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EXPLORING CONNECTIVITY

Invention, innovation and knowledge transfer in the university-industry interface

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EXPLORING CONNECTIVITY: Invention, innovation and knowledge transfer in the university-industry interface

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To my family: Magnus, Fredrika, Oscar and Carl

“Invisible threads are the strongest ties”

– Friedrich Nietzsche

ABSTRACT

Universities are expected to create knowledge and be involved in knowledge transfer with society. This is accomplished through the universities' three missions; 1) teaching, 2) research and 3) innovation and social engagement. The focus of this thesis is knowledge transfer for the purpose of innovation in the university-industry interface.

Policy makers have strong faith in innovation and emphasise the importance of innovation and knowledge transfer in the intersection between universities and industry for future economic growth and employment. University scholars have, in the multi-disciplinary field of innovation studies, spent considerable effort to shed light on knowledge transfer processes and to investigate the myriad of mechanisms through which knowledge is exchanged. For instance, efforts have been made to measure knowledge transfer itself or the outcomes of knowledge transfer. A better understanding of knowledge transfer processes, outcomes and impact could provide a foundation for more efficient and tailored innovation support infrastructures, regulations and management of university-industry interaction. However, many prior studies are built on quantitative and unidimensional methods, often based on statistics that either over- or under estimates innovation and knowledge transfer.

This thesis argues that there is a need to widen the perspective to get a better understanding of the knowledge transfer activities taking place in the university-industry interface. Also, there is a need of a more comprehensive innovation statistics and metrics in the university innovation interface. This thesis draws on, and aims at contributing to the research areas of university-industry relations, knowledge transfer and social network theory. Thus, this thesis addresses the question of *how the mapping of 'hidden' connections could provide insights into the management of knowledge transfer in the university-industry interface.*

The four included papers address this overarching question in different ways with different methodological approaches. Based on the problem of lacking statistics on university patenting, ***Paper I*** investigates how inventive productivity can be measured in the academic setting. ***Paper I*** also introduces the Karolinska Institutet Intellectual Property (KIIP) project which included a description of the construction of the KIIP database. The KIIP database contains comprehensive statistics on patented inventions derived from Karolinska Institutet between 1995 and 2010. ***Paper II,*** is a longitudinal study of knowledge transfer paths from the university to third parties. It suggests the ABC-framework of patent ownership transfer modes. Using social network analysis, ***Paper III*** investigates the board network structure, composition and evolution of 65 university spin offs. Findings show that investors hold central network positions in the network over time and are therefore in a position to both facilitate and hinder knowledge transfer. Results also show that the board network has a stabile 'small word' feature over time indicating dense clustering and short transfer distances across the network. ***Paper IV*** takes an individual level perspective and addresses the question of how individuals search for knowledge to solve problems in product development processes. Based on grounded theory methodology, an emergent theoretical framework of individual level knowledge search processes is suggested that emphasises the importance of social networks.

In conclusion, the findings of this thesis suggest the there is a need to apply a more holistic and multi-level methodological and theoretical perspectives to gain better understanding of knowledge transfer in the university-industry interface. This includes building comprehensive innovation statistics, applying analysis methods, such as social network analysis on micro-, meso- and macro level, developing qualitative impact oriented innovation measures, and using pedagogical strength of social network visualisations. By bringing such ‘hidden’ connections to the surface a more tailored management of knowledge transfer and innovation support systems could be developed.

LIST OF SCIENTIFIC PAPERS

I. **Dahlborg*, C.**, Lewensohn*, D. and Sundberg, C.J., 2013, Investigating inventive productivity at Sweden's largest medical university, International Journal of Technology Transfer and Commercialisation 12((1/2/3)), 102–120.

II. **Dahlborg, C.**, Lewensohn, D., Danell, R. and Sundberg, C.J., 2016, To invent and let others innovate: a framework of academic patent transfer modes, The Journal of Technology Transfer, 1-26.

III. **Dahlborg, C.**, Lewensohn, D., Sundberg, C.J., The anatomy of a university spin-off network – a longitudinal study of company board interlocks and affiliations (Manuscript)

IV. **Dahlborg, C.**, Vindefjärd Nilsson, A., Sundberg, C.J., Searching inside and outside – how individuals find knowledge through formal and informal social networks (Manuscript)

Other relevant publications:

Lewensohn, D., **Dahlborg, C.**, Kowalski, J. and Lundin, P., 2015, Applying patent survival analysis in the academic context, Research Evaluation 24 (2): 197-212.

*Equal contributions

CONTENTS

LIST OF ABBREVIATIONS

TTO	Technology Transfer Office
KIIP	Karolinska Institutet Intellectual Property
KI	Karolinska Institutet
SNA	Social network analysis
IP	Intellectual Property
BoD	Board of Directors
SME	Small and medium sized enterprise
MNE	Multinational enterprise
USO	University spin-off

PREFACE

‘So, you are from Sweden’, I was asked during a trip to New Zealand. ‘Maybe, you know a Sara Nilsson?’ She lives in Stockholm too! I am not the first person who has been asked such a question and actually, it is not as far-fetched as it might sound. According to Stanley Milgram any person has just ‘six degrees of separation’ to any other person.

The small world phenomenon as Watts (1999) explains it:

> The small-world phenomenon formalises the anecdotal notion that ‘you are only ever “six degrees of separation” away from anyone else on the planet.’ Almost everyone is familiar with the sensation of running into a complete stranger at a party or in some public arena and, after a short conversation, discovering that they know somebody unexpected in common. ‘Well, it’s a small world!’ they exclaim. The small-world phenomenon is a generalised version of this experience. The claim being that even when two people do not have a friend in common, they are separated by only a short chain of intermediaries.

This thesis is about connectivity. Actually, almost everything is connected. There is evidence all around us if we just want to notice it. In all scientific disciplines phenomena can be explained through interconnectedness.

Networks appear everywhere around us. In nature network patterns appear when ants scout their environment to bring resources back to the anthill. In the human body, blood vessels carry blood and exchange gases, nutrients and waste. The neural system transfers signals from one part of the body to another. Humans construct their whole society in networks and sub-networks, such as transport routes linking important locations, internet providing us with information and communication. People are part of networks of family members, friends, friends of friends, sport teams, social clubs, professionals, experts, and leadership networks, etc.

If we can better understand connections and the role and contribution of its parts, I believe that we can gain a better understanding of the world that we live in. This kind of thoughts and insights is what once made me want to do research. Curiosity!

Charlotta Dahlborg

1 INTRODUCTION

Sweden is generally known to be an innovative country with a track record of ground-breaking inventions. In international innovation rankings Sweden often receives top positions. For example, Sweden scored second place in both the *2017 Bloomberg Innovation Index*[1] and the *Global innovation index 2016*[2], as well as a first place in the *2016 European Innovation Scoreboard*[3]. Similarly, when universities are ranked for their educational and research quality in the *Shanghai Ranking 2016*[4], three Swedish universities are placed in the top 100 in the world.

Given these strong performances, it can seem surprising that when Reuters[5] ranked the world's top 100 <u>innovative</u> universities, in 2015 and 2016, there were no Swedish universities on the list. How is that possible?

