Identification of University Inventors and University Patenting Patterns at Lund University:Conceptual- Methodological & Empirical Findings

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Conceptual- Methodological & Empirical Findings

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Abstract

As discussed in the Introduction and Theoretical Sections, one of the most interesting indicators to show the change in the socio-economic role of universities in the last several decades has been the use of university patenting. However except some individual studies in European countries (e.g. Finland, Norway, Belgium, Italy, Germany and France) there has been no such a comprehensive data available for Sweden and most other European countries. The main motivation of this paper is therefore to obtain a systematic database on university patenting activities in Sweden. The main method of this research is data-matching between the EPO-patents and Lund University Faculty registers, and manual controls. The methodology of this research underlines the importance of searching for university-patents by the name of university inventors rather their affiliated university. The rate of patenting activity showed a positive trend between the years 1990 and 2004. 458 patents have been filed by Lund University researchers. The total number of inventors is 250. Although the number of large firms is lesser than the SMEs, the former group (e.g. Ericsson, Astra-Zeneca) has applied for a larger number of patents than the total number of patents of SMEs.

Introduction

The two important arguments put forward in the Introduction and Theoretical Sections are the *i) lack of micro-level research on university inventors and ii) lack-of comparable university patent data between the USA and European countries and thus the so-called European –academic-Paradox.* Based on these arguments two main questions needed to be answered: who are patenting at universities and what is the extent of patenting at universities. This Paper aims to address the second argument, European –academic-Paradox, by exploring the extent of patenting at Lund University. Yet it provides the main background information for the subsequent Papers on the micro-level analysis.

The first objective is to map the patenting patterns and the extent of inventors at LU. It constructs a database by exploring the university research results in the forms of patents at a Swedish University where University Teachers' Privilege (individual ownership of patents) is a common practice.[2] In order to be very specific and sufficiently detailed for a meaningful analysis, Lund University including the Faculties of Engineering (**LTH**), Natural Science (**NS**) and Medical (**Medfak**) are chosen.

Second objective is to create a database –a subset of university researchers- to use as the main empirical basis. This data makes the investigation of the first argument –lack of micro level research on university-inventors- possible. It provides the basic information and profiles of university inventors. Without such data the survey and interviews would not have been possible. *(Research questions 1&2). Therefore the reader would find analysis and implications of these questions in the subsequent papers.*

Returning back to the European- academic-Paradox, this Paper utilizes the empirical findings in a way to explore 3- unpretentious statements: i) whether there is really a low rate of patenting or university research results have not been patented at all, ii) whether university research results were utilized outside of Sweden and thus we do not see any new products, jobs etc. iii) whether university research results are absorbed by the existing companies (incumbents) and thus we do not see the formation of new companies and new jobs. *(Research questions, 1.1 and 3and sub questions)*

Within the scope of this Paper the first set of research questions that are formulated in the Introduction (1.2) of the PhD thesis are answered. While the first two main questions and sub-questions provide the background data for the subsequent papers, question three and sub-questions are used for examining the assumptions related to European-academic Paradox.

1. **What are the basic characteristics of patenting activity at LU?**
   - 1.1. What is the distribution of the patents at LU yearly and over selected periods?
   - 1.2. What is the distribution of patents among different faculties?
   - 1.3. Are differences among the departments/divisions within the same faculty?
2. **What are the basic characteristics of inventors of LU-patents?**
   - 2.1. What is the distribution of patenting among inventors based on i) academic ranks, ii) employment, iii) gender, iv) age
   - 2.2. What are the characteristics of co-inventing per patent?
   - 2.3. Is there any concentration of patenting activity on some inventors (*skewed distribution*) in patenting activities?
3. **What are the basic characteristics of applicants of LU-patents?**

[2] In Sweden, the law of University Teacher's Privilege (UTP, Lärarundantaget) exists since 1949. This law implies that university employees own one hundred percent of his/her research results conducted at the university where s/he is employed. Therefore in Sweden while non-university public organizations retain the ownership of intellectual property, in the case of colleges and universities employees have the right of ownership in the absence of another contract. (*Goktepe, 2004:37-38*)

3.1. What is the main scientific & technological classification of LU-patents?
3.2. Who are the main applicants of patents (e.g. Inventors, Firms, and TTOs)?
3.3. What types of industrial firms are the applicants of the patents?
3.4. What is the sectoral distribution of the applicant firms?
3.5. What is the locational distribution of applicant firms?
3.6. What are the key applicants of LU-patents?
3.7. What are the countries of applicant firms?

Findings are remarkably high and interesting for any group of people, let alone university scientists without any strong technology transfer help. Thus the extent to which university research is being commercialized and entering to market is significantly greater than what was expected from Swedish Universities. Scientist entrepreneur (or inventor) proved to be the invisible heroes of university industry relations.

This Paper is organized as follows. After this brief Introduction to the subject matter and research questions, Section 1 reminds the reader the use of patents in innovation studies. It discusses relations between knowledge, inventions, innovations and patents. Section 2 describes the data collection method thoroughly and construction of the Lund University Patent Database (LUP database hereafter). Section 3 presents the empirical findings. The empirical analyzes were organized according to the aforementioned research questions. First it describes the basic characteristics of patenting patterns at LU. Following to that it discusses the actors of patenting: inventors and applicants of patents. The Final Section summarizes the main findings, reflects on the European-academic-Paradox, and sketches the future work in terms of further methodological, empirical and theoretical questions.[3]

1. General Background

While innovation was long seen as a 'linear' process in which 'basic' knowledge from academia automatically flows to the business sector in order to be applied in innovation, the emergence of the concept of 'innovation systems' (e.g., Freeman, 1986, Lundvall, 1992, Nelson, 1993, Edquist, 1997) has put more emphasis on the circumstances in which knowledge can actually flow between researchers from the public and private sector. In the innovation systems perspective, interaction is important because the development of technology and innovation is a learning process, in which technology transfer is greatly facilitated by direct contact between researchers.

Interaction between researchers working in private firms and those working in publicly financed institutes such as universities is seen as particularly important because it may provide unique competitive advantages (e.g., associated with specific competencies of high-quality universities). The European Commission (2003) lists this as one of the six priorities for European universities in the immediate future, and concludes that "it is vital that knowledge flows from universities into business and society.

Subsequently, the two main technology transfer mechanisms i.e. patenting, licensing, and start-up company formation have been articulated as the most popular policy tool in the last two decades. This policy tool increased the debates over the role of intellectual property rights in the process of public-private knowledge transfer.

In the U.S., there is a longstanding policy debate on the potentially beneficial impact on

[3] This Paper should not be considered as the final version, and/or a stand-alone Paper. The reader should rather read this Papers as a quantitative prelude for a better understanding of UITT in terms of methodological, empirical and theoretical dimensions within the scope of a broader project

public-private knowledge transfer of universities taking out patents on their research results (see Mowery and Sampat, 2001, for an overview starting in the 1930s). With the introduction in 1980 of the so-called Bayh-Dole act, which gave U.S. universities the right to patent discoveries resulting from federally funded research, this debate was decided in favor of those supporting active patenting by universities.

The rise in university patenting observed in the U.S., and the success stories of some university discoveries that yielded high-income streams from licensing have induced European policy makers to also consider Bayh-Dole-like legislation (OECD, 2003). This argument is made against a background of, often anecdotal, empirical evidence that European universities are not very active in patenting and far behind commercialization of university research results (*European Paradox).*

The literature for this Paper is approached from two main issues. First, what are the main arguments for using university patenting to understand university industry technology transfer? Specifically what sort of information do patents provide? Second, how do these debates (*USA model versus European Paradox*) explains the reality of the specific European context? This second issue is important because, the university patenting (ownership of patents) at e.g. Swedish Universities is *(or in many other European Universities it used to be)* different in many respects from the U.S. context.

Theoretically, the relations between knowledge, inventions, innovations and patents are illustrated. It shows "only a limited amount of knowledge can be turned into patents" is one of the most important theoretical arguments that may show the overstatement of European Paradox. Empirically, the facts on the other hand, provided through the utilization of an alternative methods to identify university patent and inventors. The higher number (or even the existence) university invented or related patents may also show that European Paradox is overstated.

The aim of the Paper is not to provide the final answer to the question whether Europe needs legislation similar to the Bayh-Dole Act. Rather the aim of this Paper is provide an overview of the basic academic literature in innovation studies that deals with university patenting, and presents the use of alternative definitions and empirical research methodologies that may better explain the European context. In this way this Paper provides the background information for further theoretical, empirical research. It is hoped that the general discussion on university patenting in Sweden will become clear.

1.1. Invention, Innovation and Patent

i. Invention & Innovation

This research mainly focuses on the university knowledge that can be patentable. A focus on university patents might seem to be a strange route to better understanding of the university industry technology transfer (Henderson et al., 1995:1). Since university patents are a small fraction of all patents (Henderson et al., 1995) and only a small fraction of university knowledge can be patentable. As a result one cannot learn about the full spectrum of university research and knowledge from patent data.

This research focuses on a sub-set of university knowledge that is patentable. Yet university patents are informative, they reflect research that the university [or academic inventor e.g. in Sweden] believes has direct commercial application (Henderson, et al., 1995). University patents are also interesting in their own right since they are a unique and highly visible method of "technology transfer" (Archibugi, 1992; Basberg, 1987; Boitani and Ciciotti, 1990; Trajtenberg, 1990). Similarly understanding the university patenting patterns over time is an important dimension to understand the relationship between university and industry (Blumenthal, 1986; Caballero and Jaffe, 1993; Dasguspta and David, 1987; David, Mowery and Steinmueller, 1992; Jaffe, Trajtenberg and

Henderson, 1993; Mansfield, 1991; Pavitt, 1991).

ii. Patents

A patent is an exclusive right granted for an invention. Patents are perhaps the most important legal instruments for protecting intellectual property rights. A patent confers to a patentee the sole right to exclude others from economically exploiting the innovation for a limited period of time (e.g. 20 years from the date of filing). In return for a government-enforced monopoly franchise on the commercial exploitation of an invention, the patentee must disclose and explain the invention, in principal with sufficient detail that a knowledgeable practitioner of the relevant technology could reproduce the invention using the patent document.

