early stage of development the revenues are very low. Thus, further investments are required to develop the idea into a prototype or demo model. In this phase, some of the PVAs try to find an industrial partner that can develop the invention further together with the university. In some cases, public funding is acquired for these kinds of collaborative projects. This kind of acquisition of external funding is a means to an end, namely to further develop the invention to increase the chances to sell a licence.

Thus, external funding can be important for the further development of the invention and for the career of researchers. In general, patents can be important to attract external funding. Patents are, therefore, in a kind of double role. First, patents can be used to attract external funding since they signal to the potential financier (e.g. industry) that the researcher can perform commercially relevant research. Second, university patents often need further development which can result in additional external funding where private firms and the inventor collaborate in order to develop a prototype or equivalent. It is therefore rather surprising and counterintuitive that the quantitative regressions suggest that there is only a weak connection between sources of funding and the propensity to patent in both countries. A reasonable expectation was that researchers who receive industry funding are more inclined to apply for patents but this expectation was not confirmed by the statistical data. Research groups and others with a large share of external funds are not more patent-active as measured by patent applications between 2002 and 2004. Therefore, hypothesis 3, that argued that incentives to patent are relatively weak in research organisations with high base funding cannot be confirmed by the empirical data.

In addition, the survey results have shown that personal characteristics of the researchers are important for explaining patenting. Researchers who already hold granted patents to a considerable extent are more likely to apply for patents. The impact of previous patents on the propensity to get results patented between 2002 and 2004 is tremendously large. Furthermore, experience of joint patent applications with firms is a strong predictor of patenting in both countries. Thus, personal characteristics and the experience of the inventor can play a decisive role. This argument is strengthened further by the fact that a rather large share of respondents (about 11% in both countries) claimed that they did not apply for a patent because they lacked knowledge about the patenting process. TTOs etc. seem to have a central role in this context as will be argued below.

5.3.2 The impact of the supporting infrastructure

The results of the regression analyses have indicated that public support for patenting and commercialisation increases the propensity to patent in both countries. It seems that a well-working infrastructure for patenting and commercialisation can increase the incentives to exert effort with respect to patenting by decreasing the risks associated with it. Thus, hypothesis 5, that claims that the supporting infrastructure for patenting and commercial exploitation creates positive incentives to patent can be confirmed by the empirical data.

The type of public support provided in both countries is different. Because of the UTP, Swedish researchers do not have to use the public infrastructure for commercialisation. In Sweden, the organisation of support is primarily on the local level. The advantage of local organisation is that it increases the adjustment to local circumstances and needs. TBS have very different roles in the different regions. There are a number of different actors providing support with regard to incubator services, seed and pre-seed funding and other services with respect to start-up. The organisation of support varies considerably in the different regions in Sweden. Most of the interviewees emphasised the importance of a diverse commercialisation infrastructure. There are a lot of different ways to commercially exploit research results. There is no single optimal way. It was argued from a number of interviewees in Sweden that the UTP is not very relevant if the supporting infrastructure works. Nevertheless, it seems unlikely that the infrastructure will be able to cover its own costs as the following statement by the CEO of a TBS indicates:

“And then there is a lot of support that never pays off. Everybody knows that. There are a few hits. Stanford has maybe two gigantic projects that create money. If you are not Stanford and do not have the same quality in research then it is very difficult to handle it.”

University inventions are a risky business. A possible solution could be a national patent centre similar to the German Max-Planck patent office, as proposed by some interviewees. The following statement by the CEO of a business incubator serves as an illustration:

“The innovation system and the infrastructure are not really good today. It would be better with a national and specialised university patenting and licensing office [Forskarpatent] than the regional university patenting and licensing offices that we have today.”

Revenue from licensing is highly skewed. Most of the university patenting offices (Forskarpatent) had to close down in Sweden because of low profitability. A central patenting and licensing office for all universities could possibly pool the risks of the patenting and licensing of university patents. The survey results illustrate that the public infrastructure in Sweden offers, apart from support with respect to the patent application, financial support and support that aims at promoting the establishment and development of new enterprises. Swedish researchers receive support with regard to the patent application, but support with respect to licensing seems limited. The advantage in terms of adjustment to local needs comes at the cost of small-scale organisations. The commercial failure of most Swedish university patenting and licensing offices (*Forskarpatent*) indicates that there seems to be a lack of critical mass with respect to university inventions on the regional level. This also means that the local organisation is not likely to achieve economies of scale. However, the success of some transfer organisations shows that it is possible to establish organisations that promote start-ups. It seems that in the case of start-ups or business development, the supporting actors are able to ensure returns of investments in specific assets (through transfer of ownership in patents or enterprises). The organisation of support of start-ups can be organised on a small scale basis, as contrasted to patenting and licensing. In all Swedish regions studied, there are well-developed structures for the support of start-ups in the form of incubator services, and often even seed and risk capital.

The interviews in Sweden suggest that the public infrastructure is more frequently consulted with regard to spin-offs and start-ups as a CEO for a TBS indicated:⁹³

⁹³ There are large selection effects in Sweden. In contrast to Germany, where the researchers have to notify the university in the case of an invention, the researchers in Sweden can commercialise on their own. This means the supporting infrastructure in Sweden does not possess information about all patenting and commercialisation efforts.

“We have more spin-offs than licensing deals. That is the trend right now. I think the reason is that people have realised that it is difficult to make money with licences. There was access to a lot of risk capital for newly-established firms until one and a half years ago. So it was rather easy to finance a new firm and to make money through exit [sales of shares] than to go the licensing way. It was easier to create value with firms.”

It is very difficult and rather speculative to make statements about the number of patents, licenses or spin-offs. One respondent for a TTO claimed that 5-10% of all commercialisation efforts from universities are done through start-ups. Some universities run patenting and licensing offices but it seems that there was not much of a financial backflow as illustrated by the citation below by the CEO of a TBS:

“The TBS has established a university patenting and licensing office. There are four persons. They are professionals. The TBS has established and financed the company. We pumped in a lot of money but we have not earned much money yet. It takes a number of years.”

A number of other interviewees indicate that it is very difficult to sell patents or licences in Sweden. One reason could be the rather small Swedish market. It seems that a large share of the commercialisation efforts of the public infrastructure are directed towards the establishment of new enterprises. Whether spin-off or start-up is a feasible option depends pretty much on the type of invention and the entry barriers of the industry, as the following citation by the CEO of a TBS suggests:

“Sometimes it is better to establish a new firm, sometimes it is better to sell a licence to an existing company. It depends a lot on the product. For instance, if somebody has developed a new vaccine it is not a good idea to establish a new firm since this would require gigantic resources. It is not possible to start a new Astra Zeneca. On the other hand, if somebody has developed a new algorithm, then a new firm can be established. There is not so much risk involved. Most of the firms here [at our science park] are very advanced but do not require so much economic resources.”

Thus, it seems that a start-up can be a feasible option for inventions in the field of engineering whereas licensing can be a better way in the chemical and pharmaceutical industry.

Another reason why the public supporting actors in Sweden focus primarily on start-ups could be the tendency that licences (or options) are frequently assigned to industrial enterprises even before a technology is patented, as already mentioned. This type of technology transfer happens far away from the public supporting infrastructure because of the UTP. To illustrate this argument, Goldfarb and Henrekson (2003, p. 647) note that “however, since many technologies [in Sweden] are successfully licensed to large firms, it is possible that university personnel are successfully transferring their ideas through consulting arrangements, but not earning royalties because of insufficient licensing infrastructure”. Swedish researchers do not have to use the public infrastructure for commercialisation. The survey results suggest that the researchers demand financial support and support with regard to business development and the patent application. The public infrastructure is less used with respect to licensing.

In Germany, the situation is different. The public infrastructure supports primarily patenting and licensing. Every federal state has its own PVA that is responsible for a number of universities. This centralized organisation is likely to reduce risks associated with patenting and commercial exploitation. Only a minority of inventions from universities generate profits. The organisation of PVAs in Germany can reduce risks since centralized PVAs make it possible to achieve economies of scale and they are able to pool the risks associated with a large number of inventions in each federal state. Commercialisation of university research requires specific competence and knowledge, as the interviews indicate. The costs of commercialisation infrastructure are quite high and only a large number of commercialisation projects can justify those specific investments. Universities usually have long-term contracts, sometimes even an obligation to contract with their specific PVA. Thus, since PVAs are in a kind of monopoly position they have incentives to build up infrastructure. PVAs finance themselves primarily through royalty income from licensing, although there are notable exceptions.

The primary focus of efforts regarding commercialisation of university research in Germany is licensing, as illustrated by the following statement by the CEO of a German PVA:

“The main strategy of our PVA is licensing. The simple reason is that it is one thing to come up with an invention but it is a different story to be an entrepreneur. To be an entrepreneur requires a different qualification than to be a good researcher. Therefore, I have my doubts with regard to academic spin-offs. I support spin-offs only when I have the feeling that I have a kind of entrepreneur-type in front of me.”

Another innovation manager working at a German PVA indicated:

“We do not have the capacity to support many spin-offs. We can support contacts to venture capital firms and business angels and we inlay the industrial property right in the newly established firm in return for shares. That means we transfer the property rights in return for shares in the firm. This is a risk that we only take where we have the prospect of market capitalisation through an initial public offer or a potential sale when the technology really works.”

In those cases, where a start-up emanates from the university, newly-qualified post-graduates and PhD students are most likely to establish enterprises, as indicated by some of the interviewees. In some cases, professors hold shares in the enterprises. There are different public initiatives that promote start-ups (for instance EXIST).

As the interviews in Germany suggest, the monopoly position of PVAs comes at a cost as well. The entire focus on licensing by most of the PVAs can cause incentive conflicts. A number of interviewees highlighted the existence of a trade-off between royalty income and external private funding. In the case of research projects with a large share of external (industry) funding, the demands on the funding enterprise with respect to royalties can be lower. Basically all interviewees acknowledged the importance of the acquisition of external funds for the researchers and the university. The survey results confirm that external funding is important for the academic career. This is in line with findings from Bercovitz et al. (2001, p. 31) who found that “faculty, particularly those in materials sciences, engineering and/or agricultural sciences, are reported to be accepting of this trade-off valuing immediate support of ongoing research (and importantly, the funding of graduate students) over licensing returns.” Bercovitz et al. (2001) identify organisational structure as a possible hindrance to this trade-off. Thus, the advantage of specialised PVAs in Germany is that they are able to pool the risks of a large number of university inventions which is likely to achieve economies of scale. Most of the PVAs focus almost entirely on

royalty income which makes it easier for the shareholders of PVAs (universities/state/industry) to monitor them.⁹⁴ Moreover, incentive conflicts within PVAs are reduced since PVAs have only one mission instead of three. This specialisation with regard to patenting and licensing comes at the cost of possible conflicts with inventors who value external funding over royalties. In addition, as already argued, university inventions are often in a rather premature stage which increases the importance of further development. R&D projects between the inventor and private firms are not uncommon. This can be problematic for PVAs that focus entirely on royalties. Additional research funding could mean that the claims of the university with regard to royalties are lower since the university already receives income through sponsored research. This is also in the interest of the researchers but not the PVAs. The interviews in Germany indicate the existence of a trade-off between the rather certain income from research funding versus the rather uncertain income from licensing. How this trade-off is solved depends on the organisation of support to a considerable extent.