It all comes down to, on one hand the difficulty of mapping innovation and knowledge transfer, and on the other hand a problem of the quality and accuracy of underlying innovation statistics. Knowledge can be transferred between universities and industry through a large number of mechanisms and channels such as education, scientific publications, patents, licences, collaborations, contract research, advisory boards, spin-offs etc. (D'Este and Patel, 2007, Perkmann, et al., 2013). Contemporary innovation measures to assess university-industry knowledge transfer are often one-dimensional and are merely used due to the availability and ease to compile the underlying data (Grimaldi, et al., 2011, Perkmann, et al., 2013). Hence, there is a risk that policy makers and university managers alike make decisions based on non-comprehensive statistics. Another risk is that potentially valuable inventions are not further developed into medicines for the benefit of patients and missed regional economic growth.

In the last decades, innovation and university commercialisation have become a high priority topic for policy makers and academic researchers alike. In the wake of the knowledge economy, universities have been identified as important producers of knowledge and contributors to economic growth. Universities are expected to create knowledge and be involved in knowledge transfer with society. This is accomplished through the universities' three missions; 1) teaching, 2) research and 3) innovation and social engagement. The increased pressure on universities to disseminate knowledge through the 'third mission' has increased the interest in both new organisational and managerial solutions to facilitate and incentivise university knowledge transfer and industry relationships (Rasmussen, et al., 2006).

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[1] https://www.bloomberg.com/news/articles/2017-01-17/sweden-gains-south-korea-reigns-as-world-s-most-innovative-economies

[2] Global innovation index (2016) https://www.globalinnovationindex.org/home

[3] European Innovation Scoreboard 2016, http://europa.eu/rapid/press-release_IP-16-2486_en.htm

[4] 2016 Academic Ranking of World Universities (ARWU). Karolinska Institutet was ranked in place 44 followed by Uppsala University in place 60 and Stockholm University in place 81. http://www.shanghairanking.com/World-University-Rankings-2016/Sweden.html

[5] To create the ranking of the world's most innovative universities, Reuters News relied on data compiled by Thomson Reuters Intellectual Property & Science and several of their research platforms: InCites, Web of Science, Derwent Innovations Index, Derwent World Patents Index and Patents Citation Index.

In accordance with their responsibility to disseminate knowledge through commercialisation, many universities have developed technology transfer organisations (TTOs), science parks and incubators (Algieri, et al., 2013, Clausen and Rasmussen, 2011, Debackere and Veugelers, 2005, Etzkowitz and Goktepe-Hulten, 2010, Hackett and Dilts, 2004). This development has also led to an interest and need to measure knowledge transfer output and performance.

The knowledge economy is increasingly driven by intangible values such as knowledge, creativity and inventiveness. Research and innovation in highly dynamic and distributed knowledge environments, such as the biotechnology depend heavily on the exchange of knowledge, human capital and social capital between scientists in universities and in firms (Murray, 2004, Owen-Smith and Powell, 2003, Powell, et al., 1996). As firms become more dependent on accessing knowledge from external sources, such as universities, research institutes and universities, the locus of innovation is shifted into networks of innovation (Balconi, et al., 2004, D'Amore, et al., 2013, Østergaard, 2009, Owen-Smith and Powell, 2004, Powell, et al., 1996). Innovation processes are often overly simplified and described as linear with well-defined stages. However, innovation processes and knowledge transfer have been shown to be complex, dynamic and context specific (Clarysse, et al., 2005, Vohora, et al., 2004).

This has driven university scholars in the multi-disciplinary field of innovation studies spent considerable effort to shed light on knowledge transfer processes and to investigate the myriad of mechanisms through which knowledge is exchanged. For instance, efforts have been made to measure knowledge transfer itself or the outcomes of knowledge transfer, however many prior studies are building on quantitative, unidimensional methods often based on statistics that either over- or under estimates innovation and knowledge transfer.

This thesis argues that there is a need to widen the perspective to gain a better understanding of the knowledge transfer activities taking place in the university-industry interface. This could be done by studying invisible trails of knowledge transfer in networks of tangible and intangible innovation activities and social interactions. This also depend on the compilation of a more comprehensive innovation statistics. This thesis draws on, and aims at contributing to the research areas of university-industry relations, knowledge transfer and social network theory. A better understanding of knowledge transfer processes, outcomes and impact is believed to provide a foundation for more efficient and tailored innovation support infrastructures in universities and knowledge management in industry.

1.1 RESEARCH QUESTION

The overarching research question of this thesis is:

How can mapping of 'hidden' connections provide insights into the management of knowledge transfer in the university-industry interface?

The four independent papers presented in Table 1 address the overarching research question in four different ways.

Table 1 Overview of Paper I-VI of the thesis

Paper	Question	Problem	Results
I	How can inventive productivity be measured in the academic setting?	Statistics on university patenting is lacking leading to limitations in innovation management and fact deficits policy debates	1. Inventive productivity mapping of KI 2. Alternative measurements of inventive productivity
II	How are academic patents transferred between academic and external inventors over time?	Limitations in the knowledge of the relative contributions of transfer modes and type patent recipients may lead to a less fitted innovation support	The ABC-framework of technology transfer modes through patent ownership transfer identifying the Autonomous, Bridge and Corporate transfer modes
III	What does the board network structure of the of university spin-offs (USOs) look like and how does it evolve over time?	The board network structure and composition can affect the extent of knowledge access of USO and thus be essential for their innovation and growth. Studies on board-network evolution of USOs are limited.	1. Investors hold central network positions over time 2. BoD network has small work features over time
VI	How do individuals search for knowledge to solve problems in product development processes?	Individual level knowledge search in USOs are lacking leading to lack of theoretical foundation	1. Emergent theoretical framework of individual level knowledge search 2. Typology of knowledge search paths

1.2 OVERVIEW OF THE THESIS

This thesis consists of six chapters. Chapter 1 introduces the topic of the thesis, its rational and the overarching research question. Chapter 2 summarises previous research relevant to the thesis. Chapter 3 describes the methodology including the empirical context, research design, data collection and the analysis. Chapter 4 discusses the results and main findings in the four independent papers. Chapter 5 are the findings of the thesis discussed and implications for theory development and practitioners suggested. Finally, Chapter 6 follows the final conclusion.

2 PREVIOUS RESEARCH

This thesis draws on tree main research streams, university-industry relations (Aalbers, et al., 2013, Bercovitz and Feldman, 2006, Bozeman, et al., 2013, Etzkowitz, et al., 2000, Leydesdorff and Etzkowitz, 1996), knowledge transfer (Agrawal, 2001, Argote and Ingram, 2000) and social network theories (Burt, 2000, Freeman, 1991, Friedkin and Johnsen, 1997, Hansen, et al., 2011, Mosey and Wright, 2007, Uzzi, et al., 2007).

2.1 UNIVERSITY-INDUSTRY RELATIONS

Universities play an important role in generating and transferring new knowledge to society. One of the strongest motivations for encouraging academic knowledge transfer is that research funded by tax payers should benefit society by spurring economic growth and welfare. Therefore, in the last decades, there has been an increased focus, both by policy makers and universities themselves, to promote university-industry links and university technology transfer (Etzkowitz and Leydesdorff, 1997, Etzkowitz, et al., 2000). This trend has also been mirrored by a growing interest in this subject in academic literature (Rothaermel, et al., 2007).