When a patent is issued, a large amount of information is publicly recorded, and most of this information is now available in computerized form. The information that is available includes the following information: *1) the name(s) /or and postal address(es) of the inventor(s); 2) the organization, (applicant) if any, to which the patent property right was assigned or transferred when the patent was issued, and its legal address; 3) a detailed technological classification of the invention; 4) the patentee's specific claims regarding what the invention can do that could not be done before; and 5) citations that indicate previously existing knowledge, embodied in prior patents or other publications, upon which the patent builds (Jaffe, 1998).*

Patents provide information on the temporal, geographical, technological and sectoral distribution of inventions. They are generally considered to be important indicators of technological activities (Archibugi 1992:358, in Schild 1999:15). The availability of data in electronic format has also increased the size of the datasets being used in the literature (Pavitt, 1998).

The large and growing literature studies the patterns of technological evolution, knowledge creation and diffusion, and firm technology strategy by using patent data. Key areas of research include: the geographic localization of knowledge flows (Almeida and Kogut, 1999; Jaffe, Trajtenberg, and Henderson 1993); knowledge diffusion across and within firm boundaries (Rosenkopf and Nerkar, 2002; Song, Almeida and Wu, 2003); technological positioning of firms (Podolny, Stuart, and Hannan, 1996); factors associated with the production of important innovations (Cockburn and Henderson, 1998; Gittelman and Kogut, 2003); the impact of the structure of knowledge on knowledge diffusion and firm strategy and (Sorenson, Rivkin and Fleming, 2002, Ziedonis, 2003) [4] and university-firm technology transfer and universities as a source of important innovations (Henderson, Jaffe, Trajtenberg, 1998; Mowery, Sampat, and Ziedonis, 2003: Meyer, 2003; Saragossi and van Pottelsberghe de la Potterie, 2003; Azagra-Caro et al. 2003; Schmoch, 2000; Gulbrandsen et al., 2005; Balconi et al., 2003; Leydesdorff, 2003).

Regarding the university industry relations, Jaffe's (1989) research relies upon the number of patented inventions registered at the U.S. patent office, which he argues is a 'proxy for new economically useful knowledge' (p.958). Jaffe's (1989) Model provides statistical evidence that corporate patent activity responds positively to commercial spillovers from university patents. However, despite its widespread use, patent data has its own drawbacks such as: the propensity to patent differs across country and industry, differences in patent regulations across countries, and changes in patent laws (difficult to analyze trends over the time), value distribution of patents is skewed, finally many inventions are not patented (Pavitt, 1998).

Although patents are good indicators of new technology creation, they do not measure the economic value of these technologies (Hall et al., 2001). More specifically, to be able to give

[4] A search in Google on "patents university industry relations" gives 18, 400,000 different hits. In Econlit database a search on "university and patents" gives 638 publications. I have not read those articles which are not related to university patenting. I just made key-word research to find which sub-themes are using patent data in the broad economics and innovation research.

a fair image of the impact of university knowledge on technological development, patent data should not to be confused with data on innovations. Patents are a rather partial indicator of technological inventive activity.[5] For instance while Jaffe's (1989) Model provides explanations to the role of university research to generate 'new economically useful knowledge', Scherer, 1983; Mansfield, 1984; and Griliches, 1990 have warned that measuring the number of patented inventions is not the equivalent of a direct measure of innovative output (Acs et al., 1992). According to Griliches (1979) and Pakes and Griliches (1980, p. 378), patents are a flawed measure of innovative output particularly since not all new innovations are patented and since patents differ greatly in their economic impact.

Similar to these arguments, Pavitt (1998) also had a skeptical view of university patents as an indicator of useful university research. Pavitt (1998) further argued that patents granted to universities give a partial and distorted picture of the contributions of university research to technical change. Patenting by universities is not a potentially useful measure of university research performance. He further argued that citations in patents to published papers provide a better picture of the academic research contribution to technical change (Pavitt, 1998).

However patent citations also have several drawbacks. The patent citations are done by patent attorney and patent examiners who do not represent knowledge spill-overs between university and industry [i.e. contribution of university publications to technological development] (see Jaffe et al., 1993; Alcacer and Gittelman; 2004, Wong, 2005).

The reasons behind this critical view on the use of patents in university industry relations could also be explained by Arrow's (1962) distinctions between general knowledge and economically relevant knowledge. Based on Arrow's distinction, Acs et al. (2003) argues that knowledge is only partly economically useful and also to some extent utilized.[6]

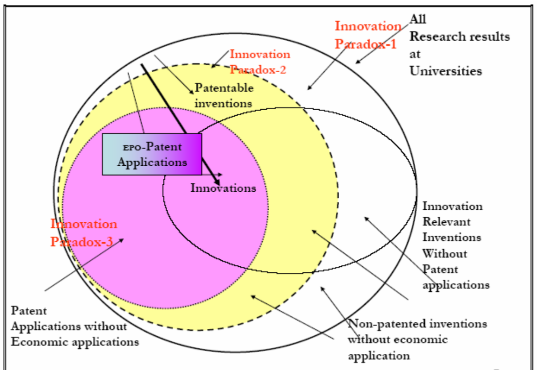
Endogenous growth model assumes that there is no barrier to the diffusion of knowledge within countries [e.g. from university to industry or among firms] to commercializing knowledge, i.e., spillovers are automatic and there is no distinction between *knowledge and commercialized knowledge* (Romer, 1990 and Grossman and Helpman, 1991).

On the other hand, not all inventions are utilized and commercialized, and lead to innovations. In the same way *Invention* refers to an idea, a sketch, or a model for a new or improved device, product, process or system. Such inventions do not necessarily have to be patented and they do not necessarily lead to technical innovations.

Fig.1.Knowledge→ Patents: Innovation Paradox

[5] Measures of technological change have typically involved one of the three major aspects of the innovative process: (1) a measure of the inputs into the innovation process, such as R&D expenditures; and R&D personnel, (2) an intermediate output, such as the number of inventions which have been patented; or (3) a direct measure of innovative output. During the 1950s and 1960s, our understanding of the economy was advanced by developing measures of research and development (R&D), an input measurement, as a proxy for innovative output. R&D suffer from measuring only the budgeted resources allocated towards trying to produce innovative activity (Acs et al. 2000:2)

[6] In essence, these models assume that knowledge – defined as codified R&D –automatically transforms into commercial activities, or what Arrow (1962) classifies as economic knowledge. However the imposition of this assumption lacks intuitive as well as empirical backing. It is one thing for technological opportunities to exist but an entirely different matter for them to be discovered, exploited and commercialized. (Acz et al. 2003).



Patents, inventions, innovations, based on Grupp, 1998 7

An *innovation* is accomplished only with the first commercial transaction involving the new product, process system or device, although the word is also after used to describe the whole process (Freeman & Soete 1997:6). Thus not all innovations are patented and some innovations are not necessarily need to be patented. The relation between inventions, innovations and patents is summarized by Grupp (1998). (A similar argument was already made by Arrow 1962.)

Similar theoretical grounds could be also found according to Narin's and his colleagues (1976) typology of research. Narin el al. (1976) classified research into four: Applied technology; engineering science-technological science; applied research and targeted basic research and basic scientific research. It is difficult to assume which of these research groups yield more patents or no patents at all. Although one can argue basic scientific research would be less likely to be patentable, or should not be patentable at all.

In the light of these arguments, we expect universities to produce general knowledge (e.g. in the forms of publications, books, conference papers, lectures and so forth), educate students and generate knowledge that can also be patentable. While the former type of knowledge will contribute and increase the public knowledge, it is difficult to measure the direct contribution of e.g. publications and students in any specific industrial innovation per se. It is certainly plausible that the pool of talented graduates, the ideas generated by faculty, and the high quality libraries and other services of universities facilitate the process of commercial innovation in their regions [e.g. Silicon Valley, Route 128 etc.], but there has been very little systematic empirical evidence for this phenomenon (Jaffe, 1989:957) due to difficulties in measurements.[7]

Keeping all these limitations in mind, within the scope of this research we cover only a sub-set of university knowledge, which is codified in the forms of patents. While patenting can be considered as the **tips of the iceberg**, other more generic mechanisms can be seen as the **deeps of this iceberg**. Therefore even though a substantial amount of technology transfer may also take place through more general mechanisms (Goktepe 2004, OECD, 2002a), it is difficult to generalize, identify and measure these mechanisms in terms of technology transfer (Audretsch et al 2005).

However in the case of most European Countries, e.g. in Sweden even the university patenting is taking place beneath the surface which needs further research to identify inventors and the extent of patenting. Thus the choice of patenting to study UITT is not at all due to practical choices i.e. availability of databases etc.

Second the focus on patenting would not undermine the importance of other mechanisms. Thus, although patent indicators reflect an important part of the overall innovation process, they should not be used in isolation. They show only one aspect of innovation, thus a consistent picture of technological change can only be achieved by combining several indicators and other qualitative works (Sirili 1992, and Grupp 1990 in OECD 1994). Therefore this research

[7] To the best of author's knowledge, a research to measure the contribution of Medical School Graduates has been carried out (a nation wide survey was sent to the medical school graduates between the years 1981-2001). However the results are not very promising in terms of measuring the direct contribution of university education on the current activities of the graduates. As most of them increased their knowledge on the job, practice and further training (Shalev and Bitterman, 2003)

utilized other methods (e.g. survey and case studies) to gather more qualitative information on the role of university inventors.

1.2. Conceptual Clarification: Definition of University-invented Patents

Patents have two main actors: Inventors and Applicants. Depending on the ownership of IPRs at universities (i.e. individual ownership or organizational ownership), university inventors can apply for patents by themselves (individually), by university technology transfer offices (hereafter TTOs) or through other actors (e.g. patent attorneys, firms, and technology transfer organizations). The inventor(s) may assign his/her rights to another party to apply for a patent. Therefore, we make a distinction between inventor and applicant of a patent as follows:

Inventor: The inventor(s) developed the idea (knowledge) represented in the patent. The inventor of a patent can be collective (co-inventorship). Inventors can be affiliated with universities, research institutes, or public & private firms.

Applicant: The patent applicant is normally the individual(s), the firm or another organization responsible for the patent costs, and who/which may assume ownership, if the patent is granted. Applicants can be different from the inventor(s) who developed the idea represented in the patent.[8]

Due to the individual ownership practices in many European Countries (e.g. Sweden, University Teacher's Privilege), there are unfortunately very little reliable historical data on patenting and licensing by universities for European Countries compared to the US and Canada (Goktepe 2004). By the same token, Geuna and Nesta (2004:7) stated that the European data on IPR available at TTO (university-owned patents such as those included in the Cesaroni and Piccaluga's database or the OECD survey) tend to be downward biased.

This is in fact due to the tendency of researchers/professors to let the ownership of the patent to be assigned to the firm that financed the research project, but to be included in the list of inventors or to apply individually as patent assignees. Therefore, in recent years, there have been a few studies that have combined data on patents (granted or applied) and university- faculty members (researchers) registers to identify university-invented patents.