When we look at the German cases that were studied in more detail, the organisation of support in Hamburg comes pretty close to a matrix organisation. The PVA in Hamburg is a subsidiary company of Tutech GmbH. Tutech GmbH incorporates the patent and exploitation agency (PVA), a contract research unit, incubator services, and it promotes spin-offs and start-ups. As such, all revenues and income generated through the different activities and transfer channels flow to Tutech GmbH regardless whether it is royalty income generated through the PVA or income from research funding through its contract research unit. Most of the externally-funded research projects from industry are handled as well. It receives about 10% of the research grant as overhead. As such, the PVA and its parent company have a vital interest in the acquisition of external funds.⁹⁵ This matrix organisation makes it easier for the PVA to finance itself as illustrated by the following citation:

⁹⁴ One of the PVAs in the sample (Tutech GmbH) is fully owned by the university. One PVA (ipal GmbH) is partly owned by a public bank that supports regional development, the remaining shares are owned by the universities in the federal state. Two PVAs (Provendis GmbH and TLB GmbH) are partly owned by industrial associations, by universities, and the state.

⁹⁵ The study of PVAs by Kienbaum (2006) has revealed that 74% of the universities do not involve PVAs in the acquisition of external funding. Only 12% of the universities involve PVAs in the acquisition of external funding projects already, whereas 14% envisage a kind of involvement or do not dismiss such an involvement in the future.

“I think a patent office should be part of every university even if it is not able to finance itself. No, it will never finance itself! The integration of our PVA finances itself only indirectly. All cooperation contracts and grants of the university are handled by us. All those contracts have commercialisation clauses. If there is an invention resulting from those projects, it comes back to us. Furthermore, because of the competence of the PVA we get cooperation contracts in which we get 10% [of the project sum as overhead]. This money does not benefit the PVA directly but our parent company.”

In contrast, the recently founded PVAs in North Rhine-Westphalia and Berlin regard themselves as pure licensing enterprises focusing primarily on the negotiation of licensing contracts, which is indicated by the following statement by a German innovation manager at a PVA:

“In the case of licensing there is always a minimum royalty. I have to admit that we are not interested whether the technology is used or not. We are only interested whether money comes in or not and we regard ourselves as pure business enterprise and no kind of incubator.”

History matters, and it seems that the ability of the technology transfer network and the support infrastructure to deal with the different incentive conflicts is further developed in older or more developed networks. The PVA in Karlsruhe emanated from a project launched in 1987. The PVA in Hamburg was established in 1992. The PVAs in North Rhine-Westphalia and Berlin were both established in 2001 and are still in a very early phase of development. The ownership structure of the four PVAs is similar, with shareholders including universities, federal state, and industrial interests or associations. In general, the PVAs in Germany have an important function. All PVAs together with their umbrella organisation “Technologieallianz” establish actually a kind of market for university inventions and licences since they provide information about inventions from universities at all German universities. This is likely to increase the market value and the price for university inventions.

5.3.3 The impact of patent rights regimes

The survey results suggest that German university teachers are as patent-active as their Swedish counterparts. About one fourth of all the responding researchers in Sweden and Germany applied for a patent between 2002 and 2004 themselves or through third parties. Although the universities own the patent rights in Germany, the majority of German university inventors themselves applied for patents. The

survey results have indicated that the country differences can be neglected. The estimation of the country dummy used to represent the two different formal patent rights regimes shows that there is no statistically significant difference with respect to propensity to patent in Sweden and Germany. With regard to hypothesis 1, the empirical analysis has shown that the incentive effects of the different patent rights regimes are similar. Thus, a patent rights regime in which the researcher can receive the entire benefit but has to bear the entire costs and risks (Sweden) creates similarly strong (or weak) incentives with respect to patenting as a patent rights regime in which the researcher does not have to bear any costs or risks but receives a rather generous compensation (Germany). The regression analyses for both countries separately have indicated that firm-patent rights (“Firm-IPR”) increase the propensity to patent in Sweden. In Germany, both university-patent rights and researcher-patent rights increase the propensity to patent although the effect of university-patent rights is larger as measured by odd ratios.⁹⁶ This opens up for speculations whether patent rights really do matter for the individual researcher.⁹⁷

A number of interviewees in Sweden claimed that the discussion should focus more on the infrastructure for commercialisation than the UTP. The following citation by a Swedish interviewee working for a TTO illustrates this:

“I think the university teachers’ privilege [Lärarundantaget] is actually fairly uninteresting. The systems around are more interesting.”

The analyses have shown that the supportive infrastructure has a strong impact on the propensity to patent. In Sweden, researchers own the patent rights, which leads to a number of different possible contractual solutions. In this context it is relevant that the Swedish UTP is a default rule (dispositive law). The researchers and other contract parties (e.g., industry, public funding agencies, TTOs, universities) can easily contract around the UTP if it is beneficial to the parties involved. Universities themselves can actually abolish the UTP in contractual negotiations with researchers. A university can actually add clauses in the employment contract that grant the patent rights in research results to it. This is done in the case of national competence centres. Researchers participating in these competence centres do not own the patent rights in their research results. Only in the case of missing contractual agreements is the researcher the owner of the research results. In that case the researcher has full discretion about the use of his patent rights. If the researcher expects a welfare gain

⁹⁶ These estimations are based on the variables related to the perceived patent rights regime.

⁹⁷ Studies from the US suggest that patent rights regimes have only limited explanatory power (e.g., Mowery et al. 2001).

by entering an agreement with the university holding or other supporting actors, then he will probably do that. The researcher has different options.

One manager at a Swedish university patenting and licensing office argued that the infrastructure is more important than the UTP and adds:

“One can state that Sweden still has the university teachers’ privilege and we had exceptionally many newly-established companies in Sweden during the boom. This depended on the fact that the researcher could go directly from idea to realisation.”

The majority of the interviewees argued that the supporting actors have to provide professional offers to the researchers. The survey has shown that about 40% of the patenting researchers in Sweden got support from the public infrastructure. About one fourth of the patenting researchers in Sweden got support from firms. The researchers can negotiate contracts with other agents. A frequent practice is that researchers surrender part of their ownership in patents or start-ups in return for financial support. One frequent condition for attracting seed and risk capital is that patents or equity shares are transferred to the seed/risk capital company.

Asked about a possible abolishment of the university teachers’ privilege, the CEO of a holding company answered:

“It is unnecessary to abolish the UTP. We can contract around it. But it would be good for the university to abolish it.”

In Germany, the abolishment of the UTP and the development of public infrastructure was intertwined. Some of the Swedish interviewees regard it the same way in Sweden, as suggested by this statement by the CEO of a Swedish TBS:

“If you say A you have to say B as well. If you abolish it you have to guarantee the set-up of professional infrastructure at universities that can handle it globally. This costs money and it is difficult to find the right people in a small country like Sweden.”

Another CEO for a Swedish TBS had a similar opinion:

“There are a number of researchers that were very successful as private persons. When you build up structures there is a risk that the really good things end up being with the individual persons and the mediocre things end up with the infrastructure and I do not think this advances the collectivity.”

The situation is different in Germany. In Germany, the patent rights regime gives title to the university. Researchers have to disclose their inventions to the university. Asked about the effect of the abolishment of the UTP, the CEO of a German PVA claims:

“It depends. Take a chemist. A chemist had good consultancy contracts with the chemical industry and through those contracts the inventions moved to the companies. Of course, the money from the consultancy contracts moved into private pockets. Those people are downright angry. A small college professor [FH-Professor] had previously no chance and thinks now ‘Hey great, now I get something for my invention if the university markets it’. Thus, even at the same university it depends on the rank of the professor how profitable it is.”

The general tenor of the interviewees in Germany is that the abolishment is likely to increase incentives of the mass of researchers towards commercial exploitation of research results.⁹⁸ As the citation above illustrates, a distinction has to be made between a small fraction of researchers that were patent-active already before the abolishment of the university teachers’ privilege and the vast majority of researchers that were not active in commercial exploitation. The former researchers are fighting against the new regulation and their incentives are likely to decrease. The latter ones are likely to be motivated by the abolishment of the university teachers’ privilege. Most of the interviewees argue that the balance between those with positive incentives and those with negative incentives after the abolishment of the UTP is still positive. In addition, it should not be forgotten that the new German regulation is not only valid for scholars included in the former university teachers’ privilege but also for researchers who have not yet become professors. Most of the German interviewees argued that this is likely to vitalize technology transfer in general.

⁹⁸ Of course, this has to be seen with caution. Primarily the “university-side” was interviewed and the answers can be biased.

The German law about employees' inventions prescribes the compensation to inventors. The compensation is important as the following response by a German TTO employee suggests:

“Of course, you should not forget that the abolishment of the UTP and the 30% of gross revenue is valid for all scientific staff and not only the professors. University staff is in a better position than staff in industry, who get 3 to 6 or maybe 7 percent at the most.”

The interviews in Germany suggest that the profit distribution is similar in all four cases. The inventor gets 30% of the gross revenue. The costs of patenting and commercialisation are not deducted. That means the inventor does not bear any costs or risks. This is mandatory in the new regulation governing employees' inventions. In addition, the department of the inventor receives the share of the university as a kind of additional external funding. In some cases some overhead is deducted. Thus, a patent can lead to two types of income to the individual inventor in Germany. First, it can generate private income by means of the mandatory inventors' share. Second, it can lead to external funding to the benefit of the inventors' research group.

Asked about the likely incentive effect of the mandatory compensation to the inventor, a German innovation manager working for a PVA argues:

“Yes, for those who did not make [apply for patents] anything before. Because they knew that the theoretically possible 100% before the abolishment of the UTP was never viable. It is different for those who were already patenting and exploiting. For those it is definitely no motivation... Those researchers are motivated now to report things [inventions] that they would not have applied for before because the effort was not justified. For those professors who already exploited successfully, the average quality of the inventions that we receive is decreasing.”

One representative of a German PVA criticized the obligation that the university has to pay 30% of gross revenue to the inventor. This regulation can be disadvantageous for the university since the university has to bear the costs for patenting and commercial exploitation and there is a risk that the university and the PVAs make losses whereas the researcher gains from commercial exploitation. This could reduce the

number of claims for inventions by the university but this has not proven true yet since the Federal Ministry of Education and Research (BMBF) still covers a share of the patenting costs.

The survey results show that the majority of the patent-active researchers in Germany themselves applied for patents. This opens up for a number of possible interpretations. First, the university did not want to exploit the invention and released the invention to the inventor. This could mean that the university sent the invention disclosure to the PVA and the PVA did not see any commercial potential. In that case, the PVA would recommend to the university not to claim the invention. In such a case, it would be unlikely that the inventor himself would apply for a patent. Another possibility could be that the university released the patent rights to the inventor in order to facilitate the surrender of patent rights to private firms, possibly in return for research funding. This could happen in the setting of an An-Institute. The statistical data show that 60% of those researchers who applied on their own got support from the public infrastructure. About 60% declared that they themselves own the patent rights, 52% regard the university as owner and only 33% regard firms as owners of their patent rights.

