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by

Devrim Göktepe

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Friedrich Schiller University Jena
Carl-Zeiss-Str. 3
D-07743 Jena
www.uni-jena.de

Max Planck Institute of Economics
Kahlaische Str. 10
D-07745 Jena
www.econ.mpg.de

A Theoretical Framework for Understanding University Inventors and Patenting

March 2008

Devrim Göktepe
Max Planck Institute of Economics

Abstract

This paper develops theoretical standpoints to investigate and analyse university inventors and patenting activities. Although the studies on academic entrepreneurship and university patenting have substantially increased, first there have not been enough studies on individual inventors and second the current theoretical studies are not eclectic enough to capture the different factors that may explain university inventors patenting activities. The framework described here addresses this need. To accomplish this we inductively derive several factors from a substantial number of studies on university patenting and entrepreneurship, and develop these factors into a tentative framework. It is our hope that this framework is useful in future empirical research on university patenting and provides a point of departure for scientists.

JEL-classification: O31, O34, B31

Keywords: theoretical approach, university patenting, inventors, incentives

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Contact: Devrim Göktepe, Max Planck Institute of Economics, Entrepreneurship, Growth and Public Policy Group, Kahlaische Strasse 10, 07745 Jena, Tel.: +49 3641 686724; Fax: +49 3641 686710
E-Mail Address: goektepe@econ.mpg.de

1. Introduction

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

- Closer links between scientific developments (university research) and their outside utilization e.g. important technological breakthroughs in computing (microprocessors), biotechnology (genetic engineering), molecular biology and nanotechnology (Mowery et al. 2004) made faster utilization of university research in industry;
- A general growth and relevance in the scientific and technical content of all types of industrial production (Mowery et al. 2001, 2004);
- A need for new sources of funding for academic research, due to budgetary stringency or general declines in research funds at the universities (Geuna 2001; Bercovitz and Feldman 2006);
- The US Congress's passage in 1980 of the Bayh-Dole Act, providing incentives for universities to patent scientific breakthroughs accomplished with federal funding (Henderson et al. 1998; Etzkowitz et al. 2000).
- Increasing emphasis on government policies aimed at raising the economic returns of publicly funded research by stimulating university-industry relations (Geuna 2001; Mowery and Sampat 2004);
- The rise in the pool and mobility of scientists and engineers, with higher numbers of scientists and engineers facilitating their movement between industrial and academic employment (Almeida and Kogut 1999; Bercovitz and Feldman 2006; Crespi et al. 2007);
- The rise of venture capital, providing ready financing for academic start-up firms dedicated to commercializing the results of university-based research (Rothaermel et al. 2007);

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

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

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

Most of these studies are based on data (number of patents, spin-offs, licensing revenues, etc.) available from TTOs or e.g. the Association of University Technology Managers (AUTM). These official registers may fail to reflect the actual number of scientists who are involved in commercialization and the actual amount of commercial activities since many scientists may avoid disclosing their inventions to TTOs officially (Audretsch et al. 2005; Markman et al. 2005b; Thursby et al. 2006). As a result, official data take into account only university-owned patents and may therefore underestimate the actual patenting activity of scientists. Thursby et al. (2006) have shown that this phenomenon (firms owning patents to university research) also occurs even in the post Bayh-Dole US, although at a relatively lower frequency than in the European cases as shown by Meyer 2003a; Meyer et al. 2003 and Meyer et al. 2005 and other similar subsequent studies.

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

The triple helix model states that increasing linkages and interaction between university, industry and government facilitate technology transfer from university to industry. In addition to increasing linkages and interaction, this model argues that each actor assumes the roles of the others (Etzkowitz and Leydesdorff 1997, 1998, 2000). Thus universities increasingly perform entrepreneurial tasks such as commercializing research results,

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

patenting, licensing or forming spin-offs. Firms take on academic roles such as sharing knowledge with one another and with universities (Etzkowitz et al. 2000). This model assumes that such co-evolutionary transformations in the structures of the university and firms will facilitate technology transfer. Universities and firms are still working quite independently of each other. The interactions between universities and firms are therefore in most cases encouraged by the governments, through new rules of the game, direct or indirect financial assistance, or legislation such as the Bayh-Dole Act or equivalent legislation adopted in several countries.

The systems of innovation and the triple helix perspectives have both emphasized the increased interaction among university and industry (Nelson 2008) and the diversity in the sources of knowledge. Although these analytical frameworks shed some light on the changing roles of universities and firms, they have a limited potential for understanding the roles of inventors per se. Instead they provide a larger picture of university-industry relations and interactions for technological development. We therefore take one step further and examine several key themes in the university-industry relations literature with a focus on patenting in order to find different factors that may explain university researchers' patenting activities.

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

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

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

In addition to this scholarly debate, there has been an increasing policy interest in UITT, accompanied by concern with increasing this kind of activity – especially in the forms of patenting, licensing and launching academic spin-off firms. At the European Union (EU) level, it has been argued that the level of commercial activity at universities is relatively low compared to the high levels of scientific performance and investment in research. This perception is exacerbated somewhat by the impression that universities in the US have performed much better in commercializing their research results due to the Bayh-Dole Act. While many other factors also came into play in the upsurge of patenting and licensing in the post-1980 period (Mowery et al. 2004, Mowery and Sampat 2004), the Bayh-Dole Act improved the ability to move ideas from R&D into the marketplace and into business in the US (Etzkowitz et al. 2000; Etzkowitz 2001, 2002). Despite sceptical views (see below), the Bayh-Dole Act has been discussed as one of the important factors for the commercialization of university research as well as for the institutionalization of technology transfer (i.e. streamlining the procedures for patenting and licensing of patents developed as a result of federally funded research) in US universities (cf. Bozeman 2000; Etzkowitz et al. 2000; Thursby and Thursby 2000, 2001, 2002, 2003; Jensen and Thursby 2001; Thursby et al. 2001; Henrekson 2002; Thursby and Kemp 2002; OECD 2003; Mowery et al. 2001; Mowery and Ziedonis 2002; Siegel et al. 2003; Mowery et al. 2004).