It has been argued that especially research and innovation in industries that are characterised as dynamic with a distributed knowledge environments, such as science-based industries, depend on the exchange of knowledge between scientists in universities and in firms (Pavitt, 1984). The development of the biotechnology industry in the 1980s and 1990s has driven university-industry interactions and knowledge transfer (McKelvey, 1996). The main actors in the university-industry interface are not only universities and firms, but also the government and investors and other financiers (Figure 1).

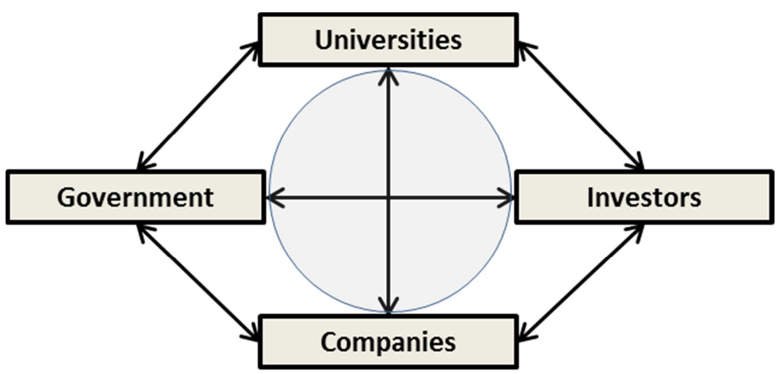

Figure 1 Central actors in the university-industry interface

Main empirical evidence of the growing relationships between universities and firms are (i) university-industry collaboration (Ankrah and Al-Tabbaa, 2015, Bodas Freitas, et al., 2013, Bozeman, et al., 2013), (ii) patenting by universities (Baldini, 2006, Baldini, et al., 2007, Crespi, et al., 2011, Ejermo and Lavesson, 2012, Geuna and Nesta, 2006), (iii) university spin-offs (Gübeli and Doloreux, 2005, Lockett, et al., 2005, Rasmussen, 2011, Rasmussen and Wright, 2015) and (iv) joint authorship of articles by university and industry researchers (Lissoni, 2010, Nelson, 2009). Regardless of the large literature on the interaction between university and industry, many researchers emphasize the current knowledge on the interaction are still limited. Especially regarding issues of systematic data analysis and the impact of knowledge diffusion between universities and firms (Geuna, et al., 2003, Geuna and Muscio, 2009, Hall, et al., 2003)

A central argument behind the enactment of the Bayh-Dole Act[6] in the US in 1980 was the need to create financial incentives for universities to promote and transfer inventions. This argument was based on an assumption that not enough technology transfer would occur without financial incentives for the university and a central coordination of technology transfer activities (Rafferty, 2008). In Europe, the ability of universities to translate publicly funded research into economic growth has been perceived as poor compared to the US. This perception is often referred to as 'the academic paradox' (Dosi, et al., 2006). In several European countries this has led policy makers to change the university intellectual property (IP) legislation to a university ownership model, i.e. Bayh-Dole Act type legislation (Geuna and Rossi, 2011).

The university ownership model gives the university the ownership stake of IP generated by their researchers. The opposite situation is called the inventor ownership model[7] where the university researcher owns the IP. Interestingly, recent studies have shown high levels of participation of academic scientists in patenting in Europe (Dahlborg, et al., 2013, Geuna and Nesta, 2006, Iversen, et al., 2007, Lissoni, et al., 2008, Meyer, 2003). According to Jacobsson et al. (2013), the 'academic paradox' builds on two main beliefs, namely that i) there are few university spin-offs generated and that ii) there is a scarcity of academic patents and licensing agreements. Based on Swedish patent and company data, Jacobsson et al (2013) and Lissoni et al (2008) have shown that the academic paradox is exaggerated and not based on adequate data. To remedy this gap, this thesis argues that there is a need to gain a deeper understanding of processes, stakeholders and outputs involved in academic knowledge transfer based on complete data on university related patents and multi-level analysis.

2.1.1 University commercialisation support

Many universities have established specialised structures, such as technology transfer offices (TTOs) and other organisational structures to support commercialisation (Chapple, et al., 2005, Clarysse, et al., 2005, Siegel, et al., 2007). Even though TTOs are only involved in a limited part of a university's overall technology transfer activities, most studies on technology transfer have taken place in a university ownership context, where TTOs are given a central role (Audretsch, et al., 2006). Some authors even argue that the TTOs have become bottlenecks and restrict effective technology transfer (Litan, et al., 2007). Similarly, Colyvas et al. (2002) question the marginal effectiveness of TTOs to market and transfer university inventions in general compared to the pathways generated by researchers. They suggest that it is only a limited number of embryonic inventions in need of further development and inventions in technological areas with limited links to industry

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[6] Enacted on December 12, 1980, the Bayh-Dole Act (P.L. 96-517, Patent and Trademark Act Amendments of 1980) enabled small businesses and non-profit organizations, including universities, to retain title to inventions made under federally-funded research programs (URL: http://www.autm.net/Bayh_Dole_Act/10117.htm; AUTM, Association of University Technology Managers August 27, 2013).

[7] In Sweden also referred to as the teacher's exemption or the professor's privilege (in Swedish: 'Lärarundantaget')

that benefit from TTO involvement. Bekkers and Bodas Freitas (2008) argue the importance of policy makers to allow for a variety of transfer channels, both formal and informal, since different channels are suitable in different contexts and serve different goals. Moreover, informal transfer channels are often an important catalyst for initiating more formal forms of transfer (Debackere and Veugelers, 2005).

In an inventor ownership regime, the choice of transfer channels is more open and it is up to the academic inventors themselves to choose transfer path. According to Bekkers and Bodas Freitas (2008) university researchers and industry use the channels that suit their purposes for interaction, even without external assistance. This give rise to complex networks of social relationships.

2.2 KNOWLEDGE TRANSFER

2.2.1 Knowledge

Knowledge is often considered to be the most valuable resource of an organisation and the basis for competitive advantage (Grant, 1996). Many scholars have stressed that an effective transfer of knowledge increases innovativeness of firms (Hansen, 2002). Yet, it is perhaps the most difficult resource to manage which is much related to its many characteristics (Cross, et al., 2001, Szulanski, 1996, Szulanski, 2000). The aim of this thesis is not to make a deep study of the concept of knowledge. However for the understanding of the challenges of transferring, identifying and, not least measuring knowledge a summative presentation of the descriptions of knowledge in prior literature is needed. Extensive efforts have been made to understand various types of knowledge, knowledge creation (Kidd, 1998, Nonaka, 1994, Nonaka, et al., 2006), knowledge absorption (Camisón and Forés, 2010, Cohen and Levinthal, 1990, Fabrizio, 2009) and its transfer and exchange.