Second, researchers who applied for patents between 2002 and 2004 on their own ignored the abolishment of the UTP or were poorly informed about the patent rights situation. Thus, researchers applied for a patent although the university formally was the owner of the patent rights. As the interviews in Germany indicate, the enforcement of the regulation is rather difficult. It seems to be difficult to hinder a researcher – in particular those that hold lifelong tenure – from entering an agreement with private industry. Empirical evidence from the US points in the same direction (Siegel et al 2003). According to the study by Kienbaum (2006, p. 39, my translation), “from the point of view of the university managements that were asked, there are still researchers who dismiss the collaboration with PVAs and who are not willing or able to understand the changes in the law governing employees’ inventions”. At the same time, the universities do not have the resources and sometimes even the willingness to control their researchers with regard to patent rights. This reflects the large information asymmetries in favour of the researchers. Whether researchers always obey the rules and regulations governing university inventions which would mean that they always submit an invention disclosure to the university in the case of a patentable invention is difficult to prove, but the statistical material shows that 40% of those researchers who patented on their own did not get support from the public infrastructure. The same is true for about 50% of those inventions that were patented by a third party. In those cases where patents were applied for by third parties, the majority of patents were filed by firms (60%) and the majority of those cases the firms were regarded the owners of the patent rights (58%), in 40% the university was regarded as the owner and merely 14% thought that they themselves were the patent right holders. Nevertheless, the survey data does not allow for a

concluding judgement about the different ways that researchers use to patent their research results on their own. Nonetheless, it should not be forgotten that even universities might have weak interests and incentives to involve the PVAs. The study of PVAs by Kienbaum (2006) has shown that there are a number of approaches by inventors and universities alike to deliberately bypass the PVAs as shown by a decline in the number of invention disclosures handled by the PVAs. Thus, it seems that there are a number of universities that allow their researchers to exploit on their own. This indicates that transaction costs with regard to transfer from researcher to industry seem to be low. It shows that universities do not always enforce the new regulation governing employees' inventions and that there are universities that encourage their researchers to bypass the PVAs. This hints at the relevance of the Coase theorem presented in the theoretical chapter, since the initial allocation of patent rights is of limited importance in Germany.

Third, another explanation why researchers applied themselves for patents is that the invention was developed in an organisational setting where other parties own the patent rights, e.g., An-Institutes or that the patent rights are not owned by the university since they are protected by older research grants and contracts (*Altverträge*).

It is also important to note that the majority of the interviewees in Germany had the opinion that it is mainly the improved infrastructure for commercialisation and not solely the abolishment of the university teachers' privilege that increases incentives for commercial exploitation. The following response by a German TTO employee illustrates this:

“I think that simply abolishing the university teachers' privilege [Hochschullehrerprivileg] without any accompanying measures would have had no effect. The patent exploitation offensive of the BMBF was important. Of course, with respect to funding but also with regard to culture to improve the patenting structure... I assume that the abolishment of the university teachers' privilege has vitalised the business but it has to be linked to a service that is working and is of good quality. We cannot say to the scholar: ‘We take your invention disclosure and you cannot publish for the next two years’. That won't work since it is his business to publish his results in the scientific community quickly. That means we have to be fast as well.”

Basically, all interviewees attested that the infrastructure for patenting and commercialisation of university research has improved a lot in Germany since the abolishment of the university teachers' privilege. Nevertheless, legal reforms and the development of infrastructure are not enough to change the motivation and incentives of researchers, as the following statement by a TTO employee illustrates:

“Maybe a good infrastructure creates incentives to patent but I am not really sure what you have to offer the people to be more flexible. I think a lot of scientists are rather conservative. This starts already during their studies with a very conservative education.”

The comparison of Germany and Sweden shows that the assignment of patent rights in research results impacts only weakly on the incentives of researchers and universities to commercially exploit research results. In Sweden, the researchers own the freedom of contract, which leads to a diversity of transfer channels and approaches. In Germany, there is not much variety with respect to transfer options. Universities have long-term contracts with “their” PVA. Private provision of transfer services is absent – possibly because of high transaction costs. Infrastructure for patenting and commercialisation is important. We have to bear in mind that the reward for the third mission is affected by patent rights and infrastructure. In Germany, the formal patent rights regime decreases the incentives of those scholars who were previously commercialising on their own, but the new regime provides incentives to researchers who were not actively involved in commercialisation before. Compensation in the case of commercialisation is quite generous, which can reduce the incentives of universities/PVAs to engage in commercialisation efforts. For both groups, incentives for the third mission depend on the success of the PVAs in commercialising research results. Furthermore, the enforcement of the formal patent rights regime in Germany is difficult for the universities because of large information asymmetries.

In sum, the empirical analyses have shown that hypothesis 1 that states that patent rights in research results create positive incentives to patent research results cannot be confirmed. Patent rights regimes have only a weak impact on the incentives to patent. The results with regard to hypothesis 2 that states that the reward system of universities rewards patents, which creates positive incentives to apply for patents are mixed. The descriptive statistics do not confirm the hypothesis, whereas the regression results have shown that researchers who regard patents as important for the academic career and for external funding (Sweden) or the salary (Germany) were also more likely to apply for patents. Hypothesis 3 that states that incentives to patent research results are relatively weak in research organisations with high base funding cannot be confirmed by the empirical data. Hypothesis 4 that states that incentives to patent research results are relatively strong in applied research can be confirmed in the German case only. Finally, hypothesis 5 that states that the support-

ing infrastructure for patenting and commercial exploitation creates positive incentives to patent research results can be confirmed by the empirical data.

6. Conclusions

The purpose of this dissertation was to assess the impact of patent rights regulation in universities in Germany and Sweden. Two empirical studies were conducted in order to answer the research question “What are the incentive effects of patent rights regimes in the university?”. A qualitative study based on interviews with representatives from the public support infrastructure in both countries assessed the role of technology transfer offices and other intermediaries in both countries. The process of patenting and commercial exploitation in Sweden and Germany was presented in stylised models. Furthermore, the qualitative interviews were used to interpret the results from a quantitative analysis based on a survey of researchers in both countries. A number of shortcomings in the quantitative design – for instance the rather low response rate, particularly in Germany – necessitates caution with respect to the interpretation of the quantitative findings. Nevertheless, the quantitative results together with the qualitative findings from the interview study allow us to draw a number of conclusions.

First of all, the incentive effects of the formal patent rights regimes in universities in Sweden and Germany are rather small. Despite two diametrically opposed patent rights regimes – Sweden with researcher-patent rights and Germany with university-patent rights – the results indicate that patenting is rather unaffected by them. Researchers in both countries are similarly patent-active. Thus, the patent rights regime has only limited explanatory power. Other factors seem to have a stronger impact on the incentives to patent. The infrastructure for patenting and commercialisation has an important role. Researchers that received support were more prone to get their results patented and the results from the interview study point out that it is mainly a well-working infrastructure that increases incentives to patent and not the patent rights regime alone. When it comes to the public infrastructure for patenting and commercial exploitation, the role of technology transfer offices and similar organisations and the type of support is different in both countries. Swedish public infrastructure provides primarily support with regard to the patent application and financial support aiming at the establishment and development of spin-offs and start-ups. German public infrastructure focuses primarily on patenting and licensing. The organisation of support has proved to be of importance since there are conflicts and trade-offs with regard to different transfer options and channels. Technology transfer offices etc. that focus only on royalties from licensing can actually block other transfer channels such as the consulting assignments of researchers or commissioned research/external funding. As mentioned, the formal patent rights regime has limited power to explain patenting. Structural factors of research organisations and the personal characteristics of the researcher are more important. Structural factors such as research orientation (applied vs. basic) can partly explain patenting behaviour. Re-

searchers that have previous experience with patenting show a larger propensity to patent. The survey results about hindrances to patenting have shown that a lot of researchers did not apply because they lacked knowledge, or regarded the patenting process to be too time-consuming or too costly. This illustrates the importance of experience and infrastructure. Researchers who lack “entrepreneurial drive” and knowledge neglect patenting. Since the university wants the researcher to accomplish all three missions (research, teaching and transfer), it has to induce the researchers to do so.

Nevertheless, the analysis of the reward system has shown that this is rarely the case. The employment contracts in universities include a rather fixed salary and a bonus. The empirical results in Sweden and Germany show that the salary is either directly or indirectly affected by publications and the extent to which the researcher acquires external funding. That means that a researcher who publishes his research results and attracts external funding has rather high chances to advance in his career and to receive a larger salary. It can reasonably be assumed that teaching is also rewarded since university professors often have minimum lecturing hours. In universities and other public organisations, career concerns are the dominant way to motivate employees. As the empirical results suggest, publications and external funding are frequently used in Sweden and Germany to assess the performance of the researchers. Thus, when researchers focus on the attraction of external funding and publication of their research results, the chances that their career is advanced and that eventually their salary will be raised are quite high. Which means that it is less risky if researcher engage in publication activities and attract external funding. In addition to career concerns and salary, researchers have the possibility to earn a bonus. This bonus is related to the third mission of universities (knowledge and technology transfer) and can take different forms. It can include honoraria for books or lectures, income from consulting assignments, or income from patents. It is therefore important to acknowledge that there is a broad range of means to transfer knowledge and technology. Consulting seems important since more than 40% of all respondents in Sweden and Germany had some form of consulting assignment between 2002 and 2004. Patents are also important as a means to achieve a bonus. Every fourth respondent in both countries got his research results patented between 2002 and 2004 either himself or through a third party. The bonus associated with consulting seems to be less risky than the potential bonus of patenting. The maximum bonus with regard to patents is determined by the formal patent rights regime. In Sweden, the university teachers can receive the entire bonus, whereas this share is limited to 30% in Germany. The chances that a bonus materialises are uncertain. The basic role of technology transfer offices and other actors that support patenting and commercialisation is to reduce the risks associated with patenting. If the risks can be reduced, the chances that a bonus will materialise are larger, which increases the incentives of researchers to make efforts with regard to patenting.

In addition, it is important to note that other transfer activities have to be taken into account. Consulting, possibly combined with additional external funding is quite

important in relation to the bonus of researchers and also the academic career. Thus, although the entire focus of PVAs in Germany on patenting and licensing has advantages as already discussed, it can distort the incentives of researchers and also universities with regard to other transfer mechanisms. An invention disclosure delivered to the technology transfer office does not mean a finished product. The active participation and involvement of the inventor is of tremendous importance for the success of commercial exploitation. Since it is difficult to enforce formal patent rights regimes (such as the new German law governing employees' inventions) it is important that the actors in the support infrastructure and universities are open for different channels and ways to exploit research results. Different means to transfer can be licences, spin-offs or consulting, depending on the case at hand. TTOs and other intermediaries that limit or disturb this choice can possibly reduce the outcome and success of the commercial exploitation of results from university research.

Finally, it was stressed in the beginning of this dissertation that universities are increasingly facing financial constraints. The patenting and commercialisation of research results from university research is often regarded as a way to overcome those financial difficulties since it can lead to additional income to universities. These developments have to be seen with caution. The outcome of university research is uncertain since researchers often conduct research in areas where no previous knowledge exists. A too dominant focus of university managements and the public on short-term accountability and profitability of universities and research departments can have detrimental effects for the whole university system. The open attitude towards novelty and different scientific approaches might suffer.