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

Many European countries, however, have had or used to have dual intellectual property rights (IPR) systems. While ownership of IPR in the non-university sector (i.e. firms and public research organizations) belongs to the organization, the university researchers have had the right to retain the ownership rights title to patents (e.g. the teacher's exception law in Sweden). Inspired by the US legislation, some EU governments have initiated legislative reforms (such reforms have been initiated widely in the EU states partly as a result of also converging policies in the EU, not necessarily solely inspired by the US. Some have indeed been inspired by the US Bayh-Dole, but that was only a minor driver compared to the EU pressure) aimed at raising the economic returns of publicly financed research by stimulating interaction between university and industry and focusing specifically on increasing technology transfer to industry from universities (Geuna 2001). Although it was argued that Bayh-Dole Act has not been designed to provide new sources of income for universities and a only a few universities earn income (Mowery et al. 2004; Nelson 2006; Verspagen 2006); a number of countries have passed legislation similar to the Bayh-Dole Act; and several other countries are considering or discussing similar changes with the hope of financial benefits.

[2] The AUTM Licensing Survey 2002 reports that 569 new commercial products were launched that year, 450 new companies were established (for a total of 4,320 since the introduction of Bayh-Dole Act in 1980, of which 2,741 were still operating in 2002), running royalties on product sales were $1.005 billion, and new licenses and options executed in 2002 increased 15.2% over 2002.

In Germany, a decision has been taken to change the ownership of IPR within the institutes of higher education by removing the exclusive ownership rights of researchers and transferring those rights to the employing organizations, though researchers will retain rights to receive two-thirds of any licensing or other income from their invention (AUTM 2003; OECD 2003; Sellenthin 2006). Denmark introduced the Act on Inventions at Public Research Organizations (PROs) in July 1999 (effective as of 1 January 2000). This act grants PROs (universities, hospitals) the title to employee inventions (Valentin and Jensen 2006). In Norway, a new bill on the commercial exploitation of inventions went into effect in January 2003 (Iversen et al. 2007). Under certain conditions, it transfers the right to commercialize an invention from researchers to the employing organization. In doing so, it has sought to establish organizational ownership by universities of IPR to the results of research carried out at universities.

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

These policy measures are motivated not only by the arguments that these new institutions and organizations can support and speed up the industrial exploitation of academic research and that the financial returns from patenting may help to support research and teaching at universities. In addition, these policies find support in declarations of a *third task* for universities (Rosenberg and Nelson 1994; Lee 1996; Etzkowitz and Leydesdorff 1997, 2000; Branscomb et al. 1999; Etzkowitz et al. 2000), alongside their two traditional tasks of teaching and research. Swedish universities, for instance, were given a third task in the Higher Education Act in 1997. Besides education and research, universities are expected to support economic and social development and play a greater role in explaining academia to the broader public (Edquist 2004: 194; Brundenius et al. 2006).

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

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

These critics have also pointed to the lack of solid, empirical support for the argument that patenting stimulates the transfer of university technology to industry, and to the ambiguous nature of current empirical evidence for the long-term implications of the role of universities. Though commercial activities are seen as potential sources of revenue for universities, as well as sources of economic growth and job creation for the regions and nations where they are located, not every university has generated revenues from licensing patents. Mowery et al. (2004) have also pointed out that the even the licensing revenues of such patent experienced universities were dominated by a very small number of block buster inventions, most of which were in biomedical sector. They have concluded that a number of developments in academic research, industry and policy thus combined to contribute to the US universities' patenting activities, and Bayh–Dole, while important, was not determinative.

In sum, the discussion above has shown that the literature on UITT still remains rather fragmented. There has been increasing debate, concern and uncertainty about the roles that universities will play in teaching, research and entrepreneurial activities. Analyses and perspectives differ not only with respect to the roles of universities, but also regarding which kinds of institutions and organizations can best facilitate university patenting activities – as well as the extent to which they should do so (see Mowery et al. 2004). Forecasts also diverge between those who believe that the future of universities is under threat from increasing pressure to engage in entrepreneurial activities (e.g. Slaughter and Leslie 1997) and those who believe that such activities will bring new opportunities and autonomy to universities (e.g. Etzkowitz 2000). Despite this fragmented picture, a number of countries have initiated policies to increase university-industry relations with the aim of enhancing the contributions of university research to innovation and economic growth. There have been two main policy tools: (i) policies encouraging the formation of regional clusters, spin-offs and science parks, incubators, techno parks, etc. around universities; and (ii) policies aiming to stimulate university patenting and licensing activities (Mowery and Sampat 2004: 225).

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

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

Phan (2005) and Phan and Siegel (2006) classified and reviewed the literature on UITT in three principal areas:[3] (i) research on the effectiveness of patenting and licensing and roles of technology transfer organizations (e.g. papers that focus on TTOs and the Bayh-Dole Act as the main units of analysis); (ii) research on the effectiveness of science parks to stimulate and support entrepreneurial activities at universities; and (iii) research on the formation of start-ups and ventures.

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

The more recent study by Rothaermel et al. (2007) highlighted that there have been 173 published articles within the last two decades on the broadly defined topic of university entrepreneurship. University entrepreneurship refers to any published research pertaining to entrepreneurial activities in which a university could be involved, including but not limited to patenting, licensing and the creation of new ventures or the facilitation of technology transfer through incubators and science parks, thereby contributing to regional economic development. Rothaermel et al. have highlighted four major research streams emerging in this area of study: (i) entrepreneurial research university, (ii) productivity of TTOs, (iii) new firm creation, and (iv) environmental contexts, including networks of innovation.

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

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

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

On the other hand, another group of studies has investigated academic entrepreneurship. These studies have focused on a few themes like the characteristics of the scientists (human capital aspects); the environment surrounding the scientists, the role of scientists (social or human capital) in the new ventures created and the process of new venture creation (see Zucker et al. 1998; Zucker et al. 2001; Murray 2004; Shane 2003). They have referred to financial incentives and support provided by institutions and organizations to explain the entrepreneurial activities of researchers.

In this work we therefore suggest a shift in the unit of analysis from universities, institutions and organizations and entrepreneurs to individual inventors. The focus on individuals should not, however, be interpreted as underestimating the roles of institutions and organizations and research groups. This approach may even be considered an important theoretical and methodological contribution to studies of UITT by studying individuals and their environment together.

This paper proceeds as follows. After a brief overview of the key themes in the literature on university-industry relations and different technology transfer mechanisms in Section 2, in Section 3 we address the main theoretical discussion on university inventors and patenting, under three themes. First, we investigate the previous research on the identification of university patents and inventors under legislation where university researchers own or used to own the patents (individual ownership of patents) as opposed to organizational ownership of patents by universities (e.g. US university model). We then present the studies that focus mainly on the relations between institutions and organizations and university patenting. Subsequently, we present the studies that investigate the roles of individuals in university patenting. In Section 4 different factors derived from the existing literature are integrated into an overall framework to guide the empirical investigation and the further theoretical analysis. Section 5 gives a brief summary of the theoretical framework suggested for to understand university inventors and patenting.