Descriptions of knowledge types have often taken the form of dichotomies. Perhaps, the most common distinction is made between tacit and explicit knowledge (Brown and Duguid, 1991, Nonaka and Takeuchi, 1995). Explicit knowledge can be expressed in writing by words, numbers and specifications which make it relatively transferable via documentation, rules and procedures to individuals that have the ability to read and understand the language (Nonaka and Takeuchi, 1995). Still, absorbing codified knowledge is not automatic but requires prior knowledge and a common reference frame of the knowledge absorber (Jensen, et al., 2007). Tacit knowledge, on the other hand, is subjective, situational and tied to the individual's experience (Kidd, 1998), which is why it cannot be formalised, documented or communicated easily to others. Lundvall and Johnson (1994) distinguish between the four knowledge types, know-what (knowledge about the world), know-why, know-how (knowledge in the form of skills and competence) and know-who (*e.g.*, who knows what). These four types of knowledge are obtained in different ways and through different mechanisms. While know-what and know-why may be obtained through for example, books, lectures and data bases, the other two categories are gained through practical experience. However, the distinction between explicit and tacit knowledge has been criticised to be too simple, since only part of the knowledge can be codified (Cowan, et al., 2000, Johnson, et al., 2002). There is most often an element of tacit knowledge to each piece of knowledge (Kogut and Zander, 1993).

Knowledge is also described dependent on where it is contained. For instance, knowledge that is subjective and residing in the individual is termed personal knowledge (Polanyi, 1975) while organisational knowledge is evolve from organisational routines, practises and collective understanding in the work place (Tsoukas and Vladimirou, 2001).

2.2.2 Knowledge transfer mechanisms

Knowledge transfer has been defined as the process through which one unit is affected by the experience of another (Argote and Ingram, 2000). The creation and transfer of knowledge are considered to be a basis for competitive advantage in firms (Grant, 1996, Hansen, 1999). Common questions on knowledge transfer (Argote, et al., 2000) include how knowledge is transferred from one unit of an organization to another; what the factors are that facilitate or impede knowledge transfer in organizations; how organisations can be designed to promote knowledge transfer and what the implications of knowledge transfer are for economic performance.

Numerous studies have focused on understanding the complexity of university entrepreneurship and technology transfer (Bozeman, 2000, Cohen, et al., 2002, Cohen, et al., 2002, Etzkowitz, et al., 2000, Henderson, et al., 1998, Laursen and Salter, 2004, Rosenberg, 1990, Rothaermel, et al., 2007). One stream of research has focused on the multitude of channels of knowledge and technology transfer from university to industry, such as contract research, research partnerships, patenting, consulting, and founding of spin-off companies etc. (Cohen, et al., 2002, Perkmann, et al., 2012). Another stream has aimed at deciding the relative importance of different channels of technology transfer, making a distinction between formal and informal channels. Some authors have pushed the importance of informal knowledge output, such as collaboration and informal contacts (Cohen, et al., 2002, Meyer-Krahmer and Schmoch, 1998).

A survey by Cohen et al. (2002) showed that firms pointed out publications, open scientific communication and consulting to be the most effective channels through which they benefit from university knowledge. Similarily, Bekkers and Bodas Freitas (2008) asked university and industry practitioners to rate the relative importance among 23 distinct channels of knowledge and technology transfer. Both groups of practitioners found classic transfer mechanisms, such as peer-reviewed publications, other publications and personal contact, to be the most important. Other authors have argued that formal and codified knowledge output, such as patents and licensing, is the most important for industrial innovation (McMillan, et al., 2000, Narin, et al., 1997). An argument in favour of patenting and licensing is that firms need an exclusive right to an invention in order to pursue commercialisation, especially since university inventions often are in an embryonic stage (Thursby and Thursby, 2007). Patents also have a signalling effect for start-up companies and increases estimations of firm-value resulting in an increased likelihood of receiving venture capital and liquidity through initial-public offerings (Hsu and Ziedonis, 2008).

2.2.3 Academic patenting

Academic patenting is one mechanism to transfer university research to industry. Several studies have reviewed the research field of academic patenting (Agrawal, 2001, Baldini, 2006, Lissoni, 2012, Mowery, 2005, Thursby, et al., 2009). For example, in Sweden, Italy and France, it has been shown that between 4% and 5% of academic researchers have filed a patent and that these levels are comparable to US universities (Balconi, et al., 2004, Lissoni, et al., 2008). One important observation has been the difficulty of tracking academic patents since a majority of patents are not owned by universities. For that reason, comprehensive statistical information on European academic patents has been scarce (Geuna and Nesta, 2006). As a result, a search for a university name in patent databases only covers a small share of the overall patenting activity of that university. Accordingly, scholars have started to assemble academic patent data by matching names of researchers as inventors with patent data (Balconi, et al., 2004, Iversen, et al., 2007, Lissoni, et al., 2008, Meyer, 2003, Thursby, et al., 2009). Researcher name-matching, rather than university-name matching, makes it possible to better compare inventive productivity across universities and countries (Dahlborg, et al., 2013). This is especially important for identification of university inventors in countries that are or have previously been subject to inventor-ownership-like legislation. In the European context, it has been shown that university ownership is often less than 10% (Lissoni, et al., 2008).

This result is to be expected considering a university subject to an inventor ownership model, which allow for an “open market” for technology transfer services. At the same time, and as argued by Aghion and Tirole (1994) and Kenney and Patton (2009), scientists subject to an university ownership model appear to bypass their TTOs, merely giving it formal, rather than real authority. Results from other studies show that 42% of inventors out of a random sample of 3200 US academic inventors bypassed their institutions (Markman, et al., 2008) and that 26% of a sample of 5811 US academic patents were assigned solely to firms (Thursby, et al., 2009).

There have been different thoughts and opinions on whether free academic research and commercial interest are possible to combine. There have also been concerns that patenting and other commercial side activities of researchers could impact the overall quality and output of research negatively (Larsen, 2011). However, recent studies have shown a positive relation between research quality and innovation (Baldini, 2006, Fabrizio and Di Minin, 2008, Martínez, et al., 2013, Meyer, 2006). Moreover, there is a positive relationship between research quality and the probability of interaction with industry (Laursen, et al., 2010, Lee, 1996, Lissoni, 2010). Moreover, the establishment of a formal technology transfer structure has been shown to be positively related to commercialisation (Della Malva, et al., 2013, Markman, et al., 2005, Markman, et al., 2005).

2.3 SOCIAL NETWORK THEORY

Growing empirical evidence points to the importance of social relationships and innovation networks to be the basis for knowledge transfer processes. An important means to find new knowledge is through relationships with other individuals. Phelps et al. (2012) stress that an increased understanding of knowledge networks and social relationships are crucial for the understanding of knowledge creation and economic growth. Innovation is fundamentally the result of knowledge recombination through interactions and knowledge exchange among individuals, groups, and organizations (Aalbers, et al., 2016, Bercovitz and Feldman, 2011, Brennecke and Rank, 2016, Hansen, et al., 2001, Henttonen, 2010).

Over the course of a life time, individuals develop different types of relationships to other people. These relationships form an informal social network including a large variety of relationships, such as family, friends, acquaintances, neighbours, colleagues, etc. Such social relationships and the potential resources that can be accessed through them are, in the literature, referred to as social capital (Adler and Kwon, 2002, Bourdieu, 1985, Coleman, 1988, Granovetter, 1973). The idea of social capital theory is that social ties can be used to access resources that are otherwise outside the knowledge scope of the individual or organisation. Coleman (1988) refers to this as the "appropriability" of social structure, meaning that one type of social relationships (*e.g.,* family or friendship) can be used for another purpose, (business), such as receiving advise or access other work related resources. For example, an individual's social relationships can be used to find employment (Granovetter, 1973, 1995; Lin & Dumin, 1996; Lin, Ensel, & Vaughn, 1981) and a firm can use the social relationships of its employees to find potential new employees by widening the search scope (Fernandez, Castilla, & Moore, 2000). Relationships that generate positive outcomes are usually based on trust (Amesse and Cohendet, 2001), frequency in interaction (Amesse and Cohendet, 2001, Bozeman, 2000) and distance between knowledge base, culture, norms (Amesse and Cohendet, 2001, Cohen and Levinthal, 1990). Whether network ties are strong or weak depend on the amount of trust invested in the relationship (Granovetter, 1973). Strong and close ties are associated with more trust, while weak ties are more casual acquaintances.