There has been some works for few European Countries, Belgium (Saragossi and van Pottelsberghe de la Potterie, 2003), Finland and Flemish Region (Meyer et al., 2003), France (Azagra-Caro et al., 2003), Germany, (Schmoch, 2000) Norvay, (Iversen et al., 2005) and Italy (Balconi et al., 2003). On the other hand, Audretsch et al. (2005) investigated the inventors at NCI in the USA, despite "TTO and AUTM data". Their work underlines the need of individual level studies even in the USA, where commercialization occurs via university-TTOs. Before investigating the Lund University inventors, a very thorough study of the previous work on university-patenting was done. The main findings of the previous researches are summarized in the appendix.[9] These scholars have identified the university-owned patents and university-invented patents from as follows:

University-Owned Patent: University-owned patents are the patents in which universities or their technology transfer offices (TTOs) are listed as applicants, owners (assignees) of these patents. As an example, according to AUTM, we see a rise in the number of university-owned patents in the USA after the initiation of Organizational ownership of intellectual property at

[8] In the United States Patent & Trademark Office (hereafter USPTO), the patent applicant is called the *patent assignee.*

[9] In some cases personal communications with other researchers are done (e.g. Iversen, Breschi, Meyer, and Schild). All comments are acknowledged.

universities for federally-funded research (i.e. Bayh-Dole Act, opening of university-TTOs).

University-Invented Patent: University-invented patents are defined through the affiliation of their inventors with a university rather than university ownership of patents. University-invented patents have a member of a university faculty among the inventors whether or not the university is the patent applicant. They provide clear empirical evidence that the number of university invented patents is much higher than the number of patents owned by universities. Thus although university-owned patents do not fully show the wealth of contributions university and researchers make to technological development, university-invented patents can be used as a more stronger indicator of the role of universities (Meyer, 2003).[10]

This argument could be further used as a motivation and justification of the use of patent data for studying university industry relations. However, the main motivation of this PhD thesis is actually not to evaluate knowledge transfer (e.g. technology transfer, university industry relations, or role of university in technological development), but mainly to find who, and to what extent are patenting at universities.

Definition of Lund University Patent (LUP): Based on the definition of university-invented patents and the distinction between university-owned versus university-invented patent Lund University Patents could be defined as the patents for which at least one of the inventors is affiliated with Lund University. In order to be counted as a university person, the inventor has to be included in the official university personnel registers be employed at the time of invention (research that leads to the patent).[11]

[10] See the summary of these different studies in Table A.1.in Appendix.

[11] Adjunct professors & lecturers nominally have 20% of their employment at a university but are involved in teaching, research and supervision. In Sweden, PhD. Students have the same working conditions as any other faculty members.

2. Methods for Data Collection

The methodological part of this Paper can be divided into several steps as follows:

1. Selection of the EPO-Patent database over PRV and USPTO
    - 1.1. Use of EPO-patent applications over granted patents
    - 1.2. Retrieving Swedish Patent applications from EPO
    - 1.3. Standardization of EPO for Swedish inventors
2. Description of LU Faculty (LUF) Registers
    - 2.1. Standardization of (LUF) Registers
3. Construction of EPO-SE-Inv-LUF: Matching between EPO-SE-inv- database and LUF
    - 3.1. Name matching between EPO-SE-inv and LUF
    - 3.2. Address matching between EPO-SE-inv and LUF
    - 3.3. Further manual checking
4. Validation of Gray zone
5. Limitations
6. LUP-database

For data collection we used a *novel* quantitative methodological approach which has become a *standard* method to identify, university inventors where individual ownership is the common practice *(Trajtenberg, 2004; Meyer et al. 2003; Balconi et al. 2004; Iversen et al. 2005).* Basically the methodology is based on a procedure which matches names and addresses between two databases i.e. university personnel registers and the patent data. The two databases that were used for identifying the university inventors are: European Patent Database (EPO) and Lund University Faculty Registers (LUF).[12]

[12] On the other hand, Wallmark (1997) for Chalmers University of Technology-Sweden and Chang et al. (2001) for Taiwan conducted surveys to find out academic patent holders instead of patent searching which was considered costly and time-consuming.

1. Selection of European Patent Office (EPO) Database over PRV and USPTO

Based on an initial comparison between EPO, PRV, USPTO, we have decided to use EPO database. Since EPO-database provides the most reliable first page information of the patents (i.e. full names and addresses of inventors and applicants, while other office databases give only the city names but do not have address information for inventors *(see Appendix for a comparison of different patent offices)*. The EPO database made it possible to find patents and patent applications that have at least one Swedish inventor.

We decided to choose EPO-database over Swedish-PRV. According to the previous studies, USPTO and EPO patents can be seen as an indicator of commercially more promising inventions than national applications. For instance sometimes national offices (e.g. Italy, France and Norway) may appear to adopt a looser interpretation of the criteria for technical novelty and inventiveness than other patent offices (e.g. EPO, Germany, and USPTO). (Meyer 2004:5). Second, since we are interested in the process of patenting in-depth and decision-making processes of inventors to patent *(such as trade-off between time and resources to be spent on higher costs of international patents or giving it up; finding financial resources; commercial potential of the patent etc.)*. We thus assume inventors who have international patent applications might have experienced a little bit more complicated decision making processes due to the higher costs of e.g. EPO patent applications (approximately ~37000 Euros).[13] Due to the lower costs of applying for national patents (approximately 4000 SEK for filing and 10000 SEK for maintaining 10 years which is approximately~1400 Euros), many people would be just interested in applying for a patent neither with so much trouble nor motivation. These patents are more suitable for international comparisons.

EPO-database is chosen over USPTO for practical reasons. Since USPTO database do not include the full-addresses of inventors, it would have been almost impossible to find whether the inventor and university researcher is the same person. Moreover since most of the Swedish applicants (e.g. firms) work with the European market, they may more likely to care for protection in the European market.

1.1. Use of EPO-Patent Applications

This study counted patent applications rather than granted patents. This is the standard practice among studies using EPO database (see Balconi et al. 2004; Schild 1999; Breschi, 2004). There are two main reasons: First, a large proportion of patent applications to EPO are eventually granted (80%). Thus the distinction between patent applications high quality inventions, and granted patents are relatively insignificant (Schild 1999:38). Second there is a time-lag between the applications and granting, this would preclude an up-to-date database, if granted patents were to be used (Schild 1999:39). By the same token, Meyer et al. (2003:33) mentioned that in certain areas such as biotechnology, examination times may take five years. The use of granted patents limits the scope of the research and prevents us to identify potential inventors.

For the sake of simplicity in this Paper and PhD Thesis in general, we use the term patents instead of patent applications.

1.2. Retrieving Swedish Patent Applications from EPO

The EPO-Swedish patent is defined as a patent where at least one of the inventors has a residing address in Sweden, i.e. having SE in the address field. In the EPO- database I have made the search query as: **INCY=** "**SE**" This query gives 35,073 patents that have at least one inventor from Sweden from 1978 till February -2005. All the bibliographic information is taken and then converted into excel file.[14]

[13] The cost of obtaining a European Patent via a Euro-direct application and maintaining the patent for a 10 year term is around 32 000 Euro. The cost of a Euro-PCT patent is about 50% higher than those of a patent obtained via a Euro-direct application.

[14] The address and zip-codes are indexed by the use of specific tools provided by the original EPO software. I acknowledge the help of Olof Ejermo in converting the original database into excel as

The patents that have application dates earlier than 1990 have been later excluded on the basis of the research objectives. (The choice of time-frame is a trade-off between taking stock of patenting activity over longer period of time on the other hand, and lowering the response and relevance rate of the inventors surveyed in the next Paper.) As a result I have 22,824 patents from 1990 to 2004 that have at least one inventor with a Swedish residence regardless of the nationality of the inventor.

1.3. Standardization of EPO-SE-Inv database for matching procedure

EPO-database cleaned manually and standardized so that they are suitable for matching. Swedish characters (Ä, Å, and Ö) are sometimes not used. They are replaced according to the table below.[15]

Swedish letter	EPO-character	Changed to
å	“	Ao
ä	„	Ae
ö	”	O
Å	A	A
Ä	Ž	Ae
Ö	™	Ö/ O
é	‚	e
ü	□	u

The empty (null) values are re-checked, and if the information is misplaced, they are all corrected manually. Empty spaces before the information in each cell is trimmed and cleaned. If any, misplaced information is controlled and they are put under the right column.

2. Lund University Faculty (LUF) Registers

The second database used in this research is Lund University Faculty (LUF) registers. LUF Registers for 3 main faculties i.e. Lund Institute of Technology, Faculty of Medicine, and Faculty of Science and Technology for the years 1999-2004 have been requested from Lund University Personnel Office. The LUF registries are provided in MS. Excel format.

Due to the lower rates of turn-over among the senior faculty at Lund University, we assumed faculty registers for the years between 2004-1999 would be reliable and enough.[16] Moreover, the quality of data becomes less reliable for the earlier years.

2.1. Standardization of the LUF-registers for matching procedure

Before starting the name and address matching process between the LUF-registries and EPO-SE-inventors database; LUF-registers also had to be controlled, i.e. cleaned manually. Each year information (1999-2004) in separate excel files was merged into one single file, and it is named LUF-all. This file has 17, 280 names, since it captures turnover both in terms of researchers and the positions and departments they are employed at. The "doubles" (the faculty who has been employed over the last five years has appeared more than once in the LUF-all file.). Those "doubles" are eliminated. This cleaned file contains 4214 unique names (LUF). However we kept the original database in order to check later the positions and departments of the inventors at the time of the invention (see Appendix).

3. Matching between EPO-SE-inv- database and LUF and Construction of LUP-database

For this research we have developed a new method through the combination of MS. Excel, access and visual basic. The matching of the two data-bases follows a logical step-

well as his guidance at the initial stages of the empirical work.

[15] Since I could not know in advance which characters have been used, the changing of characters was done when necessary instead of changing all at once.

[16] A Nordic study that Vinnova was involved in, investigated the flows to and from the universities and research institutes to other sectors in the period 1988-1998. According to this study, total mobility to and from universities and research institutes averages 23 per cent over a 10-year period (SINTEF STEP 2003). In another Vinnova study on the level of the mobility among post-graduates 68.5 per cent remained in higher education while most of those moved from one sector to another had only done so once or twice. Together these two groups make up 92 per cent of the population (Vinnova, 2006:47).

by-step procedure, often involving the repetition of the same basic steps.