2. One Step Back: University-Industry Technology Transfer Mechanisms

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

The focus in this study is on the university researchers' patenting activities. Figure 2.1 shows the classification of technology transfer mechanisms into two main sets: patenting (licensing, spin-off company formation) and other more general types of technology transfer mechanisms. The iceberg model (illustrated in Figure 1) is used as a metaphor to present university technology transfer mechanisms. Technology transfer mechanisms at the tip of the iceberg are mostly based on the transfer of particular outcomes of university research. They can be measured quantitatively using such measures as the number of university patents, licenses to industry or the number of spin-offs that are established.

Although a substantial amount of technology transfer may also take place through the less visible mechanisms, these mechanisms are beyond the scope of this study. However, the focus on university patenting should not be interpreted as an indication that the second group of mechanisms, e.g. participation in university-industry joint research projects, consortia or joint programmes and labour mobility, are unimportant (Goktepe 2004; Audretsch et al. 2005: 13). While scientists' decisions, e.g. to collaborate with industry, are not necessarily regulated by legislation, their decisions to patent or not would be subject to various factors such as patent legislation at universities, (local) contexts, national laws and university regulations, agreements with industrial partners, the culture of the research group and their own individual values and beliefs.

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

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

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

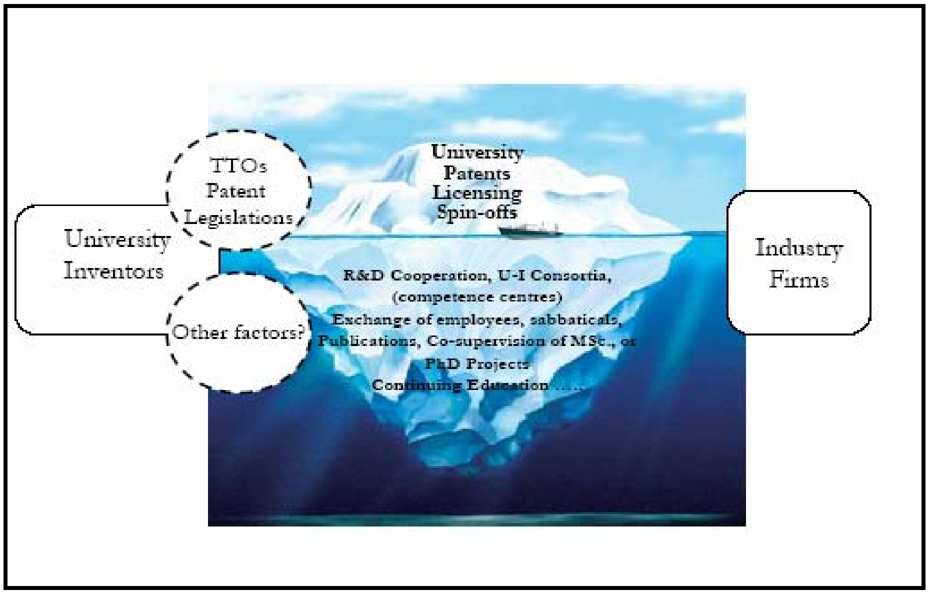

Figure 1 A Basic Illustration of UITT Mechanisms[4]

I do acknowledge the limitations of the use of patents. One cannot learn about the full spectrum of university research and knowledge generation from patent data only. They are only a rather partial indicator of inventive activity. Measuring the number of patented inventions is not the equivalent of a direct measure of innovative output, since not all innovations are patented (Griliches 1990; Anselin et al. 1997, 2000; Pavitt 1998). My aim is not to measure innovative output or impacts of university knowledge or the consequences of patenting. It is rather to investigate factors behind university researchers' patenting activities.

3. Studies on University Inventors and Patenting

The main unit of analysis in this study is the individual university inventor. We therefore focus specifically on the literature on university patenting and on university inventors. Several studies have focused on individual scientists and entrepreneurs in the context of university technology transfer, but few have examined the influence of both internal and external factors on the patenting activities of university researchers. In what follows, we review the important aspects of the literature on university inventors and patents. This review leads to a list of internal and external factors that may explain university researchers' patenting activities. Since patenting activity at universities is sometimes related to licensing or university spin-offs, we also review selected key papers that have addressed these issues.

The following review of literature on university patenting and roles of individuals highlights three main themes:

- Studies on the identification of university inventors and patents under non-Bayh-Dole regimes, where individual researchers own patents based on research conducted at universities;

[4] Own illustration, based on background picture from http://express.howstuffworks.com/gif/wq-iceberg-underwater.jpg

- Studies on the impact of institutions and organizations on patenting, licensing and spin-off company formation by university inventors;
- Studies on the roles of individuals in patenting, licensing and spin-off company formation.

The remainder of this section discusses the main findings and arguments of the three aforementioned research themes on university inventors and patents.

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

Studies that have mapped *university patenting under non-Bayh-Dole regimes* formed the main points of departure for this study. A number of scholars have shown that the number of patents applied for by US universities has increased over the last twenty years, coinciding with the introduction of the Bayh-Dole Act in the US in 1980. Over the same years, the number of science-based university spin-offs has also grown (see Henderson et al. 1998; Etzkowitz 2002; Mowery et al. 2004). Although the effects of the Act on the increase of patenting are far from definite and conclusive, universities increased their share of patenting from less than 0.3 per cent in 1963 to nearly 4 per cent by 1999 (Mowery and Sampat 2004). As a result, many observers have concluded that there may be a positive relation between the number of university patents and the Bayh-Dole Act.

In Europe, the levels of university patenting, licensing and spin-off company formation have been claimed to be low compared to the relatively high level of investment in higher education institutes or in basic research. This phenomenon has been labelled the European Paradox, according to which European countries have a strong science base but are not good at transferring research results into commercially viable new technologies (EC 1994; Tijssen and van Wijk 1999). Although there has been no systematic attempt at measurement until recently, it is well known that no European university holds a patent portfolio as large as MIT's or Stanford's. It is also believed that many European universities do not hold any patents at all (OECD 2003; Lissoni et al. 2007).