There are many, slightly different, definitions of social capital in the literature (see Adler and Kwon (2002) for a review). In the present article, we consider both internal and external social relationships to be suitable definitions. The definition by Nahapiet and Ghoshal (1998) is "Social capital is the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit. Social capital thus comprises both the network and the assets that may be mobilized through that network".

There is a myriad of relationships that span individuals, organisational and geographical boundaries form constellations of knowledge networks (Aalbers, et al., 2004, Amin and Roberts, 2008, Asheim and Coenen, 2005, Phelps, et al., 2012) and networks of innovation (Aalbers, et al., 2013, Choi, et al., 2013, Deroïan, 2002, Holmen, et al., 2005). In university-industry interactions in not only driven by a search for new technologies and knowledge. For instance, based on a study of biotechnology firms and their academic inventors, Murray (2004) shows that academic scientists contribute both human and social capital to entrepreneurial firms. The social capital of academic scientists is critical to firms because it can be transformed into scientific networks that embed the firm in the scientific community through a variety of mechanisms. Moreover the social capital of the academic inventor is shaped by the career paths. The scientific careers facilitate the networks and potential for embeddedness that an academic inventor brings to a firm. Murray (2004) highlights two parts of the social network of the academic inventor, the laboratory network and the cosmopolitan network. The laboratory network is the network that derives from the laboratory life, namely current and former students and advisors. The cosmopolitan network is the network of colleagues and co-authors established through collaboration, collegiality and competition.

3 METHODOLOGY

The studies in this thesis apply three different methodological approaches (Table 2). ***Paper I*** and ***II*** are based on quantitative analysis of patent information based on the Karolinska Institutet Intellectual Property (KIIP) database, ***Paper III*** is based on social network analysis of board of directors in university spin-offs, and ***Paper IV*** has a qualitative approach and is based on grounded theory methodology.

Table 2 Overview of the applied methodologies in Paper I-IV

Paper	Method	Unit of analysis	Data	Sample	Analysis method
I	Quantitative, longitudinal	Inventors and patents	KIIP database, Patents and academic inventors	437 inventors 703 inventions	Patent information analysis Descriptive statistics
II	Quantitative, longitudinal	Patent and patent owners	KIIP database, Patents information and company data, Patent owner data over time	703 inventions	Patent information analysis Descriptive statistics
III	Quantitative, longitudinal	Board directors in USOs	KIIP database, board of directors in USOs	65 USOs, 594 board directors	Social network analysis
VI	Qualitative, longitudinal	Individuals in SMEs	Interviews in biotechnology SMEs	Four case firms, 29 interviews	Grounded theory methodology, Inductive case-study and content analysis

This chapter is first the empirical setting of the Swedish biotechnology industry and specifically the case of Karolinska Institutet introduced. After that, the methodological considerations including the research design, data selection and collection, as well as methods of analysis methods used in the four studies are presented. This chapter also presents the Karolinska Institutet Intellectual Property (KIIP) project and the methodological steps of building the KIIP database, which constitutes an important foundation for ***Paper I-III***. Limitations in the applied methodologies are also discussed.

3.1 RESEARCH DESIGN

3.1.1 Empirical setting

Sweden is one of the few countries where the teacher's exemption is applied. This implies that university faculty own patents on their inventions stemming from research that is largely publicly funded. However, the legislation does not prevent researchers from transferring their rights to the university, to companies or to other collaboration partners. Researchers are also free to apply for patents by means of the internal university innovation system.

Karolinska Institutet (KI) is Sweden's largest and one of Europe's largest medical universities. The university was established in 1810, and is the third-oldest medical school in the country. KI is internationally well- renowned for its research excellence and is often ranked among top 15 in the Shanghai rankings in the area of Clinical Medicine and Pharmacy (Academic Ranking of World Universities, 2013). The Nobel Assembly at

Karolinska Institutet annually awards the Nobel Prize in Physiology or Medicine. Almost 30% of all researchers at Swedish academic medical faculties are employed at KI (Statistics Sweden). Moreover, more than 40% of all Swedish academic medical research is performed at KI (Karolinska Institutet, 2013). Alongside the university is the research hospital, the Karolinska University Hospital and many physicians are affiliated with both the university and the hospital.

Since 1995, at KI, there has been an increased emphasis on the creation of an innovation support infrastructure, including the establishment of a TTO. In addition, in 2009, KI was one of eight universities selected for government funding to establish 'Innovation Offices' with the aim of supporting researchers in their commercialisation efforts.

3.2 DATA COLLECTION

3.2.1 The Karolinska Institutet Intellectual Property (KIIP) project

In Sweden, there exists no systematic collection of statistics on university patenting or other academic commercialisation activities, such as university spin-offs. Put differently, as of today, there is no information of the patent output from Swedish universities.

Therefore the objective of the KIIP-project was to fill that gap and compile longitudinal patent information on patented inventions generated by researchers at KI between 1995 and 2010. The aim was twofold. Firstly, the aim was to use KI as a case to investigate patent related output as well as invention and innovation processes at Sweden's largest medical university. Secondly, the aim was to develop a method (the KIIP-methodology) to identify academic inventors and their patents that could be used at other universities. The KIIP-project was performed as a part of two dissertation projects at the Unit for Bioentrepreneurship, Department of Learning, Informatics, Management and Ethics at KI[8].

Longitudinal data was deemed necessary to be able to answer research questions of knowledge transfer trends. The time period covered is from January 1995 until November 9, 2009. The full year of 2009 is not covered due to the 18 month delay of publication of patent application after patent filing. The patents were downloaded in May 2011. The year of 1995 is interesting as it was the year of initiation of the innovation support system at Karolinska Institutet. The KIIP database covers data on patents (dates related to the patent process, patent jurisdictions, technologies, patent owners, legal status information etc.), inventors (academic position, department, research groups etc.), and companies (type of company, size, status, country, board of director information etc.).

The KIIP-methodology is a name-matching methodology that combines semi-automated stages with manual steps. The detailed process of building the KIIP-database is described in ***Paper I***, p106-110 (Dahlborg, et al., 2013). However, the mains steps are summarised below with some added aspects and explanations.

The KIIP-methodology involved the following main steps (see Figure 2):

[8] The Karolinska Institutet Intellectual Property (KIIP) project was developed on the initiative of Danielle Lewensohn and Charlotta Dahlborg between 2011 and 2013 to constitute the basis for two separate dissertations.