Step 1: Name-matching between EPO-SE-inv- and LUF

First the procedure is based on matching first two letters in the first name (e.g. **AN**ders), and full surnames of inventors (e.g. Andersson) in the EPO-SE-inv and LUF. This type of matching gives all possible combinations *(e.g. Anders Andersson---Anders Andersson but also Andrea Andersson, Andrias Andersson etc.*). [17]All these matches are controlled manually and only exact matches are taken.)

I repeated the same matching procedure for every inventor of the same patent, i.e. patents might have more than 1 inventor. Inventors' names are placed in 27 columns (**INNM 1-INNM 27**). First I matched LUF-name with INNM1 and INNM2. Later I repeated the same matching-process for INNM 3, 4, and 5. Similarly I continue matching INNM 6- till INNM 12, then to INNM 13 to INNM 20, finally INNM 21-27. Basically I matched every inventor name (from 1 to 27) with the faculty names step by step. As a result of this matching I had the exact name matches of LUF and EPO-Inventors.

Step1.a: The same matching procedure is repeated for the different combinations of first names, middle names and surnames. *(E.g. Anders Andersson → A. Sven Andersson, →Sven Andersson)*

Step1.b: However the same names (Homonyms: They have the same names but we do not know if they are the inventors or not do not mean the same person). Therefore I made a manual address, zip-code and city control and then conclude that academic person and the inventor is the same person.

Moreover some names are abbreviated (e.g. Daniel→Danny) or sometimes mid-names are not registered at all or initials are used (e.g. Anders Sven→ A.Sven, or only Sven). All these different name combinations are checked. Moreover, due to spelling mistakes sometimes use of double *ss* (e.g. Andersson is spelled as Anderson). Therefore I thoroughly went through every match and checked each name one-by-one.)

Step 2: Name, Address and zip-code matching [18]

The second stage of matching is based on name, zip-code and address and name matching. This matching provides the perfect matches since it confirmed both names and the addresses of inventors.

Step-3: Address and zip-code matching

In this step, only the addresses and zip-codes are matched. As a result of address matching some of the names that are missed (misspelled, changed, abbreviated names, use of middle names, divorced, married, different transliteration of foreign names- Chinese, Russian etc., different uses of Å, Ö, Ä etc.)

The same procedure is repeated for all the inventors from **INAD1 to INAD27**, and zip-code matching for INzip1 to INzip-27. All possible abbreviations of addresses e.g. Gatan-G, Vägen-V, Södra, Östra, Västra, Norra, abbreviations etc., different spellings of ä-å-ö are checked manually.

As a result I have two sets-of names:

- Perfect matches (i.e. the first-name, mid-names and surnames, address, zip-code and city of the inventors in EPO-SE-inv and researchers in the LUF registers are matching)
- Name-matches (the first-name, mid-names and surnames of the inventors in EPO-SE-inv and researchers in the LUF registers are matching but their addresses can not be controlled due to lack of information. Since inventor-researchers might have registered different addresses this group is checked via search engines, and

[17] All names used for methodological explanations are arbitrary and created by the author. They do not reflect the real inventor-researchers.

[18] This kind of methodology has not been used or suggested by the other researchers in the field. This method is especially important to find the misspelled names. The address-matching confirms also our choice of EPO database, but the others (USPTO, PRV etc.)

university intranet-Lucat, or personally).

Step 4: Controlling Scientific field of the Inventor-researcher Pairs and Patent Area

When necessary for further assurances, the possible relevance between the scientific fields of researchers and the patent are manually controlled.

Step 5: Co-inventors and Colleagues

I manually checked the co-inventors who have especially addresses in Lund. I have checked the LU Publications, and research projects list, staff homepages and CVs of inventors to find out if any of the co-inventors is from LU. As a result, 20 more inventor-researcher pair is identified. Their names are different and who could not be identified due to missing address (*e.g. inventors who have different name orders e.g. Arabic and Chinese names and who did not have the same addresses in databases. They were mostly foreign PhD students.).*

Step 6: Controlling Possible Inventors: *Usual Suspects*

As a result of our initial interviews with the TTOs, search in homepages, I have found around several researchers who have initiated companies with the help of TTOs or applied for patents with the help of TTOs. Since some of the names partly overlap with the results of the initial matching process, it confirms our trust into our method.

After the achievement of the *initial* inventor-researchers list, the basic profiling of the inventors and applicants are done as follows:

Step 7: Identification of Academic title and Age at the time of Patent Application

The date of patent application is used as proxy to identify the link between the inventor and LU. In order to identify the academic title of the inventor, I consider the academic title and age which is the closest to the application date of the patent.

Step 8: Identification of Academic Affiliation at the time of Patent Application:

The identification of academic affiliation has been complicated due to the ongoing changes (re-organization) at LU, especially at the Medical Faculty. Another problem is the miscoding of some of the faculty's academic affiliation. Moreover, some of the faculties has been affiliated with several divisions and it was very difficult to determine which division should be the inventors' milieu. I consider the academic affiliation which is closest to the application date of the patent.

Step 9: Matching between EPO-SE-Inv-LUF and EPO-All

I finally matched the EPO-SE-inv-Luf database with the EPO-All database. I found the applicants of the patents In order to get all the relevant information (i.e. applicants, technological classification and title of the patents).

Step 10: Identification of Patent Applicants

Change in the names of applicants, mergers (acquisitions, e.g. Astra and Astra Zeneca), use of different names (Ericsson, Telekombolaget Ericsson, etc.) abbreviations (Ceba AB and Cereals and Cereal Base AB). In order to get the most accurate information about the size, sector, location, type and linkages of applicants to the inventors (thus to LU), I checked all applicants' & proprietors' names by using search engines, homepages, business websites, Eniro etc.

To sum-up, name and address matching is much more accurate than the methods used in the previous researches. Since we have decreased the risks of exclusion of patent holders, but at the same time the risks of including none patent holders due to same names are eliminated to higher extent.

In addition to the matching procedure, the initial results of matching (approximately 280 names) were checked manually. Publications, and research projects, co-inventors, staff homepages and CVs of inventors were also used to find out if there is a link with the co-inventors. For further validation, the patent area for inventors and the departmental affiliation of the faculty was examined.

As a result of matching and manual controls we found around 273 inventors, 23 of which had only name matches (Homonym: They have the same names but we do not know if they are the inventors or not).but we could not confirm the addresses. We put these 23 inventor-researcher pair into a gray zone for further controls personally.

4. Validation of the Names in the Gray zone

This thorough methodology decreased the number of researcher-inventor pairs into 23, which needs to be further re-checked personally (by phone and emails for confirmation). First 10 out of 23 confirmed that they are the inventors and employed at LU.

3 of them stated that they were inventors but they patented at another organization not LU, and eventually asked not to be included in the LUP-database.

Regarding the last 10; 3 of them mentioned that there were actually researchers with the same name at their departments who might have patent. But they do not know for sure since they are employed at LU, after those people had left LU. 7 of them do not have current addresses and phones at the university.

As another way of confirmation, I decide to reach these 7 inventors and ask if they were employed at LU when they applied for the patent. I checked their EPO-addresses in Eniro Swedish (online yellow pages) to contact them. However this effort did not lead to any conclusion. As a result we had to take out these 10 names, including the 3 researchers (who were not employed at LU), from the LUP database.

This step-by-step, quite tedious and manual procedure has provided methodological efficiency by eliminating the risks of excluding or including wrong inventor-researcher pair (See Iversen et al. 2006, Lissoni et al. 2006). Finally we have a list of 260 confirmed inventor-researchers from LU.

5. Limitations

The use of EPO limits the scope of the analysis. By doing so, we might have excluded the inventors who have patents registered only in the other offices (e.g. USPTO, Japan Patent Office, and Swedish Patent & Registry Office-PRV, etc.). Second, the university researchers are covering Lund University employees. A broader researcher registers (covering all Swedish universities) could have been used. However given the time and resources allocated for a PhD thesis, it is far beyond the scope of a PhD thesis. Such coverage would not only be complicated but it would increase the number of false identified inventors (see Method Section). The proximity of the PhD student (author) to Lund University, the familiarity and easy access to the researchers decreased the risk of false identification of inventor-researchers.

Third, names (of inventors and researchers) were matched across the periods. Researchers employed in the 1999-2004 are matched with a larger time frame of inventors (i.e. 1990-2004). Although it is found to be a perfectly legitimate choice; it has certain limitations that we can not be sure if the inventor was employed at the university at the time of invention.

We were warned what if a significant minority of inventors may appear as inventors in patents that are not necessarily related to university research but to work carried out before joining or after leaving the university, or whilst on a sabbatical. This is especially important for pre-1999 patent applications in this study. For instance, lower rates of turn-over at the Swedish Universities, having same addresses in both databases, co-inventing with colleagues from the university might strengthen the interpretation that the inventors are employed at LU at the time of invention.

We came across this limitation when we sent the inventors survey to 260. Approximately 10 inventors responded our survey and claimed that they were not employed at the Lund University at the time of patenting. We excluded them from the surveyed sample. Few (2) of them sent emails that their inventions were not related to their work at the LU (e.g. free time activity) even though they were employed at LU during the period. Since, there is no strong convincing argument to exclude those few inventors who claimed inventions were their free time activity.

Another limitation is (as discussed briefly above) the extent we can expect to get a reasonable impression of patent growth is limited to the entire years 1990s till 2005.

6. Lund University Patent Database (LUPD)

As a result of these matching and validation processes with survey and telephone calls, a total of 458 patents with 250 university-researchers as inventors were identified at Lund University. This means that Lund University-related patents (LU-patents) account for at least 2% of the total amount of national patents (1990-2004). The following section describes the findings in details.

3. Lund University Patents

Section 3 starts with a brief description of Lund University. Following to that it presents the findings of Lund University Patent Database. Empirical data is analyzed from these following aspects: First it reflects on the patterns of LU-patents over time. Second it discusses the findings from the dimension of inventors and sets the background. Third, it presents the findings related to applicants, and proposes tentative insights where university patents are utilized.