7. References

7.1 *Written sources*

- Alchian, A. A. & Demsetz, H. (1972). Production, information costs, and economic organization, *American Economic Review*, 62, pp. 777-795.
- Anand, B. & Galetovic, A. (2000). Weak property rights and hold-up in R&D, *Journal of Economics and Management Strategy*, 9, pp. 615-642.
- Arrow, K. J. (1962). Economic welfare and the allocation of resources for inventions, in Nelson, R. R. (ed.) *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton, MA: Princeton University Press.
- Auer v., L. (1999). *Ökonometrie*, Berlin: Springer Verlag.
- Beise, M. & Stahl, H. (1999). Public research and industrial innovations in Germany, *Research Policy*, 28, pp. 397-422.
- Belitz, H. (2003). InnoNet – Ein neuer Ansatz zur Förderung der Kooperation von öffentlichen Forschungseinrichtungen mit kleinen und mittleren Unternehmen, *DIW-Wochenbericht 6/03*, Berlin: Deutsches Institut für Wirtschaftsforschung.
- Bercovitz, J., Feldman, M., Feller, I. & Burton, R. (2001). Organizational structure as a determinant of academic patent and licensing behavior: an exploratory study of Duke, Johns Hopkins, and Pennsylvania State universities, *Journal of Technology Transfer*, 26, pp. 21-35.
- Berghoff, S., Federkeil, G., Giebisch, P., Hachmeister, C.-D., & Müller-Böling, D. (2002). Das Forschungsranking deutscher Universitäten – Analysen und Daten im Detail, *Arbeitspapier Nr. 40*, Gütersloh: Centrum für Hochschulentwicklung.

- Berghoff, S., Federkeil, G., Giebisch, P., Hachmeister, C.-D., & Müller-Böling, D. (2003). Das Hochschulranking – Vorgehensweise und Indikatoren, *Arbeitspapier Nr. 46*, Gütersloh: Centrum für Hochschulentwicklung.
- Bozeman, B. (2000). Technology transfer and public policy: a review of research and theory, *Research Policy*, 29, pp. 627-655.
- Braunerhjelm, P., Svensson, P. & Westin, F. (2003). Akademiskt entreprenörskap – den svaga länken i de svenska innovationssystemen?, *Ekonomisk Debatt*, 31 (3), pp. 33-46.
- Brousseau, E. & Glachant, J.-M. (2002). The economics of contracts and the renewal of economics, in Brousseau, E. & Glachant, J.-M. *The Economics of Contracts*, New York: Cambridge University Press.
- Bryman, A. (2000). *Quantity and Quality in Social Research*, London: Routledge.
- Bryman A. (1997). *Kvantitet och kvalitet i samhällsvetenskaplig forskning*, Lund: Studentlitteratur.
- Bundesministerium für Bildung und Forschung (BMBF) (2002). *Zur Einführung der Neuheitsschonfrist im Patentrecht – ein USA-Deutschland-Vergleich bezogen auf den Hochschulbereich*, Bonn.
- Bundesministerium für Bildung und Forschung (BMBF) (2001). *Knowledge Creates Markets – Action Scheme of the German Government*, Bonn.
- Bundesministerium für Bildung und Forschung (BMBF) (2000). *EXIST: University-based Start-ups*, Bonn.
- Carlsson, B. & Fridh, A. C. (2002). Technology transfer in United States universities: a survey and statistical analysis, *Journal of Evolutionary Economics*, 12, pp. 199-232.
- Coase, R. (1960). The problem of social cost, *Journal of Law and Economics*, 3, pp. 1-44.
- Cockburn, I., Henderson, R. & Stern, S. (1999). Balancing incentives: the tension between basic and applied research, *NBER Working paper No. 6882*, Cambridge, MA: National Bureau of Economic Research.

- Cohausz, Hannig, Dawidowicz & Partner (1998). *Untersuchung zum Verwertungsprivileg – Relevanz des sog. Hochschullehrerprivilegs nach § 42 ArbNErfG*, Gutachten im Auftrag des Bundesministeriums für Bildung, Wissenschaft, Forschung und Technologie, Düsseldorf.
- Cohen, W. M & Levinthal, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation, *Administrative Science Quarterly*, 35, pp. 128-152.
- Converse, J. M & Presser, S. (1986). *Survey Questions: Handcrafting the Standardized Questionnaire*, Quantitative Applications in the Social Sciences, Beverly Hills, Calif: Sage.
- Cooter, R. & Ulen, T. (1996). *Law and Economics*, 2nd edition, New York: Addison-Wesley.
- Craswell, R. (1999). Contract law: general theories, in Bouckaert, B. & De Geest, G., *Encyclopedia of Law and Economics*, Cheltenham: Edward Elgar.
- Czarnitzki, D., Rammer, C. & Spielkamp, A. (2000). Interaktion zwischen Wissenschaft und Wirtschaft in Deutschland. Ergebnisse einer Umfrage bei Hochschulen und öffentlichen Forschungseinrichtungen, *ZEW-Dokumentation Nr. 00-14*, Mannheim: ZEW.
- Dahmström, K. (2000). *Från datainsamling till rapport – att göra en statistisk undersökning*, Lund: Studentlitteratur.
- Dasgupta P. & David, P. (1994). Toward a new economics of science, *Research Policy* 23 (5), pp. 487 – 521.
- Dasgupta, P. & David, P. (1987). Information disclosure and the economics of science and technology, in Feiwel, G. R. (ed.) *Arrow and the Ascent of Modern Economic Theory*, New York: New York University Press.
- David, P. A., Mowery, D. C. & Steinmueller, W. E. (1994). University-industry research collaborations: managing missions in conflict, paper prepared for the conference on “*University Goals, Institutional Mechanisms, and the Industrial Transferability of Research*”, Stanford, 18-20 March 1994.

- Deiaco, E., Giertz, E., Reitberger, G. & Rogberg, A. (ed.) (2002). *Teknikparkens roll i det svenska innovationssystemet – historien om kommersialisering av forskningsresultat*, VFI 2002:3, Stockholm: VINNOVA.
- Dobson, A. J (2002). *An Introduction to Generalized Linear Models*, Boca Raton: Chapman & Hall/CRC.
- Edquist, C. (1997). Systems of innovation approaches – their emergence and characteristics, in Edquist, C. (ed.), *Systems of Innovation - Technologies, Institutions and Organizations*, London: Pinter.
- Erlei, M., Leschke, M. & Sauerland, D. (1999). *Neue Institutionenökonomik*, Stuttgart: Schäffer-Poeschel.
- Etzkowitz, H. & Klofsten, M. (2005). The innovating region: toward a theory of knowledge-based regional development, *R&D Management*, 35, pp. 243-255.
- Etzkowitz, H. & Leydesdorff, L. (2000). The dynamics of innovation: from national systems and „mode 2“ to a triple helix of university-industry-government relations, *Research Policy*, 29, pp. 109-123.
- Etzkowitz, H., Webster, A., Gebhardt, C. & Terra, B. R. C. (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm, *Research Policy*, 29, pp. 313-330.
- European Commission (2001). *Benchmarking Industry-Science Relations – The Role of Framework Conditions*, Final Report, Vienna/Mannheim.
- European Patent Office (1999). *Costs of an Average European Patent*, http://www.europeanpatent-office.org/epo/new/kosten_e.pdf, download 2003-04-14.
- Faure, M. & Skogh, G. (2003). *The Economic Analysis of Environmental Policy and Law: An Introduction*, Cheltenham: Edward Elgar.

- Fier, A. & Harhoff, D. (2002). Die Evolution der bundesdeutschen Forschungs- und Technologiepolitik: Rückblick und Bestandsaufnahme, *Perspektiven der Wirtschaftspolitik*, 3 (3), pp. 279-301.
- Fleuchaus, A. & Braitmayer, S.-E. (2002). Hochschullehrerprivileg ade? In *Gewerblicher Rechtsschutz und Urheberrechtsschutz*, 8, pp. 653-658.
- Franz, W. (2000). Wirtschaftspolitische Beratung: Reminiszenzen und Reflexionen, *Perspektiven der Wirtschaftspolitik*, 1 (1), pp. 53-71.
- Frey, B. S. (1997). *Not Just for the Money: An Economic Theory of Personal Motivation*, Cheltenham: Edward Elgar.
- Gebhardt G. & Schmidt, K. M. (2002). Der Markt für Venture Capital: Anreizprobleme, Governance Strukturen und staatliche Interventionen, *Perspektiven der Wirtschaftspolitik*, 3 (3), pp. 235-255.
- Gering, T. & Schmoch, U. (2003). Management of intellectual assets by German public research organisations, in OECD (2003b) *Turning Science into Business: Patenting and Licensing at Public Research Organisations*, Paris: OECD.
- Geuna, A. (2001). The changing rationale for European university research funding: are there negative unintended consequences, *Journal of Economic Issues*, 35 (3), pp. 607-632.
- Geuna, A. (1999). *The Economics of Knowledge Production: Funding and the Structure of University Research*, Cheltenham: Edward Elgar.
- Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. & Trow, M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*, London: Sage.
- Gibbons, R. (1998). Incentives in organisations, *Journal of Economic Perspectives*, 12 (4), pp. 115-132.
- Giuri, P. & Mariani, M. (2005). Everything you always wanted to know about inventors (but never asked): evidence from the PatVal-EU Survey, *LEM Working Paper 2005/20*, Pisa: Sant' Anna School of Advanced Studies.

- Goldfarb, B. & Henrekson, M. (2003). Bottom-up versus top-down policies towards the commercialization of university intellectual property, *Research Policy*, 32, pp. 639-658.
- Granstrand, O. (2005). Innovation and intellectual property rights, in Fagerberg, J., Mowery, D. C. & Nelson, R. R. (eds.) *The Oxford Handbook of Innovation*, Oxford: Oxford University Press.
- Griliches, Z. (1990). Patent statistics as economic indicators: a survey, *Journal of Economic Literature*, 28 (4), pp. 1661-1707.
- Guldbrandsen, M. (2003). ”Jeg gjør jo ikke dette for å bli rik av det”: Kommersialisering av norsk universitetsforskning – en intervjustudie, *Rapport 6/2003*, Oslo: Norsk Institutt for Studier av Forskning og Utdanning.
- Hällsten, M. & Sandström, U. (2002). Högskoleforskningens nya miljarder, in Sandström, U. (ed.) *Det nya forskningslandskapet*, Syster, Skrifter 5, Stockholm: Nya Doxa.
- Henrekson, M. (2002). Strategier för en framgångsrikare kommersialisering av svensk universitetsforskning, *Ekonomisk Debatt*, 30 (2), pp. 159-170.
- Henrekson, M. & Rosenberg, N. (2000). *Akademiskt entreprenörskap*, Stockholm: SNS.
- Hirschman, A. O. (1970). *Exit, Voice and Loyalty: Responses to Decline in Firms, Organizations, and States*. Cambridge: Harvard University Press.
- Holmström, B. & Milgrom, W. P. (1991). Multitask principal-agent analyses, *Journal of Law, Economics and Organization*, 7, pp. 24-52.
- Holmström, B. & Milgrom, W. P. (1994). The firm as an incentive system, *American Economic Review*, 84, pp. 972-991.
- HSV (2003). *Högskoleverkets årsrapport 2003*, Stockholm: Swedish Agency for Higher Education.
- HSV (2005). NU-Database, Swedish Agency of Higher Education <http://nu.hsv.se/nu/index1.html> assessed 2005-03-18.