1. Inventor identification through name- matching
2. Validation
3. Data cleaning, normalisation and data addition

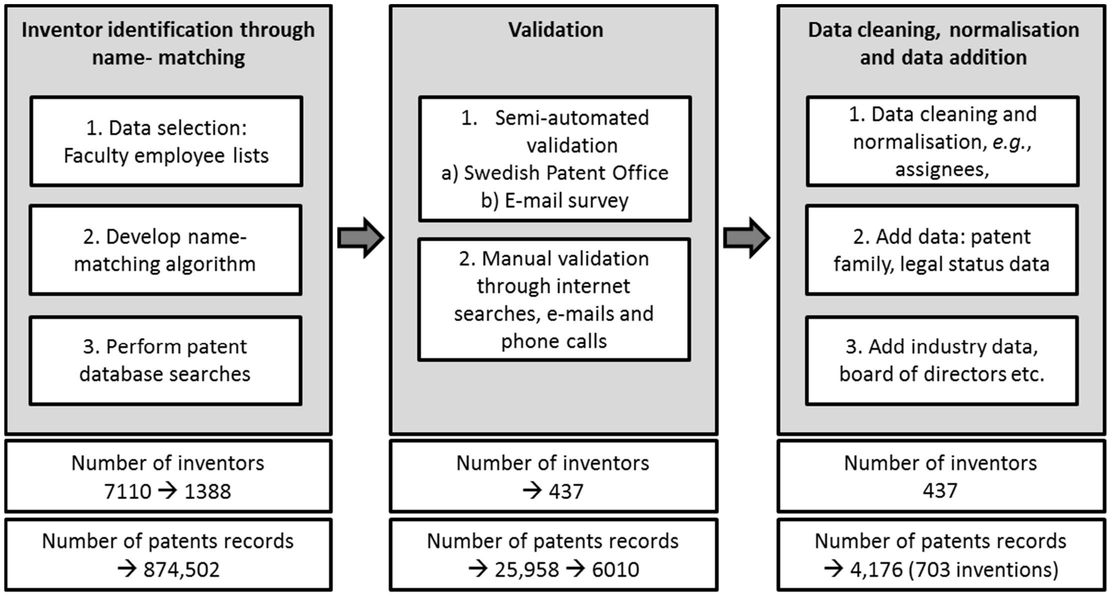

Figure 2 The KIIP-methodology; main steps in database development

KIIP database combines data from the following sources:

- Employee lists from Karolinska Institutet
- patent data from Innography®
- patent data from Thomson Reuters®
- manually collected and classified information on inventors and assignees, board of directors

3.2.2 Identification of academic inventors through name matching

Patents that are owned by a university are relatively straight forward to find in public international patent databases. The challenge arises when searching for patents generated by university researchers, but the patent is not owned by the university.

In Table 2 and 3 below are two hypothetical examples shown that illustrate how the same patent records could appear in a patent database under a 'university-ownership regime' and under an 'inventor-ownership regime'. The university inventor is '**Smith, D'** is inventor on all three patents in each scenario. In the university-ownership regime scenario all three patents would be found when searching for 'Karolinska Institutet' in the 'assignee field'.

Table 3: Example of a patent search in a university ownership regime

Appl. No.	Inventors	Source	Priority Date	Assignee
US945367	**Smith, D** | Liu, L | Dahl, R	US Grants	2004-09-27	Karolinska Institutet
GB2007046	**Smith, D** | Grey, A | Kim, J	WO Applications	2007-08-31	Karolinska Institutet
EP06343435	Grahn, K | Frei, J | **Smith, D**	EP Applications	2002-06-25	Karolinska Institutet

However, in the inventor-ownership regime scenario no patents would be found since the patents are owned by the inventor, the inventor's firm or a Pharma company. Interestingly, the patents are academic patents in both scenarios, but the second scenario would receive no hits.

Table 4: Example of a patent search in an inventor ownership regime

Appl. No.	Inventors	Source	Priority Date	Assignee
US945367	**Smith, D** | Liu, L | Dahl, R	US Grants	2004-09-27	Smith Inc.
GB2007046	**Smith, D** | Grey, A | Kim, J	WO Applications	2007-08-31	Smith, D
EP06343435	Grahn, K | Frei, J | **Smith, D**	EP Applications	2002-06-25	Merck

The common denominator between these patent records is the academic inventor name in the 'Inventor field'. Therefor similar to the methodologies applied by Meyer (2003), Baldini (2006a), Iversen et al. (2007) and Lissoni et al. (2008) a name-matching approach was developed to identify inventors.

The first step was to collect all the names of KI researchers employed in the time period between 1995 and 2010. The name lists were retrieved from Karolinska Institutet. After removing all non-researcher staff (technical an administrative), the final list contained 7,110 names of individuals that were employed during the targeted time period. Researchers on all hierarchical levels, from PhD candidates to Professors, were included in the data-set. Prior studies by, for instance Lissoni et al. (2008), have not included junior researchers. Each researcher was given a unique ID-number.

The second step was to search for all the researchers' names in patent databases. The private patent database Innography® was used. To enable an efficient search a name-matching algorithm was developed for the purpose to search for the researchers' names in the inventor field. The algorithm was constructed to take into account, for example, the employment period of the researcher, name variations due to special Swedish letters 'å', 'ä', and 'ö'. This patent search generated 1,388 inventors and 874,502 patent records. All data was assembled in an Access database.

3.2.3 Validation and normalization of inventors and patents

The validation and normalisation process included two steps; semi-automated validation and manual validation.

In the semi-automated validation the inventors (1,388) were separated into two groups depending on the number of patent hits related to the inventor. The inventors with more than 150 (131) were validated against the Swedish Patent Office or by email and phone calls. The second group was validated through combination of methods, by checking name combinations (see ***Paper I***, p 108-109), e-mail survey and finally manual validation. Through the email survey, we were able to obtain e-mail addresses for 365 of the remaining 1,032 inventors, which resulted in 120 responses and 61 confirmed inventors, 58 confirmed non-inventors and one was uncertain. The remaining 913 inventors had to be manually validated.

The manual validation was necessary to identify homonyms (Iversen, et al., 2007), *i.e.*, to distinguish real KI inventors from non-inventors with the same name (false positives). This was done through internet searches, e-mails and phone calls. The confirmation of true positives was done through three steps.

1. The IPC class, title, assignee and abstract or first claim would reveal is the patent is in the Life Science field
2. KI inventors were cross-searched against co-inventors in scientific publication databases
3. nationality and address information of the inventors in the original patent records

The validation process reduces the number of academic inventors to 437 that were associated with 6,010 patent records. Taking into account the existence of co-invention amount the academic inventors the final number of unique patent records was 4,176.

3.2.4 Adding and categorizing company information

After the validation procedure, additional data from complementary sources was linked to the database. From Thomson Innovation® was patent information such as patent legal status and patent family information added. That made it possible to aggregate the patent records into 703 inventions according to the INPADOC patent family definition.

The patent data included information on the patent owners of the inventions at patent filing and at patent download. The patent owner names needed normalisation due to misspellings and other variations. Each patent owner was categorised regarding type, size of entity, number of employees, geographic distribution and company status (Table 5). The categorisation included identifying university spin-offs defined by that the academic inventor was either a prior or current founder, board member, CEO or other leading management position in the firm. In total was 65 spin-offs identified. The spin-off information was later needed in ***Paper III*** for the retrieval of information on Board of Directors.