More specifically the empirical findings are analyzed in the lights of the research questions that are posed in the introduction as follows:

1. **What are the basic characteristics of patenting activity at LU?**
   - 1.1. What is the distribution of the patents at LU yearly and over selected periods?
   - 1.2. What is the distribution of patents among different faculties?
   - 1.3. Are differences among the departments/divisions within the same faculty?
2. **What are the basic characteristics of inventors of LU-patents?**
   - 2.1. What is the distribution of patenting among inventors based on i) academic ranks, ii) employment, iii) gender, iv) age
   - 2.2. What are the basic characteristics of patent groups (number of inventors per patent)
   - 2.3. Is there any concentration of patenting activity on some inventors (*skewed distribution*) in patenting activities?
3. **What are the basic characteristics of applicants of LU-patents?**
   - 3.1. What is the main scientific & technological classification of LU-patents?
   - 3.2. Who are the main applicants of LU-patents (e.g. Inventors, Firms, and TTOs)?
   - 3.3. What types of industrial firms are applicants of the patents?
   - 3.4. What is the sectoral distribution of applicant firms?
   - 3.5. What is the location of applicant firms?
   - 3.6. What are the key applicants of LU-patents?
   - 3.7. Where is the country of applicant firms?

Research Question-1: Basic Characteristics of Patenting Activity at LU

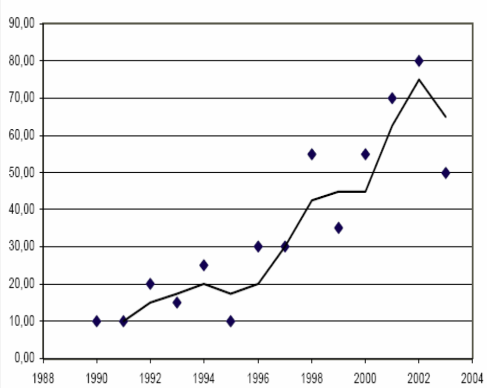
1.1. What is the Distribution of the patents at LU yearly and over selected periods?

Recalling the European- academic-Paradox, this part utilizes the empirical findings in a way to explore the first unpretentious statement, i.e. there is really a low rate of patenting or university research results have not been patented at all. Accordingly, the extents of patenting at LU yearly and over selected periods are examined.

Fig.1.1.i provides the basic answer for these questions. As shown in Fig.1.1, there has been a positive trend in the number of patents over the years 1990-2004. Although it is difficult at this point, to conclude the reasons behind this positive trend, possible macro-level explanations could be: (i) the development of new, high-opportunity technology platforms

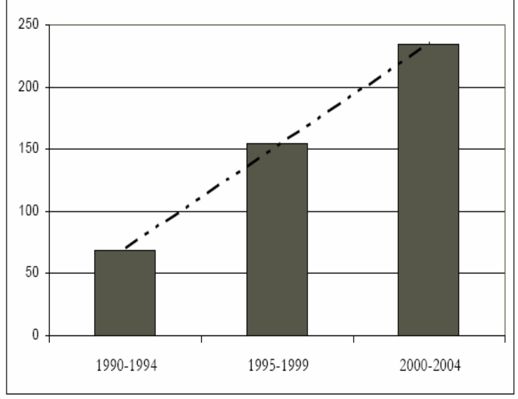
e.g. computer science, molecular biology, and material science; (ii) the more general growing scientific and technical content of all types of industrial production; (iii) the need for new sources of academic research funding created by budgetary stringency; (Bercovitz and Feldman, 2005:175) (iv) and the prominence of government policies aimed at raising the economic returns of publicly funded research by stimulating university industry technology transfer (Geuna, 2001:10), so-called "third mission activities".

Fig.1.1.i. Distribution of Patents Yearly (1990-2004)



Even though many scholars argued that university patenting has not been exceptional before 1990s, patenting has become much more common within the last 2 decades. Figure.1.1.ii. shows the positive trend in a more definite way by clustering the patents over the 5-years periods. Between 1990 & 1994; the total patents were 69, between 1995 & 1999 the number increased to 155 more than double of the previous period. Finally, the number of patents reached to around 250 between 2000 till 2004.

Fig.1.1.ii. Distribution of Patents by 5-years of Period



Although these factors are not exhaustive and conclusive, it is not feasible within the scope of this Paper, to go further in depth to find further explanations behind this positive trend. The factors behind university patenting will be addressed in the following Paper.

1.2. What is the Distribution of Patents among the Departments?

Patenting activity can also be related to the field of scientific specialization. Fig.1.2. shows the patent intensive research milieus at LU. 63% of the patents are emerged from LTH-based scientific fields e.g. electronics, chemistry etc. While 32% of the patents are related to Medical Faculty, only 5% of the patents are originated from Natural Sciences.

The basic explanation for this distribution could be while in certain fields (basic-theoretical physics, geology etc.) patenting is not the preferred route for the protection and utilization of research results (Stephan, 2005), while it might be common in some fields like biotechnology, chemistry or engineering fields in general. As shown in Fig.1.2, The NS has 36 patents. The lower rates of patenting at NS, can partly be explained by the nature of research which is more theory oriented, compared to engineering fields at LTH or Medical Faculty.

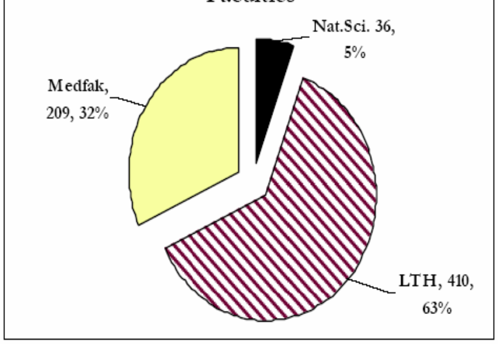


Fig.1.2. Disribution of Patents by Faculties

1.3. What is the Distribution of Patents among the Departments *within the same* Faculty?

To a considerable extent, the departments within the same faculty differ in their patenting activities. Each university patent in this study was allocated to a university department by identification of the departmental affiliation of the inventor.[19] Figure 1.3.i,ii,iii show the distribution of patents at departments of the same faculty.

Fig.1.3.i shows that the most patent intensive department is the Analytical Chemistry at the Faculty of Natural Sciences (NS). It is followed by bio-chemistry, Physics and Organic Chemistry. These departments are actually closely related to their corresponding departments at the Faculty of Engineering (LTH)

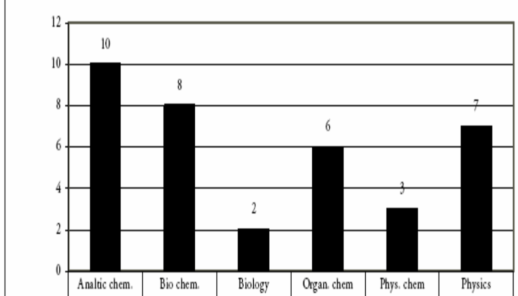


Fig.1.3.i Distribution of Patents at Natural Sciences-Departments

	Analtic chem.	Bio chem.	Biology	Organ. chem	Phys. chem	Physics
patent	10	8	2	6	3	7

According to Fig.1.3.ii, the Departments of Chemical Engineering (79), Information Communication Technologies (45), Physics (44) and Mathematics (41) Biotechnology (27), Industrial Electronic and Automation (28), have high number of patents at the LTH.

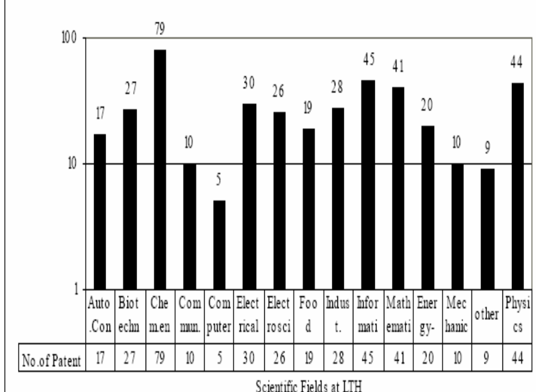


Fig.1.3.ii. Distribution of Patents at LTH-Departments

	Auto .Con	Biot echn	Che men	Com mun.	Com puter	Elect rical	Elect rosci	Foo d	Indus t.	Infor mati	Math emati	Ener gy-	Mec hanic	other	Physi cs
No.of Patent	17	27	79	10	5	30	26	19	28	45	41	20	10	9	44

Fig.1.3.iii shows the distribution of patenting at the departments of Medical Faculty.[20] The patenting activities in the Medical Faculty are concentrated to these three departments: Laboratory Medicine (102) and Clinical Sciences (86) departments, Department of Experimental Medical Sciences have (21) patents.

[19] In cases where a single patent is invented with several inventors from LU, the patent was allocated to each of the relevant inventor's department. This resulted in a small amount of double-counting. As shown in Fig.1.2. this also implies the intensity of patenting among LU. The single counting of patents is 458.

[20] From 01.01.2005, Medical Faculty has been re-organized under 6 main departments (located either at University Hospital Lund, or Malmo General Hospital-MAS).

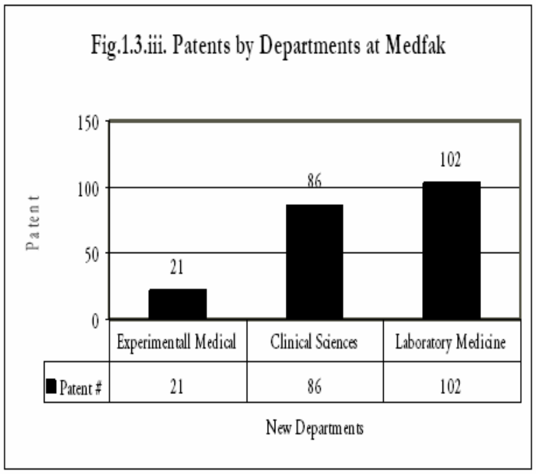


Fig.1.3.iii. Patents by Departments at Medfak

According to the former organization of Medical Faculty, inventive activity is concentrated to the divisions of Cell and Molecular Biology (60), Medical Sciences (27) and Laboratory Medicine (20).

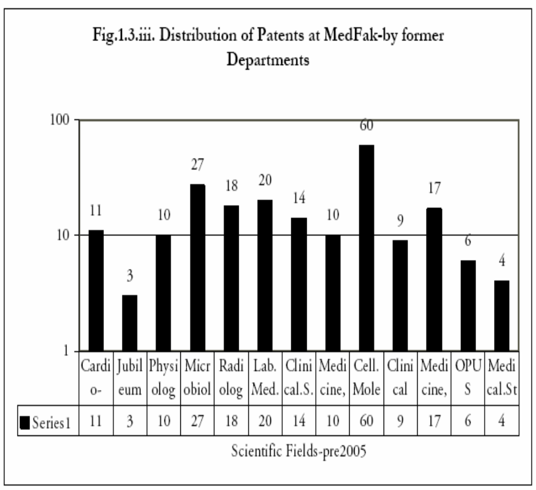


Fig.1.3.iii. Distribution of Patents at MedFak-by former Departments

However, when comparing departments & faculties in terms of patenting, it should be noted that departments and faculties vary in size (number of faculty, research expenditure, types of research etc.). The different budgets and research personnel allocated to different departments may affect the research profile and capacity of the departments. For instance in the LUF-registers, the number of faculty at LTH is 1802, at Medical Faculty it is 1610, and at NS it is 802. The industrial funding that LTH-faculty receives and the industrial networks they have may be higher than has the NS-faculty.[21]

Research Question-2: Basic Characteristics of Inventors of LU-Patents?