- Jacob, M., Lundqvist, M. & Hellsmark, H. (2003). Entrepreneurial transformations in the Swedish university system: the case of Chalmers University of Technology, *Research Policy*, 32, pp. 1555-1568.
- Jacob, H. (1984). *Using Published Data: Errors and Remedies*, Beverly Hills: Sage.
- Jacobsson S. & Rickne, A. (2004). How large is the Swedish 'academic' sector really? A critical analysis of the use of science and technology indicators, *Research Policy*, 33, pp. 1355-1372.
- Jaffe, A. B. (1989). Real effects of academic research, *American Economic Review*, 79 (5), pp. 957-970.
- Jensen, M. C & Meckling, W. H. (1976). Theory of the firm, managerial behavior, agency costs, and ownership structure, *Journal of Financial Economics*, 3, pp. 305-360.
- Jensen, R. & Thursby, M. (2001). Proofs and prototypes for sale: the tale of university licensing, *American Economic Review*, 91, pp. 240-259.
- Jonsson, P. & Sörlin, S. (2002). Extern finansiering: Exemplet SLU, in Sandström, U. (ed.) *Det nya forskningslandskapet*, Sister Skrifter 5, Stockholm: Nya Doxa.
- Kalton, G. (1983). *Introduction to Survey Sampling*, Quantitative Applications in the Social Sciences, Beverly Hills: Sage.
- Keck, O. (1993). The national system for technical innovation in Germany, in Nelson, R. R. (ed.), *National Innovation Systems: A Comparative Analysis*, Oxford: Oxford University Press.
- Kienbaum Management (2006). *Abschlussbericht: "Weiterentwicklung von Kriterien sowie Datenerhebung auf der Basis der Kriterien und Datenauswertung bezüglich der Kompetenz und Leistungsfähigkeit der Patent- und Verwertungsagenturen"*, Düsseldorf: Kienbaum Management.
- Kitch, E. W. (1998). Patents, in Newman, P. (ed.) *The New Palgrave Dictionary of Economics*, Vol. 3, London/New York: Macmillan.

- Kline, S. & Rosenberg, N (1986). An overview of innovation, in Landau, R. & Rosenberg, N. (eds.) *The Positive Sum Strategy*, Washington D.C: National Academy.
- Klofsten, M. & Jones-Evans, D. (2000). Comparing academic entrepreneurship in Europe – the case of Sweden and Ireland, *Small Business Economics*, 14, pp. 299-309.
- Kräkel, M. (2006). Zur Reform der Professorenbesoldung in Deutschland, *Perspektiven der Wirtschaftspolitik*, 7(1), pp. 105-126.
- Lazear, E. P. (1979). Why is there mandatory retirement?, *Journal of Political Economy*, 87 (6), pp. 1261-1284.
- Lee E. S., Forthofer, R. N. & Lorimer, R. J. (1989). *Analyzing Complex Survey Data*, Quantitative Applications in the Social Sciences, Newbury Park, Calif: Sage.
- Liao, T. F. (1994). *Interpreting Probability Models: Logit, Probit, and other Generalized Linear Models*, Quantitative Applications in the Social Sciences, Thousand Oaks, Calif: Sage.
- Lohr, S. L (1999). *Sampling: Design and Analysis*, Pacific Grove, Calif.; Duxbury Press.
- Macneil, I. R. (1974). The many futures of contracts, *Southern California Law Review*, 47 (688), pp. 691-816.
- Mansfield, E. (1995). Academic research underlying industrial innovations: sources, characteristics, and financing, *Review of Economics and Statistics* 77, pp. 55-65.
- Mansfield, E. (1998). Academic research and industrial innovation: an update of empirical findings, *Research Policy*, 26, pp. 773-776.
- Meyer-Krahmer, F. & Kulicke, M. (2002). Gründungen an der Schnittstelle zwischen Wissenschaft und Wirtschaft – die Rolle der Hochschulen, *Perspektiven der Wirtschaftspolitik*, 3 (3), pp. 257 – 277.
- Meyer-Krahmer, F. & Schmoch, U. (1998). Science-based technologies: university-industry interactions in four fields, *Research Policy*, 27, pp. 835-851.

- Michie, J., Oughton, C. & Pianta, M. (2002). Innovation and the economy, *International Review of Applied Economics*, 16 (3), pp. 253 – 264.
- Miles, M. B. & Huberman, A. M. (1994). *Qualitative Data Analysis: An Expanded Source Book*, Thousand Oaks, Calif: Sage.
- Milgrom, P. & Roberts, J. (1992). *Economics, Organization and Management*, Englewood Cliffs, N. J.: Prentice-Hall.
- Mohnen, P. & Hoareau, C. (2003). What types of enterprise forges close links with universities and government labs? Evidence from CIS 2, *Managerial and Decision Economics*, 24, pp. 133-145.
- Mowery, D. C. & Sampat, B. N. (2005). Universities in national innovation systems, in Fagerberg, J., Mowery, D. C. & Nelson, R. R. (eds.) *The Oxford Handbook of Innovation*, Oxford: Oxford University Press.
- Mowery, D. C., Nelson, R. R., Sampat, B. N. & Ziedonis, A. A. (2001). The growth of patenting and licensing by U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980, *Research Policy*, 30, pp. 99 – 119.
- Mowery, D. C. & Rosenberg, N. (1993). The US national innovation system, in Nelson, R. R. (ed.) *National Innovation Systems: A Comparative Analysis*, Oxford: Oxford University Press.
- Nählinder, J. (2005). *Innovation and Employment in Services. The Case of Knowledge Intensive Business Services in Sweden*, Linköping: Linköping Studies in Arts and Science No. 334.
- Nelson R. R. (1959). The simple economics of basic scientific research, *Journal of Political Economy*, 67, pp. 297-306.
- Nelson, R. R. & Winter, S. (1982). *An Evolutionary Theory of Economic Change*, Cambridge, Mass.: Harvard University Press.
- Niskanen, W.A. (1971). *Bureaucracy and Representative Government*, Chicago: Aldine.
- North, D. C. (1990). *Institutions, Institutional Change and Economic Performance*, Cambridge: Cambridge University Press.
- OECD (2005). *Main Science and Technology Indicators*, Paris: OECD.

- OECD (2004a). *OECD Science, Technology and Industry Outlook 2004: Country Response to Policy Questionnaire Sweden*, Paris: OECD.
- OECD (2004b). *OECD Science, Technology and Industry Outlook 2004: Country Response to Policy Questionnaire Germany*, Paris: OECD.
- OECD (2004c). *Science and Technology Statistical Compendium*, Paris: OECD.
- OECD (2003a). *Governance of Public Research*, Paris: OECD.
- OECD (2003b). *Turning Science into Business: Patenting and Licensing at Public Research Organisations*, Paris: OECD.
- OECD (2003c). *Science, Technology and Industry Scoreboard 2003*, Paris: OECD.
- OECD (2002). *Benchmarking Industry-Science Relationships*, Paris: OECD.
- OECD (1999). *University Research in Transition*, Paris: OECD.
- Ochel, W. (2004). Lernen von anderen Ländern: Zum international Vergleich und Transfer von Arbeitsmarktinstitutionen, *Perspektiven der Wirtschaftspolitik*, 5 (2), pp. 139-158.
- Olofsson, C. & Wahlbin, C. (1993). *Teknikbaserade företag från högskolan*, Linköping: IMIT.
- Owen-Smith, J. & Powell, W. W. (2001). To patent or not: faculty decisions and institutional success at technology transfer, *Journal of Technology Transfer*, 26, pp. 99-114.
- Palmberg, C. (2003). *Turning Opportunities into Innovations – Essays on the Sources, Nature and Success of Innovations*, Stockholm: Royal Institute of Technology.
- Pavitt, K. (2005). Innovation processes, in Fagerberg, J., Mowery, D. C. & Nelson, R. R. (eds.) *The Oxford Handbook of Innovation*, Oxford: Oxford University Press.
- Polanyi, M. (1958). *Personal Knowledge*, London: Routledge.
- Powell, W. W. & Owen-Smith, J. (1998). Universities and the market for intellectual property in the life sciences, *Journal of Policy Analysis and Management*, 17 (2), pp. 253 – 277.

- Reese, M. (2000). Logistische Regression, in Backhaus, K., Erichson, B., Plinke, W. & Weiber, R. *Multivariate Analysemethoden: Eine anwendungsorientierte Einführung*, Berlin: Springer Verlag.
- Reitberger, G. (1983). STU-Projekt med villkorlig återbetalningsskyldighet: Analys och utvärdering av effekter, *Dnr 83-4014*, Täby: Konsultrapport till STU.
- Romer, P. M. (1994). The origins of endogenous growth, *Journal of Economic Perspectives*, 8, (1), pp 3-22.
- RRV 2001:11. *Från forskning till tillväxt – statligt stöd till samverkan mellan högskola och näringsliv*, Stockholm: Riksrevisionsverket.
- Ruist, E. (1990). *Modellbygge för empirisk analys*, Lund: Studentlitteratur.
- Sandven, T. & Smith, K. (1998). Using Community Innovation Survey data for empirical analysis – data reliability and issues for analysts, *IDEA Paper Series No. 4*, Oslo: STEP.
- Saxenian, A. (1991). The origins and dynamics of production networks in Silicon Valley, *Research Policy*, 20, pp. 423-437.
- Schartinger, D., Rammer, C., Fischer, M. M. & Fröhlich, J. (2002). Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants, *Research Policy*, 31, pp. 303-328.
- Schartinger, D., Schibany, A. & Gassler, H. (2001). Interactive relations between universities and firms: empirical evidence for Austria, *Journal of Technology Transfer*, 26, pp. 255-268.
- Schild, I. (1999). A regional patent study to investigate inventive activity in East Gothia, *Working Paper No. 207*, Linköping: Department of Technology and Social Change, Linköping University.
- Schmidtchen, D. (1998). Funktionen und Schutz von “property rights”. Eine ökonomische Analyse. *Discussion Paper 9804*, Saarbrücken: Center for the Study of Law and Economics, University of Saarland.
- Schmoch, U., Licht, G. & Reinhard, M. (eds.) (2000). *Wissens- und Technologietransfer in Deutschland*, Stuttgart: Fraunhofer.

- Sellenthin, M. O. (2004). Who should own university research? An exploratory study of the impact of patent rights regimes in Sweden and Germany on the incentives to patent research results, *Publication A2004:013*, Östersund: Swedish Institute for Growth Policy Studies (ITPS).
- Sellenthin, M. O. (2003). Universities in innovation networks: the impact of patent rights regimes on the commercialisation of research in Sweden and Germany, in Elsner, W. & Biesecker, A. (eds.) *Neuartige Netzwerke und nachhaltige Entwicklung: Komplexität und Koordination in Industrie und Region*, Hamburg: Peter Lang.
- Sellenthin, M. O. (2002). Commercialisation of university research from a governance perspective, *Working Paper No. 253*, Linköping: Department of Technology and Social Change, Linköping University.
- Sellenthin, M. O. & Hommen, L. (2002). How innovative is Swedish industry? A factor and cluster analysis of CIS II, *International Review of Applied Economics*, 16 (3), pp. 319-331.
- Sellenthin, M. O. & Skogh, G. (2004). Property rights in endangered species: the wolverine case, *European Journal of Law and Economics*, 18, pp. 239-247.
- Siegel, D., Waldman, D. & Link, A. (2003). Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study, *Research Policy*, 32, pp. 27-48.
- SOU 1996:70. *Samverkan mellan högskolan och näringslivet. Huvudbetänkande av NYFOR*, Stockholm: Fritzes.
- SOU 2005:95. *Nyttiggörande av högskoleuppfindingar. Utredningen om rätten till resultaten av högskoleforskningen*, Stockholm: Fritzes.
- Stankiewicz, R. (1986). *Academics and Entrepreneurs. Developing University-Industry Relations*, London: Pinter.
- Statistisches Bundesamt (2003). Fachserie 11, R 4.4, Wiesbaden.
- Thursby, J.G., Jensen, R., Thursby, M. C. (2001). Objectives, characteristics and outcomes of university licensing: a survey of major U.S. universities, *Journal of Technology Transfer*, 26, pp. 59-72.