Table 5: Spin-off company statistics (Paper III)

Number of companies	65 companies
Categories	Private companies: 56 Public companies: 9
Status (2015-12-31)	Active: 50 Bankrupt: 3 Fusion: 4 Liquidation: 8
Registration period	1972 to 2010
Average age	12 years
Median age	11 years

The next step was to add information on board members. In Sweden is information on company board members is available from the Swedish Companies Registration Office (Bolagsverket). All generations of Board of directors were compiled from the foundation until the end of 2015 for each of the 65 spin-off firms that were registered in Sweden. Each board member was given a unique ID-number. Moreover, this data was complemented with affiliation information of each board member through a variety of Internet sources such as company reports, company webpages, LinkedIn®, ResearchGate® etc. The board members were categorised into position type, university inventor, university researcher, TTO affiliation or investor affiliation. As with all previous data, this data addition required an extensive cleaning procedure to ensure accuracy and to identify interlocks. The interlock information is crucial to perform social network analysis in ***Paper III***. An interlock appear when one board member hold multiple board positions. In the spin off sample had 20% of the 594 board members more than one board position. Table 6 show the interlock distribution. Moreover board tenure, number of board interlocks; age at the time of entering the board, genus was calculated or identified for all board members through public sources.

Table 6: Number of board positions among the board directors (Paper III)

No. board positions	No. of directors	Percent
1	474	79.8%
2	76	12.8%
3	23	3.9%
4	16	2.7%
5	2	0.3%
6	2	0.3%
9	1	0.2%
Tot:	594	100%

3.2.5 Case studies and interviews

The research methodology used in ***Paper IV*** was grounded theory (Glaser, 1992, Glaser and Strauss, 1967, Strauss and Corbin, 1998). Grounded theory has become a widely used research methodology in social sciences and business research (Lehmann and Gallupe, 2005, Urquhart, et al., 2010). It is an inductive methodology suitable when the theoretical foundation is limited, as was the case in ***Paper IV***. Therefore a case-based research design used (Eisenhardt, 1989, Yin, 1994). While ***Paper I*** and ***II*** investigated the knowledge originating at a university, ***Paper IV*** focused on biotechnology firms that were recipients of university knowledge. Even though the study objects were firms the study took an individual level perspective.

Four case firms were selected and were investigated over a two-year time period. Following the technique of theoretical sampling (Glaser and Strauss, 1967) the case firms were selected for their similarities and for their differences. For instance, they all were 1) operating in an industry with a dynamic and distributed knowledge environment (biotechnology or medical technology), 2) from the same region, and 3) dependent on patented university findings (Dahlborg, et al., 2013, Lawson, 2013, Meyer, 2006, Owen-Smith and Powell, 2003). The case firms differed regarding, 1) firm size[9], 2) firm origin, 3) strategy and culture (see Table 7). A full account of the characteristics of the case firms is found in Table 7.

[9] According to the European Commission definition of micro, small and medium-sized enterprises (SME) (http://eur-lex.europa.eu/legal-content/EN/LSU/?uri=CELEX:32003H0361).

Table 7: Selection properties of case study firms (Paper IV)

	Alphatech 'The bridge builder'	**Betacell 'The spider in the web'**	**Celliverse 'The multi-tasking marketer'**	**Bionew 'The hesitant collaborator'**
Industry	Biotechnology and medical technology	Biotechnology	Medical technology	Biotechnology
Location	Stockholm-Uppsala	Stockholm-Uppsala	Stockholm-Uppsala	Stockholm-Uppsala
Product development phase	Biotechnology & drug discovery: preclinical	Drug discovery: phase 1	Engineering, instruments	Drug discovery: phase 1
Firm-size	Small	Micro	Small	Medium
Firm origin	USO	USO	USOs merged with non-academic firms	Corporate origin
Strategy and knowledge refinement	Moving from biotech/ medtech towards drug discovery	Moving from diagnostics and service towards drug discovery	Moving from instrumentation to application	Moving towards becoming fully integrated and marketing oriented
Origin of university research	Local universities	Local university	Local universities	Local and international universities
Inter-connectedness	Strongly connected to various universities	Integrated into the university community	Relatively few university ties remained. Customer oriented.	Builds external ties through collaboration, in-licensing and acquisition
Collaboration culture	Academia is seen as the company's research department	Operates in academia through direct and indirect ties. A virtual organisation	Internal development, with focus on customer collaboration. Process oriented risk reducer	Foremost internal focus, but has identified the need to look outside the firm

The interviews were semi-structured interviews (Qu and Dumay, 2011, Rabionet, 2011). The interview guide (see Appendix 1) was used to guide the discussion in each of the five topics. However, all questions were not necessarily posed and often other questions were necessary. In general, the questions were posed as open-ended in order to stimulate the interviewee to talk relatively freely. Also a smaller number of project meetings were attended and recorded. Prior to the interviews a desk-top research was done to gain general understanding of the overall context of the firms.

Table 8 Overview of the empirical cases, number of interviews and interview time (Paper IV)

Function: / No. of interviews:	Alphatech	Betacell	Celliverse	Bionew	Time (h)
Management	1			2	5h
Business development	1	3	2	1	3.5h
R&D	1		2	3	8h
Project team	2		2	1	6h
Specialist function	1		1		1h
Scientific advisory board	1				1.5h
University	2	1			4h
Product management			1		1.5h
Financier	1				1h
Internal meeting			6	1	14h
External industry specialist					2.5h
SUM:	10	4	14	8	48 h

An overview of the types of interviewees and the number of interviews is found in Table 8. In total were 29 interviews performed that ranged between 50 and 120 minutes. They were recorded and transcribed for further content analysis in NVivo®.

3.3 DATA ANALYSIS

Figure 3 gives an overview of the different analysis methods applied in the four papers. The analysis methods will be more thoroughly presents further down.

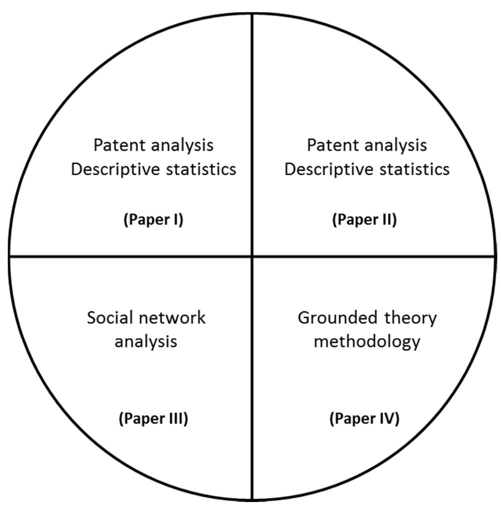

Figure 3: Analysis methods used in Paper I-IV

3.3.1 Patent information analysis

Patent information analysis was used in ***Paper I*** and ***II***. The data analysis in ***Paper I*** was descriptive statistics that was performed in the Access database and in Excel. It included developing various 'keys' to link different part of the data with each other as well as to identify appropriate representatives within, for example a patent family or in a patent jurisdiction.

In ***Paper II*** investigated longitudinal patent ownership transfers. As discussed in Paper I, the choice of patent metrics is crucial to assess an inventive productivity that best reflect the activity at the university. To answer the research question in ***Paper II*** it was relevant to trace what paths inventions take from the university setting to external actors. Therefore patent ownership transfer was traced for each invention (703).