Given the impression of higher numbers of university patents and spin-offs, and higher licensing revenues for the US universities, an emulation of the US Bayh-Dole Act has been advised by many European policy-makers.[5] Some concerns have been raised, however, that such policy suggestions are based to a large extent on unrealistic and faulty assumptions which are in turn based on inadequate or erroneous information (Geuna and Nesta 2006; Verspagen 2006). Most information on university patenting, licensing and spin-off company formation comes from surveys submitted to university TTOs or even from newly established TTOs, or on cursory searches for university names or university TTOs as the applicants for patents. Construction of systematic data on patents for European universities and further investigations of the European Paradox have been suggested recently by scholars (Lissoni et al. 2007).

A series of European studies on university patenting has been conducted to gauge the rate of university patenting in Europe and to create patent data sets comparable with those of US universities (Schild 1999; Meyer 2003a; Meyer et al 2003; Balconi et al. 2004; Meyer et al. 2005; Azagra-Caro et al. 2006; Iversen et al. 2007; Lissoni et al. 2007). Due to the

[5] Germany, Denmark, Norway have adopted patent legislation similar to the Bayh-Dole Act.

different institutional and organizational set-ups at European universities, university patenting should be investigated by finding the names of university scientists who are also registered as inventors in patent databases. For these reasons, then, the distinction between the inventor and the applicant should be highlighted:

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

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

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

The studies cited above have taken the distinction between the inventor of a patent and the applicant for a patent as their point of departure (Schild 1999; Meyer 2003a, Meyer et al. 2003; Balconi et al. 2004; Meyer et al. 2005; Azagra-Caro et al. 2006; Iversen et al. 2007; Lissoni et al. 2007). They argued that, depending on the ownership of IPR at universities (i.e. individual ownership or organizational ownership); university inventors can apply for patents by themselves (individually). Or inventors may assign their rights to another party to apply for a patent with the aid of TTOs or through other actors such as firms or patent consultants. These scholars thereby argued that the different patenting regimes at European universities require another methodology. They suggested the approach of finding how many university researchers are actually listed as inventors of patents, instead of searching for university names or newly established university TTOs as applicants of patents. Before these studies, university patents were often understood as patents assigned to universities, and the patenting activities of university researchers were more or less invisible in European studies (see Cesaroni and Piccaluga 2002; Saragossi and von Pottelsberghe de la Potterie 2003).

In order to identify the university-invented patents, these aforementioned scholars matched two different databases. Databases of patent applications (e.g. national patent offices, European Patent Office (EPO), United States Patents and Trademark Organization (USPTO)) were matched with the so-called university researchers' registers which contain information on employees at the universities, university colleges, state colleges and research institutes. In these studies, the results of name-matching between scientists and inventors have had to be validated for each patent by direct contacts with the inventors to confirm the name-matching between inventors and university employees. The common finding of these studies is that there are many more university-invented patents than university-owned patents across European countries. Hence, the inventive output of European universities or university researchers is more common and higher than previously thought. In what follows we present the findings of each individual study.

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

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

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

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

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

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

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

Giuri et al. (2006) showed that the total number of university patents in the PatVal survey of inventors for six European countries (Italy, United Kingdom, the Netherlands, France, Germany and Spain) was 433.[6] Based on the PatVal survey, Crespi et al. (2007) further investigated these 433 university patents and found that much of the university research that leads to patents in Europe does not show up in the statistics, because it is private firms rather than the universities themselves that apply for the patent. About 80 per cent of the EPO patents with at least one academic inventor are not owned by the university. Hence, there is no statistical record of the university involvement in the patent office records. Thus, the lack of university patents in Europe is really a lack of university-owned patents, not necessarily a lack of university-invented patents. Once the data are corrected to take into account the different ownership structure in Europe and the US, simple calculations suggest that the European academic system seems to perform much better than had been believed until now. In relative terms, European universities' patenting output lags only marginally behind that of US universities (Crespi et al. 2007).

University-invented patents can also be analysed by looking at the distribution across science and technology fields. The studies presented above show that patenting is most frequent in biotechnology and pharmaceuticals (Geuna and Nesta 2006). The strongest technological sectors in each country also tend to be those in which university patents are heavily concentrated. For instance, patents in telecommunication in Finland account for 12 per cent of university-invented patents while pharmaceuticals and biotechnology account for about 9 per cent each (Meyer et al. 2003). The broadly defined research area of biotechnology and pharmaceuticals tends to be an area of extremely high university patenting activity in many countries.[7]

These empirical investigations support the view that *university patenting is not a new phenomenon for European universities*. They show that the more inclusive approach of tracing

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

[7] These studies have found almost the same tendencies as in the US. In 1998, 41% of US academic USPTO patents were in three areas of biomedicine, indicating a strong focus on developments in the life sciences and biotechnology. In terms of revenues, about half of the total royalties were related to life sciences, including biotechnology (NSF 2002). Whether a corresponding degree of concentration in this area exists for university patents in Europe is less clear-cut, but the available evidence is not at odds with this assumption (Geuna and Nesta 2006).

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

A final conclusion of these studies can be summarized as follows: although the number of university-owned patents is limited, these universities or countries do not necessarily lag behind US universities. The difference in numbers can be explained by different institutions and organizations. However, these studies have not investigated why researchers patent and what are the main factors behind patenting activities in European universities in a systematic way, except for a few recent studies by Gulbrandsen (2005), Giuri et al. (2006)[8] and Baldini et al. (2007) to date.

3.2 Organizations and Institutions and University Patenting

A burgeoning literature has investigated the effects of organizations such as TTOs, universities, firms, science parks and so forth, and/or institutions such as the Bayh-Dole Act, the third task, academic culture, university policy and strategies and government policies on university patenting. Most scholars have referred mainly to the AUTM databases, or to results and data from their surveys or interviews at American universities (Bozeman 2000; Etzkowitz 2000; Bercovitz et al. 2001; Link and Siegel 2001; Thursby et al. 2001; Carlsson and Fridh 2002; Friedman and Silberman 2003; Graff et al. 2002; Thursby and Kemp 2002; Thursby and Thursby 2002; Jensen et al. 2003; Siegel et al. 2003a; Siegel et al. 2003b; Lach and Schankerman 2003; Mowery et al. 2004). They have aimed to investigate university patenting and licensing phenomena by assessing patent legislation, university structures and TTOs, industrial trends, and so on.

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

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

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

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

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

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

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

Most of the studies on patenting, licensing and spin-off company formation are dominated by the cases from the US with a specific focus on elite research universities such as MIT, Stanford and the University of California.[9] The findings are not generalizable to other institutes and organizations that do not have similar legislative or other conditions, since the unique experiences and structures of these universities may explain university patenting. There have been few studies for European universities, and the lack of systematic data on university patents and inventors for the European universities is an important motivation for carrying out this research at a Swedish university.