- Tirole, J. (1994). The internal organisation of government, *Oxford Economic Papers*, 46, pp. 1–29.
- Vademecum (2003). Stätten der Forschung, 9. Auflage 2003, CD-ROM version, Berlin: Raabe.
- VINNOVA (2003a). *VINNFORSK – VINNOVAs förslag till förbättrad kommersialisering och ökad avkastning i tillväxt på forskningsinvesteringar vid högskolor*, Stockholm: VINNOVA.
- VINNOVA (2003b). *Swedish Competence Centres Programme – Performance and Output Data*, Stockholm: VINNOVA.
- Wadensjö, E. (1994). Anställningskontraktet, in Bjuggren, P.-O. & Skogh, G. (eds.) *Företaget – en kontraktsekonomisk analys*, Stockholm: SNS.
- Westergren, A., Karlsson, S., Andersson, P., Ohlsson, O. & Hallberg, I. R. (2001). Eating difficulties, need for assisted eating, nutritional status and pressure ulcers in patients admitted for stroke rehabilitation, *Journal of Clinical Nursing*, 10, pp. 257-269
- Will, B. & Kirstein, R. (2002). Effiziente Vergütung von Arbeitnehmererfindungen. Eine ökonomische Analyse einer deutschen Gesetzesreform, *Discussion Paper 2002-12*, Saarbrücken: Center for the Study of Law and Economics, University of Saarland.
- Williamson, O. E. (1985). *The Economic Institutions of Capitalism*, New York: Free Press.
- Yin, R. K. (1994). *Case Study Research: Design and Methods*, Thousand Oaks, Calif: Sage.

7.2 Interviews

Sweden:

Stockholm:

Representative for KTH Innovation, interview, 2004-03-05.

CEO of Technology Bridging Foundation in Stockholm (Teknikbrostiftelsen),
interview, 2004-03-05.

Gothenburg:

CEO of Technology Bridging Foundation in Gothenburg (Teknikbrostiftelsen),
interview, 2004-03-01.

Vice president and responsible for technology transfer (näringslivsrelationer),
Chalmers University of Technology, Gothenburg, interview, 2004-03-02.

Project manager Chalmers Technology Licensing AB, also project manager at
Chalmers Industriteknik AB, telephone interview, 2004-03-23.

CEO of GU Holding, Gothenburg, telephone interview, 2004-03-17.

Linköping:

CEO of Mjärdevi Business Incubator AB, interview, 2003-11-21.

CEO of Linköping University Holding (Universitetsholding i Linköping AB),
interview, 2003-12-10.

CEO of Technology Bridging Foundation in Linköping (Teknikbrostiftelsen i
Linköping AB), also CEO of Iteksa AB, interview, 2004-03-10.

Lund:

CEO of University Holding in Lund (LUAB), also head of the Industrial Liaison
Office, Lund University, interview, 2004-03-04.

CEO of Technology Bridging Foundation in Lund (Teknikbrostiftelsen i Lund),
interview, 2004-03-04.

CEO of Forskarpatent i Syd AB, Lund, telephone interview, 2004-03-09.

Germany:

Aachen:

CEO of Provendis GmbH (PVA), telephone interview, 2003-09-15.

Representative for Office of Technology Transfer and Advanced Training
(Büro Technologietransfer und Wiss. Weiterbildung (BTW)) at RWTH
Aachen, interview, 2003-09-30.

Karlsruhe:

Representative for Office of Technology Transfer (Abt. Technologietransfer) at the
University of Karlsruhe, interview, 2003-09-23.

CEO of TLB GmbH (PVA), interview, 2003-09-22.

Hamburg:

Head of the PVA at TUHH Technologie GmbH (TuTech GmbH),
interview, 2003-09-16.

Berlin:

Project manager at ipal GmbH (PVA), interview, 2003-09-18.

Representative for Office of Knowledge and Technology Transfer
(Abt. Wissens- und Technologietransfer) at the Technical University of
Berlin, interview, 2003-09-18.

Researchers:

Professor at IMT/NIMED, Linköping University, interview, 2002-06-13.

Professor at ISY, Linköping University, interview, 2002-06-12.

Professor and Head of Institute ika (Institut für Kraftfahrwesen), RWTH Aachen,
telephone interview, 2004-03-09.

Professor in electrical engineering at a German university who wanted to stay
anonymous.

8. Appendix

8.1 *Interview guide*

This is the translation of the interview guide. The questions were originally posed in German and Swedish to avoid interpretation mistakes.

List of questions 1: The role of the organisation

- Which role does your organisation play in technology transfer in general and in particular in relation to patenting and commercialisation of research results from university?
- Which other actors do exist? Do the different actors compete or collaborate?
- Please explain the process of patenting and commercial exploitation from your perspective. Distinguish between patenting & commercialisation!
- Does a good infrastructure for commercialisation increase the incentives of the researchers to patent and commercially exploit research results? How does effective infrastructure look like?
- How is your organisation funded?

List of questions 2: The role of the IPR regime

- Which role does the IPR regime play?
- Does the university teacher privilege (in Sweden) / the abolishment of the university teacher privilege (in Germany) create incentives to patent and commercialise university research?

- Only in S: Do you think the university teacher privilege should be abolished?
- Only in S: What should replace the university teachers' privilege?
 - o Why would that be better?
- Only in S: How does the UTP create incentives to patent and commercialise?
- What happens with IPRs in case of externally funded research projects? Distinguish between different sources of external funding (private vs. public financiers).
- What happens with IPRs in case of industry funding?

List of questions 3: Costs and benefits of patenting and commercial exploitation

- How committed are the researchers during patenting and commercial exploitation?
- Does the full ownership (in Sweden) / the part ownership (in Germany) of the research results provide incentives to patent and commercially exploit research results?
- Do the patent costs hinder from applying for a patent?
- Who bears the costs?
- How do you assess the inventions? How are possible revenues calculated?
- How large is the share of patents in your portfolio that generates revenues?
- How are licencees identified?
- Is the industry interested in single patents from universities?

List of questions 4: publication vs. patent

- Which role does commercial success play for the career of researchers?
- What is the status of a patent for the career of the researcher?

List of questions 5: External funding

- Why is industry funding research at universities?
- Is it better to found a new enterprise for commercial exploitation or to sell a licence to an existing enterprise?
- Is there a risk that a firm acquires a licence to avoid competition from other firms? That means the firm acquires a licence to avoid commercial exploitation by other enterprises.

List of questions 6: Academic start-ups and spin-offs

- How is patenting and commercial exploitation financed? Distinguish between patenting and commercial exploitation.
- Is there access to seed capital? Private or public?
- Is there access to risk capital?
- How many spin-offs and start-ups did you have in the last years?
- Who founds new enterprises? (Professors/students/PhD students, entrepreneurs etc.)
- How and under which conditions does the university promote start-ups or spin-offs?
- Who else is promoting start-ups and spin-offs?

Supplementary questions:

- How could the process of patenting and commercial exploitation of research results be improved?
- What works particularly well or bad?

Important quantitative indicators:

- How many patent applications? By whom?
- How many invention disclosures?
- How many employees in your organisation are working with patenting and commercial exploitation?
- How many patents generate revenue?
- How large is your budget in your organisation for patenting and commercial exploitation?
- How are the revenues/profits from licenses shared?

8.2 *The questionnaire*

Remarks to the questionnaire:

The questionnaire was distributed via Internet. Since the screenshots of the original questionnaire would have taken too much space (over 50 pages), the questionnaire below shows only the questions in text format.

Parts of the questionnaire were posed to different groups of respondents. The key question is 46, where the respondents are asked about their patenting experiences (2002 – 2004). Depending on how they answer this question, they have to answer different questions. In the questionnaire below this is indicated by e.g., If 46=1: which means that the question has to be answered only if question 46 was answered with answering alternative 1. Of course, the respondents did not see those “jump-

ing” orders. ALL means that all respondents were asked the question. S only and D only means that the question was posed to Swedish respondents and German respondents only.

All:

1 Which year are you born?

All:

2 How long have you been doing research inside academia?

All:

3 Are you a professor?

0 No

1 Yes

If 3=1:

4 How many years have you been a professor?

All:

5 Are you responsible for a research group? (This can even include a working group, an institute or a chair)

0 No

1 Yes

If 5=1:

6 How many people are working in your research group? (Research staff incl. PhD students in fulltime equivalents.)

If 5=1

How is your research group (working group, institute) funded? (in percent)

7 Base funding

8 Research council (DFG/Vetenskapsrådet)

9 Research foundations and other public sources

9a European Union (EU)

10 Industry

11 other sources (please indicate those sources)

12 Abstain

13 I don't know

If 5=1 and

If answer to 10 Industry > 10%:

14 Industry is an important financier of your research. What is the relation between funding and ownership in the research results?

0 Firms that finance my research do not claim patent rights in the research results.

1 Firms that finance my research do claim patent rights in the research results.

2 Firms that finance my research reserve the right to claim patent rights in the research results (e.g., they claim the option to apply for a patent).

3 In case of a patentable invention this is negotiable.

4 Alternative: (please indicate)

If 5=1:

How has the funding of your research group (institute etc.) changed in the last three years (2002-2004)?

(Likert scale:) 1 decreased heavily 7 increased heavily

15 Base funding

16 Research council

- 17 Research foundations
- 17a European Union (EU)
- 18 Industry
- 19 other sources
- 20 Abstain
- 21 I don't know

All:

22 Do you have patents (only granted patents)?

- 1 yes
- 0 no
- 8 Abstain

If 22=1

23 How many granted patents do you have?

All:

24 I am carrying out primarily:

- 4 Applied research
- 1 Basic research
- 3 Equally applied research and basic research
- 2 It is impossible to distinguish sharply between basic and applied research in my research field
- 0 I do not carry out research currently

All:

25 Did you had consulting assignments between 2002 and 2004?

- 0 No
- 1 Yes

All:

Please comment the following statements:

(External funding includes all funding that is not base funding. It includes funding from research councils, research foundations, and industry where you can apply for research funding).

(Likert scale:) 1 Disagree totally 7 Agree totally Abstain I don't know

26 Publications are important for a career inside academia.

27 Publications have an impact on my salary in the long run.

28 Patents are important for a career inside academia.

29 Patents are important to attract external funding.

30 Patents have an impact on my salary in the long run.

31 External funding is important for a career inside academia.

32 External funding has an impact on my salary in the long run.

All:

What is your attitude towards commercialisation of research results?

(Likert scale:) 1 Disagree totally 7 Agree totally Abstain I don't know

33 Collaboration between university and industry is important.

34 Free research is endangered since too much weight is put on collaboration with external actors.

35 The information about how a researcher should behave in contacts with industry should be improved.

36 The other duties at work should be reduced in favour for collaboration with industry.

37 I think it is negative if more research is financed by private actors.

38 An abolishment of the university teachers' privilege (the right that gives ownership in research results to the researcher) would decrease (in S) / decreases (in D) the chances to commercialise research results.