The total number of LUF is 4214, 250 of them are found as inventors in EPO database. The second research question is related to to find out the basic characteristics of these 250 inventors. This is important to understand why some university scientists become inventors. To do individual level analysis, "academic rank, scientific field, employment status, gender, age and even residence of inventors" are investigated. The basic descriptions of the inventors by these aforementioned features[22] would imply what sort of faculty members are involved in patenting. This analysis may help us to distinguish what might be the main the motivations and incentives of each group of inventors. This analysis would also indicate if there is any specific group of faculty, who was not involved in patenting. The basic profiling in this Paper sets the background for an in-depth analysis in the following paper.

2.1. What is the distribution of patenting among inventors based on i) academic ranks, ii) Scientific field/Faculty iii) employment status, iv) gender, v) gender & age?

Fig.2.1.i, shows the distribution of inventors by academic ranks. Most of the patenting activity is concentrated among professors (103), it is followed by associate professors (Docents, 53), PhD students (50), and Post-doctoral fellows (including assistant professors). A special group is the university employees who are adjuncts (working part-time at LU). Out of 366 adjunct-employees, 14 of them are inventors. One can argue that

[21] Information about the industrial funds that each faculty receives, and the joint projects with industry need further investigation.

[22] Academic Ranking, employment status, and age of the inventors are based on the priority date or 18 months before the patent application has been made.

their invention is done at their industrial jobs, but they are part of the university research group. This issue is questioned in the following Papers

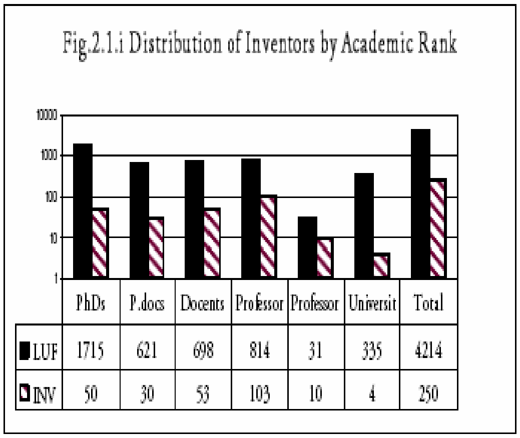


Fig.2.1.i Distribution of Inventors by Academic Rank

According to Fig.2.1.ii, inventors are classified by Scientific Fields. Faculty of Engineering (LTH) has the highest number of inventors (138 out of 250), it is followed by Medical Faculty and finally there are 15 inventor-researchers affiliated with Faculty of Natural Sciences.

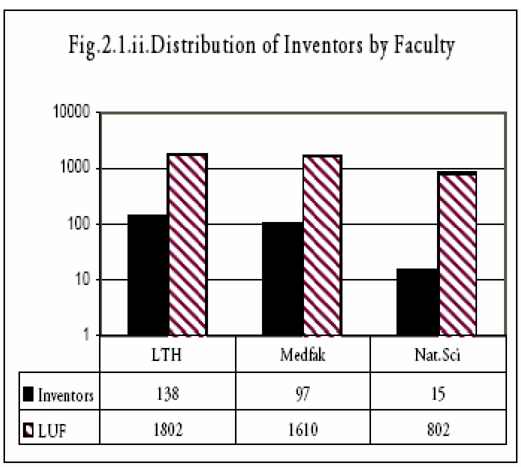


Fig.2.1.ii.Distribution of Inventors by Faculty

To make it more visible, the inventors are grouped into three main levels: seniors (full professors, professor adjuncts), middle-level (associate professors), and juniors (post-docs, assistant professors and PhD students). After this classification, the inventors are distributed by their scientific fields. Fig. 2.1.i&ii shows the distribution of inventors by Academic Ranks & Scientific Fields. At the Natural Sciences, 10 of the inventors are full professors as compared to 5 inventors who are either at their middle or early levels of career. At the Medical Faculty, the number of professor-inventors is 48, and the number of inventors from other ranks is 49. At the Engineering School, out of 142 inventors, professor-inventors are 55, while the total of other groups is 83.

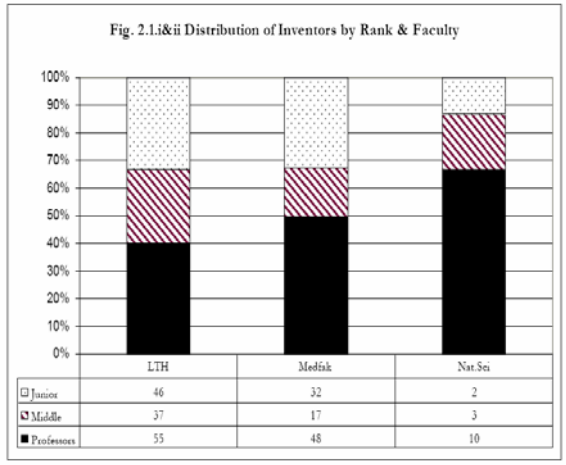


Fig. 2.1.i&ii Distribution of Inventors by Rank & Faculty

Fig.2.1.iii, shows the distribution of inventors by employment status. Most of the LU-inventors are employed full time. The inventors who have less than half-time employment are mostly adjunct professors. Their patents need further identification if those patents were the direct results of their activities at their other jobs, or a result of interaction with their university colleagues.

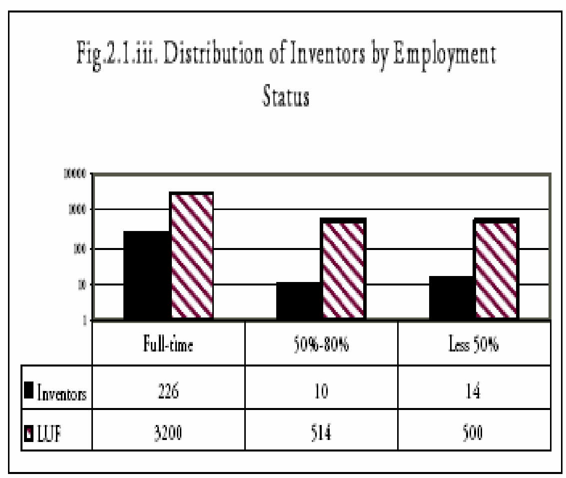


Fig.2.1.iii. Distribution of Inventors by Employment Status

Fig.2.1.iv, shows the distribution of inventors by gender. The number of women inventors is quite low, compared to their total employment at LU. The reasons for the lower

participation of women are of crucial interest and will be examined.

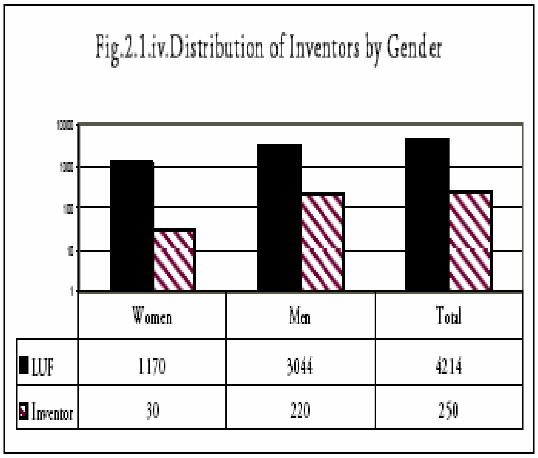


Fig.2.1.iv.Distribution of Inventors by Gender

Fig.2.1.v, shows the distribution of inventors by gender & age. Similar to the academic ranking discussions, to determine the impact of age on the productivity of the scientists is problematic. The findings show that the numbers of men and women inventors are highest between the ages 45-50. The oldest man inventor at LU is around 60, while it is 50 for woman. The age of the youngest inventor for both men and women is around 26 to 30 which may be during their doctoral education. Yet women inventors have started to do patenting later than the men.

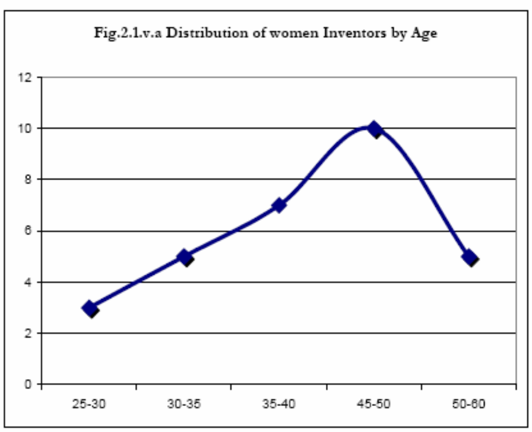


Fig.2.1.v.a Distribution of women Inventors by Age

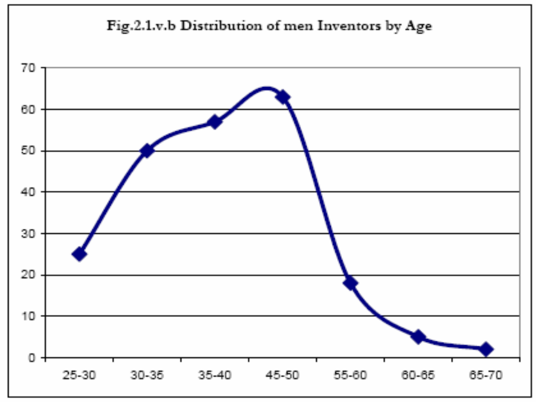


Fig.2.1.v.b Distribution of men Inventors by Age

2.2. What are the basic characteristics of patent groups (number of inventors per patent)

Fig.2.2 shows the number of co-inventors per patent. Around 80 patents have single inventors, while patents invented by groups of two to three inventors reach a peak of around 200 patents out of 458. The number of patents decreases to 100 as the number of inventors increased to four to five. The number falls below 50 for patents with more than six inventors.