3.3 Individuals and University Patenting

Science and technology policy analysts have paid relatively little attention to independent or lone inventors (Meyer 2005: 113). Jewkes et al. (1966) and Schmookler (1957) even claimed that studying individual inventors might seem somewhat obsolete in the twenty-first century (both cited in Amesse et al. 1991). They hypothesized that individual inventors were more often associated with the era of industrialization than with the age of innovation. Industrial firms, R&D labs, universities and research centres are now considered to be the sources of invention.[10]

Nevertheless, individual inventors are still important, even if their activities may not increase to the same extent as corporate patenting (Meyer 2005). Lee (1996) mentioned that studying the role of individuals would be an important contribution to research on university-industry relations. Several scholars have also underlined the importance of the scientists for the commercialization of university research, since the decisions to patent and/or be involved in commercial activities are a matter of personal choice, and the decision to patent may depend on the scientists' perceptions of the effects of academic patenting and the costs and benefits of patenting (Sirilli 1987; Macdonald 1984, 1986; Amesse et al. 1991; Lee 2000; Owen-Smith and Powell 2001; Thursby et al. 2001; Acs and Audretsch 2003; Shane 2003; Bercovitz and Feldman 2004; Libecap 2005).[11]

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

- **Traits of Inventors**

The first group of studies of individuals is inspired partly by psychology and behavioural sciences. These studies have asked *who the inventors are and what their characteristics are.* Macdonald (1984, 1986), Sirilli (1987), Amesse et al. (1990), Klofsten and Jones-Evans (2000)[12] and Giuri et al. (2006) have investigated the characteristics, background and socio-

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

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

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

[12] A note should be made here. Klofsten and Jones-Evans (2000) investigated all university scientists; they did not make any distinction between a university inventor and scientists

demographic features of inventors. The socio-demographic findings of different studies are fairly consistent. Inventors were most often men, their average age being between 45 and 48. They were highly educated and had technical and commercial knowledge and had experience above the average.

Stephan and Levin (2005) investigated whether personal characteristics, age (life-cycle), citizenship status, gender and receipt of federal funding were related to patenting activities. They found little evidence of age effects, yet they found that tenured scientists are more likely to patent than non-tenured ones (Levin and Stephan 1991; Stephan 1996). Women patent less than men, although the effect is smaller since the number of women employed in universities relative to men is low.

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

- **Factors behind Patenting or Commercializing Academic Research**

The second group of studies on the roles of individuals has taken one step further and has asked *why university researchers commercialize their research results, or why they became involved in patenting, licensing, spin-off company formation*. Bercovitz and Feldman (2004) studied the individual scientists. They looked at invention disclosure activities across two medical schools at Johns Hopkins and Duke Universities. They found that certain high-opportunity departments, such as genetics and pharmacology, showed high levels of disclosure events per researcher. They found a wide variation across these two medical schools in other departments. While technological opportunity, scientific fields and university incentives (e.g. royalty shares, rewards, etc.) play a role, it is clear that these are not the only factors at work. Norms associated with training influence subsequent behaviour and drive the adoption and diffusion of new practices. Professional training does more than simply transfer technical knowledge; it actively socializes people to value certain things above others. Bercovitz and Feldman (2004) hypothesized that the decision of the scientists to participate in invention disclosures is strongly influenced by three factors:

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

Louis et al. (1989) analysed the commercialization activities of life-science researchers from fifty research universities. They found that the most important factor behind the involvement of scientists in commercialization was local group norms and culture. They argued that a culture that encourages and advocates entrepreneurship is critical. University strategies, policies and structures have a relatively small effect on commercialization activities. Roberts (1991) found that social norms and the university's tradition and

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without a patent. The socio-demographic results from Klofsten and Jones-Evans (2000) are therefore not included.

encouragement of entrepreneurship were important determinants of successful and widespread entrepreneurship at MIT.

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

Stephan et al. (2007) discussed incentives behind patenting as follows: an interest in solving research problems, gaining recognition and reputation, gaining economic rewards (from the university or external organizations), and interacting with industry (industry has a patent focus and patent know-how and industry may steer towards patentable research).[13] They further assumed that the culture of the university, the effectiveness of the TTO, the field of specialization, and duality (patentable research is also publishable) most likely affect the patenting activities of scientists.

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

Gulbrandsen (2005) found that personal satisfaction and doing something professionally enjoyable were important reasons for scientists to be involved in commercialization. Despite their important contributions to individual-level analysis, most of these studies did not investigate further whether there are any differences among the inventors. Giuri et al. (2006) investigated the motives of all types of inventors to invent. They asked whether monetary rewards or non-monetary rewards were important motivations for patenting. They found that social and personal rewards (i.e. the fact that the innovation might increase the performance of the organization where the inventor works), personal satisfaction in showing that something is technically possible, and prestige/reputation were considered by the inventors to be more important than other types of compensation like monetary rewards and career advancement. On a similar note, Baldini et al. (2007: 333) showed that university inventors get involved in patenting activities to enhance their prestige and reputation, and to look for new stimuli for their research; personal earnings do not represent a main incentive. University-level patent regulations reduce the obstacles perceived by inventors, as far as they signal universities' commitment to legitimate patenting activities.

- **Differences among Inventors**

Researchers have hitherto focused on differentiating inventors and entrepreneurs from the rest of the population, while implicitly assuming that almost all inventors and entrepreneurs

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

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

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

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

Zucker et al. (1998) found that a large number of scientists who patent are either *star scientists* themselves or are affiliated with the most highly ranked research universities. Zucker et al. (2001) argued that a scientist who is involved in industry is not necessarily a loss to the progress of science at her or his university. They found that ties between star scientists and firm scientists have positive effects on research productivity. Star scientists are identified by the number of granted patents, number of products in development and number of products on the market.

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

Inventors may either form a spin-off based on the patent, or the patent may be commercialized by a third party to whom inventors sell (license or transfer) the rights to the patents. On a similar note, many scholars have systematically referred to academic entrepreneurship as activities like patenting, licensing and spin-off company formation rather than regular contract research work or consultancy for established industrial firms (see Etzkowitz 1996; Zucker et al. 1998; Meyer 2003; 2005; Gulbrandsen 2005), although they acknowledge the importance of other channels of technology transfer.