39 The collaboration with firms is not profitable enough for researchers.

43 I prefer to surrender patent rights to firms (eventually in return for research funding).

All:

46 Have you (or somebody else) applied for a patent for your research results between 2002 and 2004?

1 Yes, I have applied for one or more patents for my research results between 2002 and 2004.

2 Yes, somebody else has applied for one or more patents for my research results between 2002 and 2004.

3 No, I have not applied for a patent but I have the intention to apply for a patent.

4 No, I have not applied for a patent but somebody else has the intention to apply for a patent for my research results.

5 No, neither me nor somebody else have applied for a patent. But my research results have commercial potential.

6 No, my research results cannot be patented.

If 46=2:

47 Who has applied for a patent for your research results? (If somebody else has applied for more than one patent please answer with regard to the most successful patent).

1 Technology transfer office of the university or another administrative unit inside the university (not the university holding company).

2 Technology bridging foundation (in S only) / Patent and exploitation agency (in D only).

3 University holding company / independent technology transfer company (not the PVA in D only).

4 A firm.

5 other: (please indicate)

If 46=2:

48 Why did you not apply for a patent on your own?

1 I do not own the patent rights for my research results.

2 I lack knowledge about patenting.

3 I think the patenting process is too time-consuming.

4 I think it is too risky to apply for a patent.

5 I think it is too costly to apply for a patent.

6 Other reason: (please indicate).

If 46=1 OR 2:

Please provide reasons why you (or somebody else) applied for a patent:

(Likert scale:) 1 Disagree totally 7 Agree totally Abstain I don't know

49 To allow for commercial exploitation of my research results later on.

50 To hinder others from commercially exploiting my research results.

51 To get additional personal income, e.g., through sales of licenses.

52 To attract research funding.

53 I was obliged to notify the university about my invention.

54 I thin it is exciting to take risks.

If 46=1 OR 2:

99 Has the patent resulted in income? (This refers to the patent that you or somebody else applied for between 2002 and 2004. In case of more patents answer with respect to the most successful patent. Income refers to any gross income resulting from the patent. This can be royalties from licensing, single payments, recurring payments, bonuses from firms and alike.)

0 No, the patent did not result in any income.

1 Yes.

8 Abstain

9 I don't know.

If 46=1 or 2:

If 99=0:

56 You have not received income from the patent. Do you expect any income?

0 No

1 Yes.

If 46=1 or 2:

If 56=1:

57 How large are your expectations with respect to income from the patent?

(Likert scale:): 1 very small 7 very large

If 46=1 or 2:

If 99=1:

55 The patent resulted in income. Who benefited from it? (This refers to the patent that you or somebody else applied for between 2002 and 2004. In case of more patents answer with respect to the most successful patent. Income refers to any gross income resulting from the patent. This can be royalties from licensing, single payments, recurring payments, bonuses from firms and alike.)

- 1 The patent resulted in personal income.
- 2 The patent resulted in income to my research group or alike.
- 3 The patent resulted in income to a spin-off company.
- 4 The patent resulted in income to a financier.
- 5 The patent resulted in income to the university.
- 6 The patent resulted in income to somebody else who is not mentioned above.

If 46=1 or 2:

If 99=1:

58 How large is or was your income from the patent that you applied for between 2002 and 2004? (This refers to the patent that you or somebody else applied for between 2002 and 2004. In case of more patents answer with respect to the most successful patent. Income refers to any gross income resulting from the patent. This can be royalties from licensing, single payments, recurring payments, bonuses from firms and alike. In case of recurring payments please provide the sum of income.)

- 1 Less than 150,000 SEK / 15,000 €
- 2 Between 150,001 SEK and 30,000 SEK / 15,001 € and 30,000 €
- 3 Between 300,001 SEK and 450,000 SEK / 30,001 € and 45,000 €

4. More than 450,001 SEK / 45,001 €

8 Abstain.

9 I don't know.

If 46=1 or 2:

59 Has the idea or technical solution that is described in the patent been published in a scientific journal?

0 No.

1 Yes, with less than one months delay.

2 Yes, with less than six months delay.

3 Yes, with more than six months delay.

If 46= 1 or 2:

60 Which actors provided you with support?

1 Technology transfer office of the university or administrative unit inside the university (not the university holding company in S only).

2 University holding company (in S only) / Independent technology transfer office (not the PVA in D only).

3 Technology bridging foundation (in S only) / Patent and exploitation agency (in D only).

4 Science parks.

5 ALMI / NUTEK (in S only) / Fraunhofer Patent Centre for German Research (in D only).

7 Technology transfer office of the local authorities.

10 Länsstyrelsen (in S only) / Support by the federal state (Bundesland in D only).

11 Business incubator.

13 I did not get any support.

12 I got support from other actors: (please indicate).

If 46=1 or 2:

If 60=1:

61 Which kind of support did you get from the technology transfer office or another administrative unit of the university? (not the university holding company in S).

- 1 I got support working with the patent application.
- 2 I got support working with licensing.
- 3 I got support working with market analysis/business plans.
- 4 I got financial support.
- 5 I got support working with competence development regarding management knowledge.
- 6 I got support working with marketing.
- 7 I got administrative support (e.g., rooms).
- 10 I got support working with brokerage.
- 11 I got other kind of support: (please indicate).

If 46=1 or 2:

If 60=1:

62 Are you satisfied with the support that you received from the technology transfer office or another administrative unit of the university? (not the university holding company in S).

(Likert scale:) 1 not satisfied at all 7 absolutely satisfied

If 46=1 or 2:

If 60=2:

63 Which kind of support did you get from the university holding company (in S) /an independent technology transfer office (not the PVA in D)?

- 1 I got support working with the patent application.
- 2 I got support working with licensing.
- 3 I got support working with market analysis/business plans.
- 4 I got financial support.

5 I got support working with competence development regarding management knowledge.

6 I got support working with marketing.

7 I got administrative support (e.g., rooms).

10 I got support working with brokerage.

11 I got other kind of support: (please indicate).

If 46=1 or 2:

If 60=2:

64 Are you satisfied with the support that you received from the university holding company (in S) / an independent technology transfer office (not the PVA in D)?

(Likert scale:) 1 not satisfied at all

7 absolutely satisfied

If 46=1 or 2:

If 60=3:

65 Which kind of support did you get from the technology bridging foundation (in S) / the patent and exploitation agency (in D)?

1 I got support working with the patent application.

2 I got support working with licensing.

3 I got support working with market analysis/business plans.

4 I got financial support.

5 I got support working with competence development regarding management knowledge.

6 I got support working with marketing.

7 I got administrative support (e.g., rooms).

10 I got support working with brokerage.

11 I got other kind of support: (please indicate).

If 46=1 or 2:

If 60=3:

66 Are you satisfied with the support that you received from the technology bridging foundation (in S only) / the patent and exploitation agency (in D only)?

(Likert scale:) 1 not satisfied at all 7 absolutely satisfied

If 46=3:

67 In what way do you want to commercialise your research results?

- 1 I would like the invention to be sold to an existing company.
- 2 I would like the invention to be developed further inside a company that I am controlling on my own.
- 3 I would like the invention to be developed further inside a company that somebody else controls.
- 4 Alternative: (please indicate)

If 46=3:

68 In which areas will you need support?

- 1 I will need support working with the patent application.
- 2 I will need support working with licensing.
- 3 I will need support working with market analysis/business plans.
- 4 I will need financial support.
- 5 I will need support working with competence development regarding management knowledge.
- 6 I will need support working with marketing.
- 7 I will need administrative support (e.g., rooms).
- 10 I will need support working with brokerage.
- 11 Other kind of support: (please indicate)

If 46=3:

69 Do you know who you can contact to get support?

0 No.

1 Yes.

If 46=3:

70 Do you know the kind of support that the university (including the university holding company in S) offers?

1 Yes and I am interested in getting support from them.

2 Yes but the kind of support that they offer does not seem interesting to me.

3 No, I do not know what kind of support they can offer.

If 46=3:

71 Do you know the kind of support that the technology bridging foundation (in S) / patent and exploitation agency (in D) offers?

1 Yes and I am interested in getting support from them.

2 Yes but the kind of support that they offer does not seem interesting to me.

3 No, I do not know what kind of support they can offer.

If 46=3:

72 How large are your expectations with respect to income from the patent?

(Likert scale:) 1 very small 7 very large

If 46=3:

Why do you apply for a patent

(Likert scale:) 1 Disagree totally 7 Agree totally Abstain I don't know

73 To allow for commercial exploitation of my research results later on.

74 To hinder others from commercially exploiting my research results.

75 To get additional personal income, e.g., through sales of licenses.

76 To attract research funding.

77 I was obliged to notify the university about my invention.

78 I think it is exciting to take risks.

If 46 = 4:

79 Who will apply for a patent for your research results?

1 Technology transfer office of the university or another administrative unit inside the university (not the university holding company in S only).

2 Technology bridging foundation (in S) / Patent and exploitation agency (in D only).

3 University holding company / independent technology transfer company (not the PVA in D only).

4 A firm.

5 other: (please indicate)

If 46=4:

80 Why will you not apply for a patent on your own?

1 I do not own the patent rights for my research results.

2 I lack knowledge about patenting.

3 I think the patenting process is too time-consuming.

4 I think it is too risky to apply for a patent.

5 I think it is too costly to apply for a patent.

6 Other reason: (please indicate).

If 46=4:

Please provide reasons why somebody else will apply for a patent

(Likert scale:) 1 Disagree totally 7 Agree totally Abstain I don't know

81 To allow for commercial exploitation of my research results later on.

82 To hinder others from commercially exploiting my research results.

83 To get additional personal income, e.g., through sales of licenses.

84 To attract research funding.

85 I was obliged to notify the university about my invention.

86 I do not like to take risks

If 46=4:

87 How large are your expectations with respect to income from the patent?

(Likert scale:) 1 very small 7 very large

If 46=5 or 6:

88 Why did you not apply for a patent for your research results?

1 I do not own the patent rights for my research results.

2 I lack knowledge about patenting.

3 I think the patenting process is too time-consuming.

4 I think it is too risky to apply for a patent.

5 I think it is too costly to apply for a patent.

7 I do not want my research results to be used in that way.

8 The degree of inventive ingenuity is not high enough. Further development is needed until a patent can be applied for.

9 My research results cannot be patented (e.g., algorithms).

10 Because of the attitude towards patenting and commercialisation

in my institution.

6 Other reason: (please indicate).

All:

How important are the following mechanisms for contacts with industry and your institution?

(Likert scale:) 1 not important 7 very important Abstain I don't know

93 Personnel mobility (employees are getting employed in industry).

94 Competence development (e.g., courses for firms).

95 Speeches and lectures for firms, organisations or associations.

96 Diploma thesis/master thesis/doctoral thesis in collaboration with firms.

97 Contacts from previous occupations in industry.

98 Establishment of firms by employees.

99a Research collaboration and cooperation with firms.

100 Commissioned research for firms.

101 Joint patent applications with firms.

102 Publication of research results in scientific journals.

103 Publication of research results in popular scientific journals, magazines or newspapers.

104 Other mechanisms: (please indicate).

All:

105 What is your personal experience from collaboration with firms?

0 No experience.

1 Research collaboration and cooperation.

2 Commissioned research/problem solving for a company.

3 Lectures or training for a company.

4 Joint patent application.

5 More general activities to get in contact.

6 Alternative: (please indicate).

All:

106 Who owns the patent rights in your research results?

- 1 Myself.
- 2 The university.
- 3 A financier of my research.
- 4 A company.
- 9 I don't know.
- 8 Abstain.
- 5 Alternative: (please indicate).