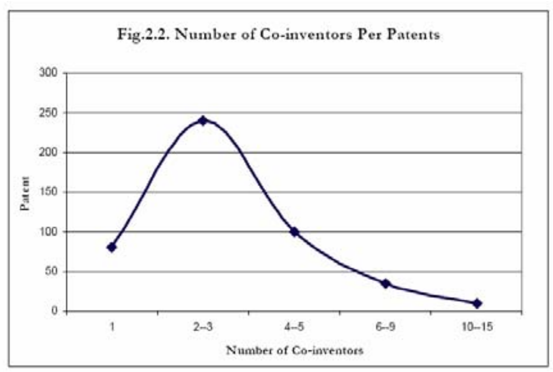


Fig.2.2. Number of Co-inventors Per Patents

The breaking-down of the number of co-inventing over time (year by year, and over three and five years) do not yield any significant differences. In these time periods, it was also found that patents with two to three inventors are the highest. With regard to clustering based on technological fields, while chemistry related patents slightly higher co-inventors, traditional engineering sectors (machine tools, controls) have lesser co-inventors. However differences are not very significant.

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

2.3. Is there any concentration of patenting activity on some inventors (*skewed distribution*) in patenting activities?

Out of 250 inventors, 130 of them only have one patent. After the fifth patent, the number of inventors is decreasing sharply. The Fig.2.3 shows a skewed distribution of patenting activity. Five times of patenting could be considered as a threshold level for becoming a more patent productive inventor. The number of inventors who have five or more patents is 40. These 40 inventors can be are named *serial inventors*. This implies that university patents are concentrated on some serial inventors.

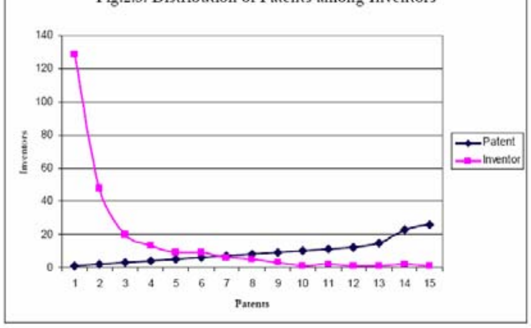


Fig.2.3. Distribution of Patents among Inventors

The basic explanations behind this skewed distribution of patenting could be: ability to recognize the patentability of research result, having resources to apply for patent. The more they do patenting, the more they learn what is patentable and how to apply for a patent, and even they might have established their networks to get their research results patented. Hence the process becomes less burdensome. The details of the skewed distribution of patenting, role of serial inventors and their research group (members) are analyzed in (Goktepe, 2007)

Research Question-3: What are the Basic Characteristics of the Applicants of LU- Patents

This part focuses on the applicants of the LU-patents. There is a burgeoning amount of literature examining when, why, how and which types of firms that collaborate with university and faculty (e.g. Community Innovation Survey etc.). Within the scope of this research, the patent applicants are examined.

Due to the special character of IPR regimes at Swedish Universities, this analysis highlights (i) the use of the Law of University Teachers Privilege (Lärarundantaget)[23] in the forms of inventors as applicants, (ii) use of third agents (technology transfer organizations) and (iii) it gives tentative insights about the relations between faculty and industry such as which types of firms are the main applicants of LU-patents in which sectors patents are applied for and so on. It gives some tentative description of the nature of relations between LU and industrial partners according to the type, sector and location of firms.

3.1 What is the distribution of patents by the technological classification?

LU-patents are classified according to technological and industrial sectors.[24] According to Fig.3.1. Pharmaceuticals, biotech, and ICT (including telecom) are the largest sectors. The number of patens in ICT, Biotech and Pharmaceuticals are quite close to each other. However, the number of firms is

[23] Due to the Law of University Teacher's Privilege (Lärarundantaget), in Sweden, the university researchers can either apply for a patent by themselves or they can assign their rights to a variety of organization and actor.

[24] The classification scheme that I tried to use was originally developed by the Fraunhofer Institute in Karlsruhe in collaboration with the French Science and Technology Observatory OST and IP agency INPI (Meyer et al., 2003). The scheme is based on the International Patent Classification and provides a more aggregated view of patenting by distinguishing thirty technological sectors.

very low in the ICT (i.e. dominance of Ericsson), while there are more firms (71) in the other two sectors.

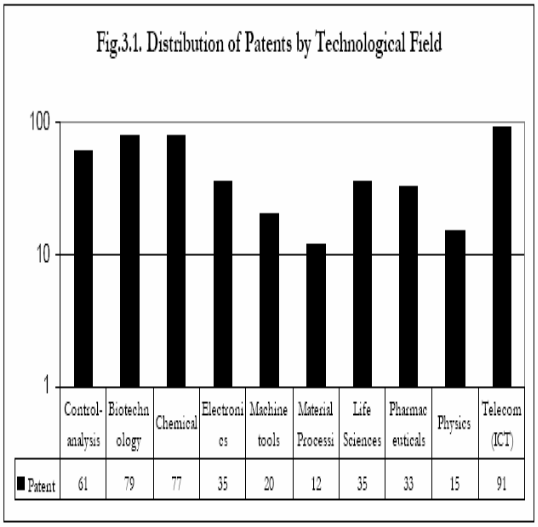


Fig.3.1. Distribution of Patents by Technological Field

3.2 Who are the main applicants of LU-patents (e.g. Inventors, Firms and TTOs)?

Fig.3.2. shows firms are the main applicants of patents; they have applied for 377 patents. 62 patents were applied for by the inventors themselves. Those 62 patents are unassigned to any company at the time of application. Inventors most probably assign (license-sell or give) the patents to firms after the application. Public research institutes (e.g. Lund University and several other research centers) and the third agents (Forskarpatent i Syd AB, BTG international and so forth) applied for a relatively low number of patents. The choice of different applicants or individual applications and outcomes of different processes are examined in Goktepe, 2006.

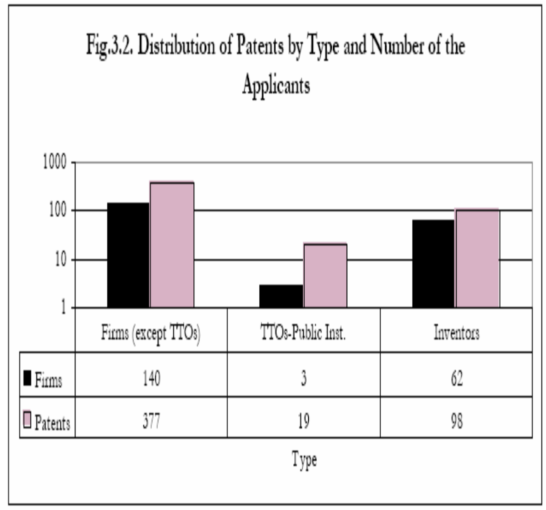


Fig.3.2. Distribution of Patents by Type and Number of the Applicants

3.3 What types of industrial firms are applicants of the patents?

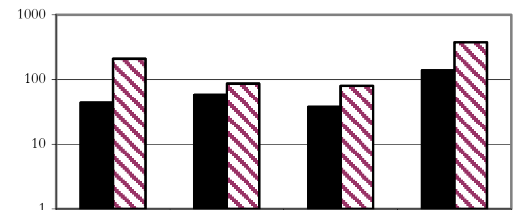
Fig.3.3 shows how LU-Patents are distributed by the sizes of firms.[25] The number of large firms (44) is less than SMEs (59) as applicants of LU-patents. However, the number of patents applied for by large firms (210) is much higher than the total number of patents applied for by SMEs (87) and Spin-offs (80). This could be explained by the dominance of large firms in the Swedish economy. Moreover these large firms could be the funders of research that leads to that patent; they would naturally be the applicants of the patents. It should also be mentioned that large firms can afford the cost of patenting more easily than SMEs or spin-offs. Additionally, since faculty may be more aware of the research areas of large firms than unknown SMEs, they may hence contact the large firms.

These findings have different implications to understand second assumption about European-academic- Paradox, i.e. *whether university research results are absorbed by the existing companies (incumbents) and thus we do not see the formation of new companies and new jobs."* Despite the dominance of big companies, mainly (Ericsson see below), there has been substantial amount of companies spinning-out from Lund University. However, their

[25] Patents applied for by inventors are not included.

economic implications (e.g. growth effects etc.) have not measurable yet. Still there is no evidence that European universities are not generating spin-offs at all or all of their research results are taken by existing (incumbent) firms.

Fig.3.3. Distribution of Patents by Size of the Applicant Firms

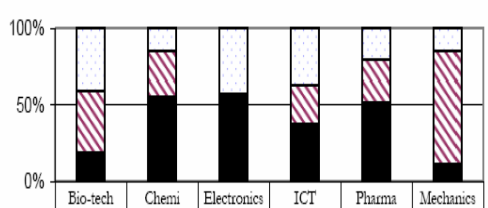


	Large C	SMEs	Spin-offs	Firms (except TTOs)
Firms	44	58	38	140
Patents	210	87	80	377

3.4 What is the distribution of the applicant firms by the sectors and size?

Fig.3.4. shows the distribution of the applicant firms by the sector and size. As shown in Fig.3.4. there are 91 patents in ICT sector, but only there are 8 companies, in which 78 of the patents are applied for by one large company (i.e. Ericsson). To some extent we see the majority of large firms in the sectors of pharmaceuticals, chemistry and electronics. In sectors such as mechanics and biotech, there are more SMEs and spin-off firms.

Fig.3.4.Distribution of the Applicant Firms by Sector and Size

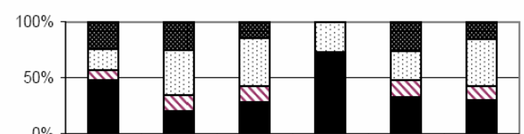


	Bio-tech	Chemi	Electronics	ICT	Pharma	Mechanics
Spin-offs	17	3	3	3	6	5
SMEs	17	6	0	2	8	25
Large	8	11	4	3	15	4

3.5 What is the distribution of patents by the technological field & location of applicant firms?

Returning back to the last unpretentious statement of European- academic-Paradox: "i) *whether university research results were utilized outside of Sweden and thus we do not see any new products, jobs etc. there is no strong evidence to confirm it*. To the contrary as shown in Fig.3.5, the university research is mostly utilized by firms located in Lund (53). Around 30 of them are located in the Ideon Science Park, which also implies the importance of science parks around universities. After Lund Malmö, Stockholm, Uppsala, Gothenburg and Västerås are the main cities where companies that applied for LU-Patents are located.