Some scholars have tried to identify why and how scientists choose a particular mode for technology transfer and have aimed to categorize the scientists into different groups on the basis of such differences. Etzkowitz (1998: 830, 2002: 134) characterized four ways that scientists can be involved in technology transfer:

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

Etzkowitz's classification is based on the *scientists' technology transfer types*, *not on the type of inventors or entrepreneurs*. Rather than stylizing different types of inventors and describing their motivations and the specific traits of different types of inventors, Etzkowitz has only suggested four kinds of interaction with industry. His classification may provide only a limited insight about different types of scientists. He has not investigated the motivations of scientists to commercialize their research results, or why scientists choose different modes of commercialization.

Meyer (2003b) distinguished between *academic entrepreneurs* and *entrepreneurial academics*. The former type tries to implement their research results in the form of university spin-offs by starting their own business. The latter type refers to scientists who adapt their basic research agendas to the new funding sources (industry) but without a financial growth motive or any perspective of leaving academia.[14] However, Meyer has not characterized these two types of scientists further, and he has not investigated their motivations for choosing different modes of implementation. He has focused mainly on the impacts of public support measures on the activities of inventors, and whether or not their needs are met by the existing mechanisms. Like Etzkowitz, he has not inquired whether there are different factors that motivate scientists to choose particular modes of commercialization. Meyer (2006: 509) has recently suggested that the further exploration of inventors' and other stakeholders' perception of support measures, local policies, the entrepreneurial orientation of the university and the motivation for entrepreneurial activity on the part of academics is necessary to learn to what extent these factors influence the commercialization paths of scientists.

Gulbrandsen (2005: 55-56) suggested two types of university scientists. He also took some steps beyond his predecessors in terms of investigating motivations. The first type he has described is *basic (academic) researchers* who have a clear academic orientation. Researchers

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

of this type have moderate interests in commercialization activities and consider their patents mainly as an extension of their academic efforts. They use consultants (e.g. TTOs or other actors) to handle their entrepreneurial activities. Although they have shown and expressed an interest in the commercialization of their research results, they prefer to spend little time on it, and they do not want to be involved too much in commercialization. The second type Gulbrandsen has described is *liminal scientists*. Researchers of this type have expressed a certain detachment from the academic world as well as from the commercial world. They have carried out a lot of the entrepreneurial work themselves and have spent more time on commercialization than the basic researchers.

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

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

Gulbrandsen (2005) further compared the views of liminal and basic researchers on the patent legislation at universities.[15] While basic researchers did not dispute the new law, some liminal scientists were more critical about the recent changes and more sceptical about the ability of universities to handle patenting and company formation in a better way. Liminal scientists seem to be excluded from the planning processes for initiatives like TTOs following the legislative change regarding ownership of research results in Norway. Although he found differences between these two types, the distinction is sometimes blurred and in most cases it is not significant due to the limited number of observations. Gulbrandsen (2005) suggested that further evidence is required from countries with a different legislative history and status with regard to university patenting.

Gulbrandsen (2005: 71) concluded that the classification of academic entrepreneurs into *basic* and *liminal scientists* with an interest in commercialization fits well with earlier categorizations. In Meyer's (2003b) terms, the basic scientist is similar to the *entrepreneurial academic* who extends fundamental research interests into new settings. Liminal is similar to the *academic entrepreneur* who actually initiates firms. In terms of Etzkowitz's (1998)

[15] Norway abolished the 'teacher's exception' in 2003. Universities and colleges were assigned formal responsibility for ensuring the utilization of patentable research results (Gulbrandsen 2005: 53).

classification, the liminal scientists correspond slightly to the *knowledgeable partner* who believes that all ideas belong to the originator, while the basic scientist is similar to the *hands-off* category who leaves commercialization to a third party.

Different categorizations that have thus far been developed suggest that there may be differences even among the entrepreneurially oriented scientists. However, these analyses cannot be generalized. First, they are based on a small sample of scientists. Second, while some scholars identified only different levels of patenting, others discussed only the modes of utilization of patents or technology transfer. We therefore try in this study to integrate both dimensions, i.e. different paths of commercializing patents and level of patenting, in order to categorize inventors.

- **Patenting versus Publishing**

A fourth theme in the studies of individual inventors, albeit one which is somewhat less relevant for this study, has raised the question *of whether the recent increase in university patenting has challenged the open nature of university research and shifted academic research towards more commercialization*. A number of scholars have investigated the relationship between patenting and open dissemination of research results by scientists in the forms of publications (see Agrawal and Henderson 2002; Stephan et al. 2002; Breschi el al. 2005, 2007; Fabrizio and DiMinin 2005; Azoulay et al. 2006; Meyer 2006; Van Looy et al. 2006). These studies have found that publication and patenting are complementary and *not* competing activities of university researchers. Most of these studies have found a positive relationship between scientific publication and patenting activities.

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

In the preceding sections, we have analysed the existing literature on university patenting under three main headings. In what follows we summarize the key findings of these studies and reflect on the further steps taken by this study. Our current understanding of the factors behind university researchers' patenting activities is far from complete, for four reasons which we discuss below.

The common conclusion of the studies on the extent of university patenting in Europe is that European university researchers are patenting almost as extensively as the American researchers, even without the Bayh-Dole Act. This conclusion has several implications. Different technology transfer infrastructures and patent legislation at European universities require a different methodological approach. Finding the names of university inventors by matching them with the names of inventors in patent databases, rather making than cursory investigations of the names of universities or TTOs as applicants for patents, gives a better picture of the extent of university-based patenting. In countries where universities do not own the patents based on university research, researchers may still make substantial contributions to patenting. European universities do not necessarily need to emulate the Bayh-Dole Act in order to increase university patenting. European university scientists may already be just as inventive and/or entrepreneurial as their US counterparts. However, our understanding of university patenting in Europe is still incomplete for reasons that we now address.

First, while this paper builds on previous studies on identifying university patents and inventors, it goes some steps further than these studies. This study is concerned not only with establishing the extent of patenting and the number of patents at a university where individuals own patents based on university research. It also aims to provide a theoretical framework w*hy and how do university researchers patent?*

Second, most of the research to date has focused on universities, firms, science parks and TTOs as the most common units of analysis. There are only a few studies that have focused on individual university inventors. Such studies have used only a few factors, mainly financial (e.g. rewards versus costs of patenting) or institutional, to explain the perceptions and behaviours of scientists towards commercializing their research results. We do not know if there are any different types of academic inventors, and to what extent different inventors have the same skills or different needs. We do not know the extent to which their needs are met by the existing support system and patent legislation.