If 46=4-6:

89 Do you know the kind of support that the university (including the university holding company in S) offers with respect to patenting and commercialisation of research results?

- 1 Yes and I am interested in getting support from them.
- 2 Yes but the kind of support that they offer does not seem interesting to me.
- 3 No, I do not know what kind of support they can offer.

If 46=4-6:

90 Do you know the kind of support that the technology bridging foundation (in S) / patent and exploitation agency (in D) offers with respect to patenting and commercialisation of research results?

- 1 Yes and I am interested in getting support from them.
- 2 Yes but the kind of support that they offer does not seem interesting to me.
- 3 No, I do not know what kind of support they can offer.

All:

107 I am...

1 female.

0 male.

All:

92 Do you have further comments? (please indicate)

All:

91 Would you like to receive a copy of the research report from this survey?

0 No.

1 Yes.

8.3 *Statistical appendix*

8.3.1 Estimation of sampling error

Germany	Size	Base funding	Industry funding	Patent
Survey mean	10.39	40.77	11.87	0.277
Mean 1	10.74	43.71	11.01	0.289
Mean 2	11.90	38.91	9.94	0.298
Mean 3	9.64	49.74	9.83	0.200
Mean 4	9.10	37.82	14.29	0.293
Mean 5	8.63	48.00	13.90	0.289
Mean 6	12.23	39.48	10.43	0.352
Mean 7	9.63	32.60	10.24	0.289
Mean 8	11.66	33.71	15.32	0.209
Range	3.60	17.14	5.49	0.152
Variance	1.66	33.97	4.40	0.002
Standard error	0.49	2.20	0.79	0.018
Standard error SRS	0.65	1.22	1.00	0.023
Relation S.E/SRS	0.75	1.80	0.80	0.780
Sweden	Size	Base funding	Industry funding	Patent
Survey mean	9.46	33.26	10.52	0.238
Mean 1	13.23	29.98	11.20	0.302
Mean 2	8.86	37.33	8.69	0.083
Mean 3	7.79	30.61	8.64	0.263
Mean 4	6.63	36.51	9.20	0.196
Mean 5	10.09	36.59	6.89	0.232
Mean 6	9.94	35.40	11.00	0.240

Mean 7	9.11	28.46	18.31	0.302
Mean 8	9.91	30.16	10.56	0.283
Range	6.61	8.87	11.42	0.219
Variance	3.29	11.67	10.40	0.005
Standard error	0.69	1.29	1.22	0.026
Standard error SRS	0.65	1.22	1.00	0.021
Relation S.E./SRS	1.05	1.06	1.22	1.206

*Table 8-1: Estimation of standard errors from replicates for selected variables.
Source: own calculations.*

8.3.2 Logistic regression model

To illustrate the statistical approach, one of the regression models is presented in more detail (Model 15 from Table 5-13).

Case Processing Summary

		N	Marginal Percentage
Var46:1&2	,00	408	70,7%
	1,00	169	29,3%
Previous patents	,00	373	64,6%
	1,00	204	35,4%
Support	,00	390	67,6%
	1,00	187	32,4%
Firm-IPR	,00	448	77,6%
	1,00	129	22,4%
Joint-patent	,00	460	79,7%
	1,00	117	20,3%
Basic research	,00	371	64,3%
	1,00	206	35,7%
Valid		577	100,0%
Missing		224	
Total		801	

Table 8-2: Case processing summary.

Source: own survey.

Model Fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	678,782			
Final	404,051	274,731	7	,000

Table 8-3: Model fitting information.

Source: own survey.

Pseudo R-Square

Cox and Snell	,379
Nagelkerke	,540
McFadden	,394

Table 8-4: Pseudo R-square.

Source: own survey.

Likelihood Ratio Tests

Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	404,051(a)	,000	0	.
Size	408,417	4,366	1	,037
Industry-funding	406,323	2,272	1	,132
Previous patents	473,399	69,348	1	,000
Support	418,314	14,263	1	,000
Firm-IPR	409,980	5,929	1	,015
Joint-patent	414,447	10,396	1	,001
Basic re-search	405,335	1,285	1	,257

The chi-square statistic is the difference in -2 log-likelihoods between the final model and a reduced model. The reduced model is formed by omitting an effect from the final model. The null hypothesis is that all parameters of that effect are 0.

a This reduced model is equivalent to the final model because omitting the effect does not increase the degrees of freedom.

Table 8-5: Likelihood ratio tests.

Source: own survey.

Parameter Estimates

Var46: 1&2(a)		B	Std. Error	Wald	df	Sig.	Exp(B)
	Intercept	-1,618	,405	15,980	1	,000	
	Size	-,021	,010	3,902	1	,048	,980
	Industry fund- ing	-,010	,007	2,314	1	,128	,990
	Previous pat- ents	2,292	,283	65,598	1	,000	9,897
	Support	,970	,259	14,039	1	,000	2,638
	Firm-IPR	,740	,301	6,030	1	,014	2,095
	Joint-patent	,999	,310	10,358	1	,001	2,715
	Basic research	-,320	,282	1,281	1	,258	,727

Table 8-6: Parameter estimates.

Source: own survey.

Classification

Observed	Predicted		
	,00	1,00	Percent Correct
,00	362	46	88,7%
1,00	42	127	75,1%
Overall Percentage	70,0%	30,0%	84,7%

Table 8-7: Classification.

Source: own survey.

8.3.3 Chi-square analysis

		Patent	Support	Applied	Basic	Joint patent	Re-searcher-IPR
Patent	Pearson Chi-Square		40,888	20,277	16,315	191,207	52,837
	Sig.		0,000	0,000	0,000	0,000	0,000
	N		727	801	801	785	757
Support	Pearson Chi-Square	40,888		0,984	1,304	6,303	3,784
	Sig.	0,000		0,321	0,254	0,012	0,052
	N	727		727	727	723	696
Applied	Pearson Chi-Square	20,277	0,984		718,303	14,374	3,763
	Sig.	0,000	0,321		0,000	0,000	0,052
	N	801	727		801	785	757
Basic	Pearson Chi-Square	16,315	1,304	718,303		12,298	2,745
	Sig.	0,000	0,254	0,000		0,000	0,098
	N	801	727	801		785	757
Joint patent	Pearson Chi-Square	191,207	6,303	14,374	12,298		29,836
	Sig.	0,000	0,012	0,000	0,000		0,000
	N	785	723	785	785		756
Researcher-IPR	Pearson Chi-Square	52,837	3,784	3,763	2,745	29,836	
	Sig.	0,000	0,052	0,052	0,098	0,000	
	N	757	696	757	757	756	

Uni-IPR	Pearson Chi-Square	20,817	32,471	2,276	1,817	0,110	7,406
	Sig.	0,000	0,000	0,131	0,178	0,740	0,007
	N	757	696	757	757	756	757
Firm-IPR	Pearson Chi-Square	131,813	3,688	20,402	17,695	193,789	2,998
	Sig.	0,000	0,055	0,000	0,000	0,000	0,083
	N	757	696	757	757	756	757
Country	Pearson Chi-Square	1,632	24,172	0,221	0,037	0,054	63,696
	Sig.	0,201	0,000	0,638	0,847	0,816	0,000
	N	801	727	801	801	785	757
Natural sciences	Pearson Chi-Square	2,498	0,051	36,054	31,743	4,932	4,196
	Sig.	0,114	0,822	0,000	0,000	0,026	0,041
	N	801	727	801	801	785	757
Technical sciences	Pearson Chi-Square	0,171	0,009	40,283	38,076	1,538	0,057
	Sig.	0,679	0,923	0,000	0,000	0,215	0,811
	N	801	727	801	801	785	757
Medical sciences	Pearson Chi-Square	4,093	0,108	0,515	0,814	0,835	3,260
	Sig.	0,043	0,742	0,473	0,367	0,361	0,071
	N	801	727	801	801	785	757
Previous patents (22)	P.Ch-Square	304,301	33,924	27,653	25,938	272,353	71,451
	Sig.	0,000	0,000	0,000	0,000	0,000	0,000
	N	784	715	784	784	768	741

		Uni-IPR	Firm-IPR	Country	Natural	Technical	Medical	Previous patents (22)
Patent	Pearson Chi-Square	20,817	131,813	1,632	2,498	0,171	4,093	304,301
	Sig.	0,000	0,000	0,201	0,114	0,679	0,043	0,000
	N	757	757	801	801	801	801	784
Support	Pearson Chi-Square	32,471	3,688	24,172	0,051	0,009	0,108	33,924
	Sig.	0,000	0,055	0,000	0,822	0,923	0,742	0,000
	N	696	696	727	727	727	727	715
Applied	Pearson Chi-Square	2,276	20,402	0,221	36,054	40,283	0,515	27,653
	Sig.	0,131	0,000	0,638	0,000	0,000	0,473	0,000
	N	757	757	801	801	801	801	784
Basic	Pearson Chi-Square	1,817	17,695	0,037	31,743	38,076	0,814	25,938
	Sig.	0,178	0,000	0,847	0,000	0,000	0,367	0,000
	N	757	757	801	801	801	801	784
Joint patent	Pearson Chi-Square	0,110	193,789	0,054	4,932	1,538	0,835	272,353
	Sig.	0,740	0,000	0,816	0,026	0,215	0,361	0,000
	N	756	756	785	785	785	785	768
Re-searcher-IPR	Pearson Chi-Square	7,406	2,998	63,696	4,196	0,057	3,260	71,451
	Sig.	0,007	0,083	0,000	0,041	0,811	0,071	0,000
	N	757	757	757	757	757	757	741
Uni-IPR	Pearson Chi-Square		0,869	68,874	0,000	0,001	0,002	12,278
	Sig.		0,351	0,000	0,989	0,980	0,967	0,000
	N		757	757	757	757	757	741

Firm-IPR	Pearson Chi-Square	0,869		1,015	3,970	8,065	1,047	187,907
	Sig.	0,351		0,314	0,046	0,005	0,306	0,000
	N	757		757	757	757	757	741
Country	Pearson Chi-Square	68,874	1,015		1,016	0,095	0,465	6,803
	Sig.	0,000	0,314		0,314	0,757	0,495	0,009
	N	757	757		801	801	801	784
Natural sciences	Pearson Chi-Square	0,000	3,970	1,016		226,385	153,708	7,509
	Sig.	0,989	0,046	0,314		0,000	0,000	0,006
	N	757	757	801		801	801	784
Technical sciences	Pearson Chi-Square	0,001	8,065	0,095	226,385		223,733	3,139
	Sig.	0,980	0,005	0,757	0,000		0,000	0,076
	N	757	757	801	801		801	784
Medical sciences	Pearson Chi-Square	0,002	1,047	0,465	153,708	223,733		0,774
	Sig.	0,967	0,306	0,495	0,000	0,000		0,379
	N	757	757	801	801	801		784
Previous patents (22)	Pearson Chi-Square	12,278	187,907	6,803	7,509	3,139	0,774	
	Sig.	0,000	0,000	0,009	0,006	0,076	0,379	
	N	741	741	784	784	784	784	

Table 8-8: Chi-square analysis.

Source: own survey.