Fig.3.5 Distribution of the Applicant firms by sector & location

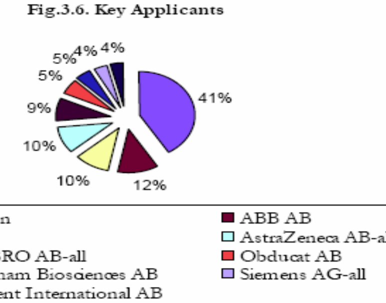


	Bio-tech	Chemi	Electronics	ICT	Pharma	Mechanics
Outside SE	10	5	1	0	7	5
Sweden	8	8	3	3	7	14
Skåne	4	3	1	0	4	4
Lund	20	4	2	8	9	10

3.6 What is the distribution of patents by the key applicant?

Fig.3.6. shows that LU-Patents are concentrated to small number of key applicants. Ericsson, Astra-Zeneca, ABB, and Gambro are the key applicants of the LU-patents. Obducat, Amersham, Bioinvent and Probi are small sized firms that were originated from and still have links with LU.

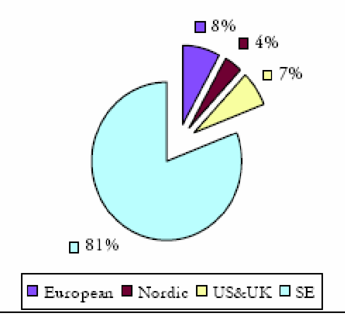
Fig.3.6. Key Applicants



3.7 What is the distribution of patents by applicant firms' countries?

Fig.3.7. show the applicants' countries. Sweden is the main country of the applicants. This implies that most of the LU-Patents are applied for by firms located in Sweden.[26] These findings also underline the view that there is not so much strong evidence that Swedish research result are flowing out of Sweden and causing lower levels of the utilization of research results.

Fig.3.7. Applicant Firms' Country



[26] However, if a patent has more than one applicant, each applicant's country is counted. Therefore, the number of applicants (and countries) is higher than the actual patent number.

4. Summary and Concluding Remarks

This study has demonstrated that in countries where individual ownership is the common practice, the share of contributions to technological development in terms of patenting can be best determined by tracking university patents by the names of university inventors, rather than by universities. This approach gives a more appropriate picture of the role of universities in technology transfer, especially for a European context (e.g. Sweden, where university technology transfer infrastructure-TTOs- are not only inexperienced, but quite new to the faculty).[27] Thus this aspect may give some further insights to the policy-makers when they devise new institutional set-ups for increasing UITT.

In this study, a total of 458 patents with 250 university-researchers as inventors were identified at Lund University. This means that Lund University-related patents (LU-patents) account for at least 2% of the total amount of national patents (1990-2004). One must bear in mind that this is a conservative measure since only four /five years of personnel register were available for the analysis, compared to 15 years of EPO database. As there are long examination times, especially for life science related applications, not all inventive activity in these areas could be considered here.

Inventive activity is shown to be concentrated in terms of both inventors and faculties. We have identified 40 serial inventors who are quite prolific in patenting. This study showed that some departments (i.e. electronics, telecommunications, physics, mathematics, chemistry, biotechnology, laboratory medicine) account for the highest number of LU-patents.

Similarly to the inventor concentrations, there is also a concentration on key assignees. Mostly large firms are applicants (e.g. Ericsson or Astra Zeneca) of LU-patents. A technology transfer organization (Forskarpatent i Syd AB) featured in 7 cases. The chief technological contributions of Lund University-based inventors are in biotechnology, pharmaceuticals and telecommunications sectors. Foreign-owned LU-patents patents invented in Sweden but owned by an overseas organization are limited.

Returning back to European Paradox, in the early 1990s the concept has been introduced to show a mismatch in the scientific investments and thus expected outcomes e.g. high-tech exports. Since then the pendulum has gone too far to many countries to show similar mismatches with other types of R&D input-output indicators. The pendulum has been exacerbated with the myopic comparative studies between Europe and exceptional USA studies. There has been an increasing research and complain that European universities are so incompetent to transform the university knowledge to the benefits of society. And this is why Europe has been lagging behind the USA. On the other hand, now the pendulum has been shifting reverse by trying to disprove that –paradox- is nothing more than a myth, and a political tool. Now it has become popular to argue that EU countries do not and should not emulate the so-called USA model etc…

[27] The tracking of university inventors illustrates a more inclusive notion of university-related or academic patents and it captures more comprehensively the contributions of academic science to a technological base. Naturally, also academic patents are only one of several indicators of useful research. Due to the individual ownership practices in Sweden, the number of Lund University-owned patents is only 1 out of 458 patents which have at least one inventor affiliated with LU. While they seem to capture the inventive activity of researchers more comprehensively, they still remain a partial measure of scientific contributions to technological change Meyer (2003).

Rather than being torn between these pendulum shifts, this Paper first presents theoretical grounds to explain the relations between knowledge, invention, innovation and patents and suggest it is unrealistic to expect all investments to R&D (universities) would lead to knowledge that is patentable and/or commercialized. Only a sub-set of knowledge can be commercialized. Second by adopting an extensive research strategy; this Paper constructs the university patent and inventor data base to analyze the extent of patenting at a Swedish University. However, proving a number of university-related patents are not enough to conclude there is no paradox. One needs to investigate whether these university-related patents were really invented by the university employees during their employment or were the patents produced before or after their employment at the universities. Second, one needs to examine whether these patents are utilized by the incumbents versus spin-offs, and if they were utilized within the country versus outside of the country.

The main implications of this Paper to European Paradox can be summarized as follows. First of all, this research does not find any strong evidence that utilization of university research results in the forms of patenting is low in Sweden where individual ownership of patents at universities is the common practice. However, even though we found a substantial amount of patents related to Lund University, we questioned if those patents are utilized by the existing companies and thus we can not see new companies and jobs. The findings should be treated with caution. Even though most of the patents are owned by big companies (*usual suspects*, i.e. Ericsson, AstraZeneca Gambro etc.); there are around 40 spin-off companies, and several SMEs which had spun-out from LU or had initiated by former LU-employees. Finally, we questioned whether patents are utilized outside of Sweden. However only a limited number foreign companies are the applicants of LU-patents. Thus we do see any convincing evidence for a paradoxical situation neither in the amount nor in the utilization places patents.

In the subsequent papers factors (individual motivations and incentives) behind university patenting are investigated through inventor survey. Information on the nature and intensity of the relations among the actors relevant for patents are collected. For instance with whom inventors have been partnering for doing research, i.e. researchers from the same department, other departments and universities, or researchers from industry, or foreign researchers. Actually, more information on this point will help us to refine the positive evaluation of the role of universities.

Second the roles of serial inventors and co-inventors & research groups are examined in another Paper. Specifically, we questioned whether serial university inventors that enter the network are, on average, more central than other inventors in terms of exchanging information with more people and across more organizations, if they play a key role in connecting individuals and organizations.

Other questions of interest relate to the role of serial inventors with regard to co-inventors such as, connecting university and industry for longer term and other types of relations, introducing young researchers to the community of industrial researchers. Furthermore, we need more information if the involvement in an applied research field, lead to any changes such as emergence of new scientific disciplines, establishment of joint research centers etc. Concerning the inventors having one or two patents; we need further information if this was an incidental behavior, in which university scientists sell some of their research ideas on an occasional basis. Or those single patent owners could not achieve in their previous applications on the grounds of scientific and financial problems.

Finally, the initiation of new technology transfer infrastructures, research consortia, and joint research centers, projects are investigated in Goktepe 2006. It questions whether technology transfer infrastructure motivated university researchers to do patenting more or not at all effect.

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Appendix

Previous Empirical Research on University Patents

Table. 1 Summary of Empirical Research on University-Invented Patents

Country	Time Period Database	#of University-invented Patents	# of University-owned Patents	Main Technological Category of Patents	Type of University investigated
Finland (Meyer et al.2003a)	1986-2000 USPTO	530 patent 285 inventors	36	Telecom Instruments Pharmaceuticals	All universities except Social Science & Arts etc.
Flanders (Meyer et al.2003b)	1986-2000 USPTO	379 x	100 (TTOs)	Organic chem. Life Science	Technical Universities
France (Azagra-Cara & Llerena 2003) (Univ.of Strasbourg)	1993-2000 French National Patent Office	463	62	Genetics Biology Physics	Univ.of Strasbourg 82 Research Laboratories
Germany (Schmoch 2000)	1970-2000 EPO	1800 (2000) and 200 (1970)	NA	Biotech, Medical Engineering, Organic Chemistry	All University Professors. Title of Professor is searched
Italy (Balcani et al.) & other Boccani studies	1978-1999 EPO	1,475 919 inventors	40	Biotechnology Drugs, organic chemistry	All Professors registered to Ministry of Education and Research
Norway (Gulbrandsen et al)	1998-200 Norvegian Domestic Patents)	307 (8-12% of all Norvegian Domestic Patents)	NA	Life sciences Instruments	All researchers at universities - colleges
Sweden-Chalmers (Wallmark-Survey)	1943-1994 Swedish Patents or EPO	417 68	NA	Chemical Engineering Electrical Engineering	Chalmers University of Technology
Sweden-East Gothia (Schild) Linkoping University (LiU)	1980-1996 (Swedish-PCT filings from East Gothia)	88 (Swedish-PCT filings from East Gothia) 82 Inventor	NA	Instruments Electricity Health & amusement	Linköping University Technical Faculties
Sweden Lund (Goktepe 2005)	1990-2004 EPO	458 EPO-patent 250 inventor	1	ICT, biotech, pharmaceuticals	Lund Univeristy Except Social Science
Taiwan (Survey)	2000	174	Public ownership (Patent Database of Academic R&D)	Engineering (other than electronics)	All professors registered in National Science Council

Lund University

Lund University was founded in 1666 in the south of Sweden. It is the largest unit for research and higher education in Sweden (and in Scandinavia) with eight faculties and a multitude of research centers and specialized institutes. It has faculties in three cities: Lund, Helsingborg and Malmö. The University has 42,500 students and 6 000 employees. More than 3 000 post-graduates work at LU, 45% of them women. Most doctorates are awarded in medical sciences, followed closely by technology and natural sciences. In 2004 the University had 554 professors, of which 14% were women. 435 new research students were accepted in 2004, half of them were women. 458 doctorates were awarded the same year. Towards the establishment of technology transfer infrastructure LU has taken important steps. For instance, The LU-Innovation unit (former industrial liaison office), LUAB, LU-Development Company, provide business advice to university researchers. Additionally, regional actors (Innovation Bridging Company, Forskarpatent, Teknopol and so forth) have been established in the last decade to guide and help university researchers for commercializing their research results.