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

4. Factors Behind University Researchers' Patenting Activities

Having presented the studies on university patenting and inventors as reported in Section 3, we will now proceed to compile a list of factors affecting university researchers' patenting activities. We first group the main factors that previous studies have suggested into two main categories.

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

Table 1 Classification of Factors behind University Patenting

Internal Factors		External Factors	
Triggers	Enablers	Triggers	Enablers
Solving the research question Job satisfaction	Scientists' career life cycle Scientific human capital	New academic culture Social imprinting	Patent legislation (ownership of patents)
Social and personal	Industrial	Scientific	TTOs

rewards Reputation Promotion	experience & diversity of career	discipline & industrial relevance	
Personal income, benefits	Image & confidence	Industrial funding and resources	Third task
Job security & alternative career options	Social capital & networks	Society, culture and location	University strategy & policy

The second category is *external factors*, which focuses primarily on institutions and organizations such as patent legislation (e.g. the teacher's exception in Sweden), the third task mandate, TTOs, university structure and culture, as well as increasing relations with industry, new academic culture (e.g. social imprinting). Factors such as patent legislation, TTOs, the third task or strategies and policies of university administration enable scientists to patent. These factors may facilitate scientists' patenting activities by providing scientists with the necessary resources, skills and infrastructure. Factors such as the new academic culture, role models, research areas, scientific fields, industrial funding and getting access to external resources may, on the other hand, trigger scientists towards patenting. External and internal factors that have been discussed above are classified in Table 1 in order to show how these factors are grouped.

4.1 Internal Factors

Internal factors that are listed above in Table 1 to explain why university researchers patent are summarized as follows:

1. **Solving the Research Question:** Scientists have intrinsic pleasure and interest in solving research questions and problems (Hagstrom 1965: 16 in Levin and Stephan 1991; Hull 1988: 306 in Stephan et al. 2007). The innate curiosity of scientists and the fascination of the research process itself (Stephan et al. 2007) motivate scientist to do research. Solving research problems is believed to give job satisfaction to scientists (see Arvey et al. 1989, Thursby and Thursby 2007). In addition to Mertonian norms[16] (see Merton 1979); there is considerable evidence that scientists have a taste for inventing (Stern 2004). Scientists at universities are intrinsically motivated to do research. Much of the incentive to invent comes from the joy of solving research questions (Levin and Stephan 1991; Stephan 1996). Thus they are intrinsically motivated to conduct research, quite apart from the ability to earn financial rents from their effort (Hellmann 2007). Recent empirical studies have also confirmed that the innate curiosity of scientists make them research that can bring reputation and visibility (Gulbrandsen 2005; Giuri et al. 2006).

2. **Social and Personal Rewards:** In addition to curiosity-driven research, researchers are motivated to achieve reputation and recognition among their peers in a timely fashion (Merton 1957). Scientists are motivated by rewards of recognition and prestige among

[16] Merton suggested four norms of science: universalism, communism (or communalism), disinterestedness, and organized scepticism.

peers, and they have a strong interest in winning the game. Patenting can enhance the prestige and increase the scientific productivity of the scientists by reaffirming the novelty and usefulness of their research (Owen-Smith and Powell 2001, 2003). Although there is no explicit evidence that patents are used as a criterion to evaluate the academic merits of the researchers (e.g. in academic promotion), some researchers may consider patenting in order to increase their visibility and reputation. On the other hand, scientists who are concerned with more traditional academic values like *publish or perish* might be less motivated to patent for the sake of academic promotion.

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

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

4. **Job Security and Alternative Career Paths**: In order to develop job opportunities in industry, some researchers who do not have permanent positions yet (e.g. Ph.D. students, post-doctoral fellows) might be motivated to patent in order to have job options in industry, even if they may want to pursue an academic career. Moreover, reasons for junior researchers (post-docs, Ph.D.s) to patent could be expectations (plans) to change their career paths from academy to industry. Such expectations could arise due to tight job opportunities in the existing academic labour market. Dreams of having their own businesses could also lead junior researchers to get involved in more commercial activities.
5. **Traits:** Socio-demographic studies have highlighted that inventors are mostly men whose average age is between 45 and 48. They are highly educated and have above-average technical and commercial knowledge and experience. These specific traits are discussed below. People who are making entrepreneurial decisions show higher levels of initiative, need for achievement, need for affiliation, need for authority, self-efficacy and creativity (Shane 1994). Moreover, entrepreneurs are described as more risk tolerant, more profit driven, and having stronger personal motivations (Autio and Kauranen 1994) relative to non-entrepreneurs.

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

7. **Scientific Human Capital (Image)**: This factor refers to the scientific reputation and status as well as the individual skills and talents of scientists. Commercialization of scientific research results is risky and uncertain (Audretsch and Stephan 2000). The scientific reputation and skills of scientists provide credibility and capability to any anticipated commercial project (Audretsch et al. 2005: 25). Due to low risks of losing their image and credibility, scientists with strong scientific reputations have higher incentives to patent. The propensity of a scientist to engage in patenting is positively related to the amount of the expected rewards. If scientists believe they will receive a greater award amount, or will not damage their image and credibility, they will be more likely to patent (ibid.). A similar argument concerns the academic quality of the scientists. The literature shows that so-called star scientists are the ones who are most interested in commercializing their research results, in contrast to those who claim that academic capitalism lowers the academic quality, novelty and scientific relevance of the research agenda (Agrawal and Henderson 2002; Fabrizio and DiMinin 2005; Azuloay et al. 2006; Meyer 2006; Van Looy et al. 2006; Breschi el al. 2007). These studies underline that faculty entrepreneurs appear to be better researchers with more publications and citations as compared to their peers. It is also claimed that starting a firm does not appear to be costly for scientists. Thus entrepreneurship does not decrease research output among faculty in absolute terms, or versus their co-authors and peers (Lowe 1993; Zucker et al. 1998; Agrawal and Henderson 2002; Stephan et al. 2002; Thursby and Thursby 2003; Van Looy et al. 2004; Lowe and Gonzales-Brambila 2007).

8. **Social Capital (Industrial Experience and Diversity of Career):** The concept of social capital (Putnam 1993 in Audretsch et al. 2005: 22) refers to connections among individuals or social networks. By analogy with notions of physical capital and human capital, which enhance individual productivity by adding tools and training, social capital facilitates individual productivity by facilitating coordination and cooperation for mutual benefits. Scientists who have stronger social networks may have easier access to complementary skills and resources that may be necessary for patenting. They may therefore patent more than scientists who do not enjoy the same social networks. Researchers who change jobs between academia, industry and government, sometimes changing sectors, or working in multiple settings simultaneously, should have developed more diverse skills and networks that may motivate them to patent (Dietz and Bozeman

2005: 351). Such people should increase their social capital (networks), which facilitates individual productivity by facilitating coordination and cooperation for mutual benefits. Social capital refers to meaningful relations and linkages that scientists have with others.

4.2 External Factors

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

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

2. **Research Funds and Getting Access to External Funds:** The literature argues that patents can be used as a chit to trade with industry for access to funding, equipment, materials and other opportunities from industry (Stephan and Levin 1991; Owen-Smith and Powell 2001; Bercovitz and Feldman 2004; Mallon and Korn 2004). University scientists who want to have more industrial support are more likely to patent their research results. In this case, these research results would be likely to be patented with the industrial financier of the project.

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

4. **University Policy and System:** Universities that have more experience in technology transfer, that have a more entrepreneurial culture and encourage commercialization, are expected to be more successful in motivating inventors towards patenting (e.g. Etkowitz 2000; Di Gregorio and Shane 2003). Researchers in such institutes are believed to

generate more invention disclosures, patents, spin-offs and license income. On the other hand, incompatible strategies regarding patenting from different groups (e.g. university administration, research group, etc.) may confound scientists' attitudes towards patenting.

5. **Location, Society and Culture:** Scientists' national or regional location is also claimed to be an important factor behind their commercial activities. Knowledge tends to spill over within geographically bounded regions (Jaffe 1989; Jaffe et al. 1993; Audretsch and Feldman 1996; Jaffe and Trajtenberg 1996). This implies that scientists working in regions with high levels of investments in new knowledge can more easily access and generate new knowledge. Louis et al. (1989) and Audretsch et al. (2005: 29) also found that the local norms of behaviours and attitudes towards commercialization are important factors in shaping the propensity of scientists to engage in commercialization activities, i.e. starting a new firm. In parallel to the opinion of Bercovitz and Feldman (2004) mentioned above, societies, scientific departments or research groups which are relatively open social structures that accept and reward enterprising behaviour seem to produce more inventive and creative people.

6. **Patent Legislation:** Laws and regulations not only provide incentives to patent, but also constrain university researchers' patenting activities in certain ways. Under systems with organizational ownership of patents, university scientists are required to disclose their inventions to the university TTO. On the other hand, individual ownership of patents creates incentives for researchers to engage in commercialization. There are two main types of patent legislation at universities: the so-called Bayh-Dole and the teacher's exception. Patent legislation provides institutionalized behaviours, and these, whether they are based on organizational ownership or individual ownership, thereby provide efficiency (see Sampat and Nelson 1999; Nelson 2008). Since institutionalized behaviours are customary and expected, and also because they tend to be meshed with complementary patterns of behaviours, they will lower the transaction costs of commercialization. Second, since they are customary and widely employed, they tend to be sharpened and honed by cumulative social learning (Sampat and Nelson 1999). Therefore the main motivating or compelling aspects of patent legislation depend on how much the given legislation has become customary, habitual, widely accepted and used by the scientists.

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

8. **Third Task**: The notion of a 'third stream' of activities or third mission developed from research activities. The starting point is the assimilation of fundamental research into codified knowledge and thus into information. This economic assimilation is critical, as it tells that this good, once produced, is very difficult to appropriate. This view generated two consequences (Laredo 2007). Alongside a university's core missions of teaching and research, there is a third task of using its knowledge to support economic development, social well-being and policy-making. This covers a number of industrial, commercial, entrepreneurial or other societal or policy-related activities (Martin 2003).

5. Summary

This paper has discussed the previous literature on university patenting in order to derive a list of factors to guide the empirical investigation. All the aforementioned factors are investigated in the empirical analysis to identify the main factors that influence the patenting activities of the scientists (Goktepe 2007). The list also provides other scholars with a tool to start investigating the patenting activities at universities or other public research organizations.

A multitude of scholars have examined the university-industry technology transfer (UITT) process. Except for a small number of recent studies on university inventors (see Owen-Smith and Powell 2001; Thursby et al. 2001; Meyer 2003a; Meyer et al. 2003; Bercovitz and Feldman 2004; Gulbrandsen 2005; Meyer 2005; Giuri et al. 2006; Baldini et al. 2007), most UITT studies have focused on the roles of technology transfer institutions and organizations or on academic entrepreneurs, new venture creation and the consequences of university-industry relations. However, these studies on university inventors have not addressed the phenomenon of university inventors per se, and they have discussed few factors to explain why scientists patent. The aim of this thesis is to address this theoretical gap and to contribute to the current debate by compiling and recognizing different factors to explain university researchers' patenting activities.

The theoretical discussion in this paper attempted to integrate external and internal factors. Through an in-depth literature review, several different kinds of explanatory factors were derived deductively from the existing UITT research literature, particularly previous studies that had proposed explanations for university patenting.

Apart from the analytical framework discussed above, one of the main contributions of the theoretical work carried out in this paper was thus a systematic literature review investigating the various factors that influence university patenting. The analytical framework developed on the basis of this literature review may be considered to be an important contribution in itself, since its utility as an analytical tool is not limited to the specific purposes of one study. Rather, the framework is an instrument that can also be used, possibly with some adaptation, in other empirical research on, and analyses of, university patenting. Moreover, in a much broader sense, most innovation studies (e.g. systems of innovation, triple helix, etc.) in this subject area tend to treat universities and TTOs or other organizations as the main units of analysis.[17] Most of the studies on UITT have thus sought to answer questions related to a central empirical focus on what universities and TTOs do. This study, on the other hand, has focused on individual inventors as well as the

[17] Treating heterogeneous organizations as homogeneous units is a general problem of economic thought (Wittrock 1993: 1 cited in Geuna 2001).

environment surrounding them. Therefore, the shift in the unit of analysis from universities to individuals may also be considered as another important theoretical and methodological contribution to UITT innovation studies. In addition to this study's methodology and its analytical framework, its in-depth empirical investigation of university patenting may be seen as another important contribution, and the study as a whole can be regarded as an important addition to the study of university-industry relations.

This study has emphasized that neither external nor internal factors by themselves provide sufficient causes or conditions for scientists to patent. Depending on the type of inventor – and the associated set of needs and expectations – the importance of both kinds of factors may vary, and merits further empirical investigation. This framework can be used as theoretical tool for such endeavours.

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