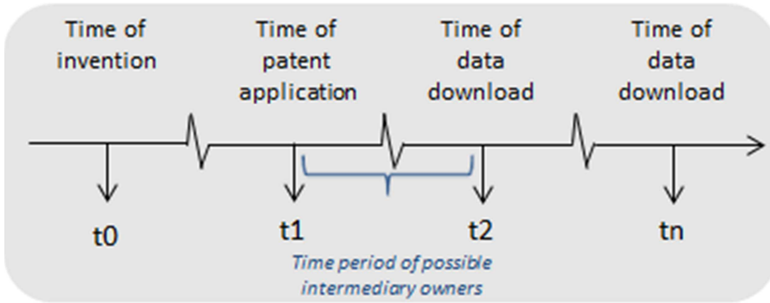

Figure 4 Method of analysing patent ownership changes over time. Information of ownership status at the events t0, t1, t2 and tn provide the empirical foundation (Dahlborg, et al., 2016).

The problem that arose was how to choose relevant patent family representatives for each invention. To include the maximum number of events, the *first published* patent document in a patent family was selected to represent to *t1* (original owner) and the *last published* patent document to represent at *t2* *(*current owner). Mostly, this resulted in two different patent records for each invention. The methodological model described in ***Paper II*** also allow for additional ownership transfers that could have occur during the time period between *t1* and *t2*, and at time points beyond *t2 (tn)* (see Figure 4).

3.3.2 Social network analysis

Social network analysis is an analysis method that is applied in many disciplines, such as mathematics, biology, biomedicine, psychology, sociology, economics and organisation and management studies. In all these disciplines are researchers interested in the nature of the network, its structural features. Networks consist primarily made of two types of components, namely nodes and edges. Nodes are the actors or people in the network and the edges that are the ties connecting the nodes.

A network can be analysed on a network level, where the characteristics overall network is at focus, or on an individual level, where the characteristics of certain nodes are investigated. In ***Paper III*** is a network of corporate-board-directors studied. The network structure arises as certain number of board directors has multiple board assignments in different firms simultaneously. The connection that is created when a board director has a double affiliation is called an interlock.

A network of corporate boards is an affiliation network, which is represented by a network with two types of nodes, firms and board members. This is called a two-mode-network or a bipartite network (Robins and Alexander, 2004). Edges can only be drawn between nodes of different types in a two-mode-network. A one-mode network has only one type of nodes. For the visualisations and network measures was the open-source software Gephi 0.9.1[10] used. The visualisation covers the full time period 1994 until end of 2015.

[10] https://gephi.org/

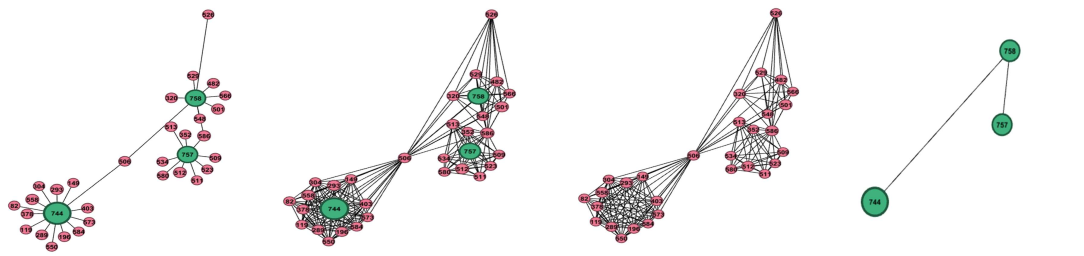

Figure 5 Two mode cluster involving three companies and 30 board members (first and second) and one-mode network projections to individual-level (third) and firm-level (fourth) (Paper III)

In order to be able to analyse the connections between individuals in Paper III, the two-mode network was restructured into a one-mode network. This was done by evacuating all 'firms' from the network and joining the individuals (see example in Figure 5).

To investigate the network over time it was divided into four intervals (*i.e.*, 1994 to 2003, 2004 to 2007, 2008 to 2011, 2012 to 2015) resulting in four snapshots of the network structure (see Figure 6). The first interval was nine years and the three later time periods each covered four years. Each time period had a larger main component and a varying number of small components consisting of one to seven companies.

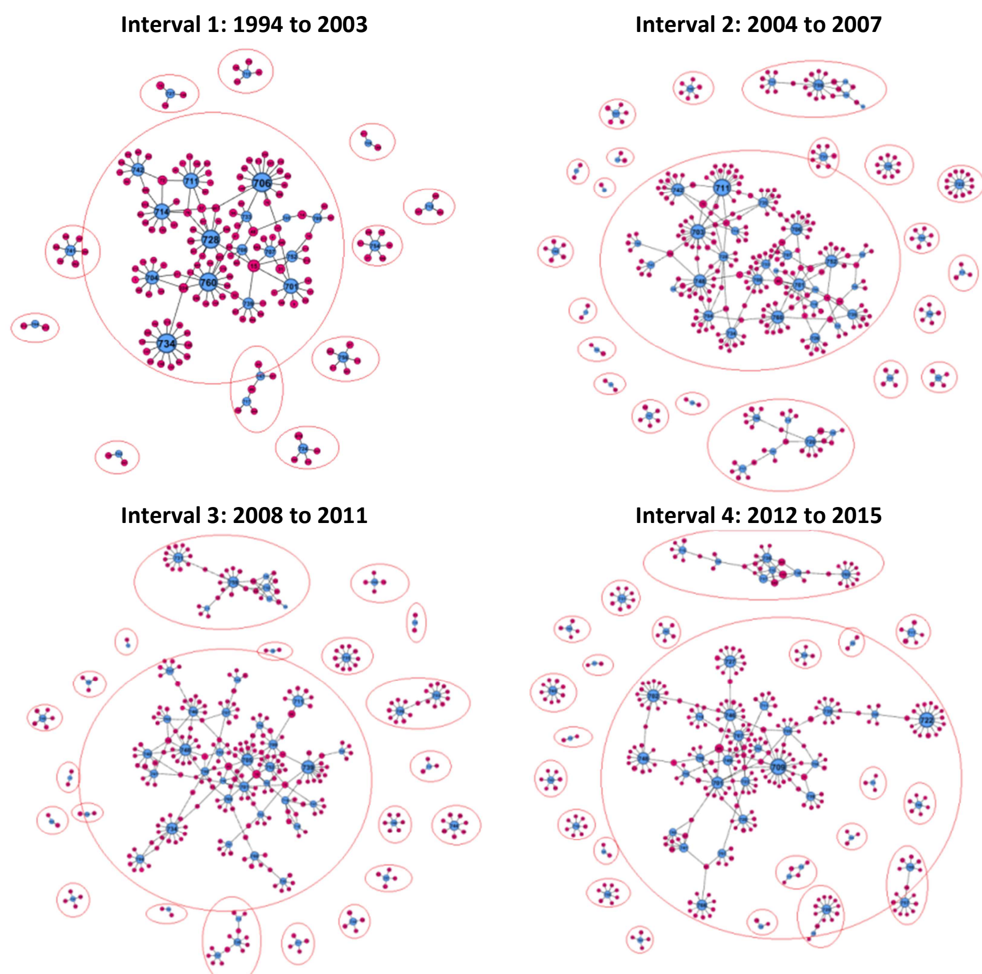

Figure 6 Two-mode networks at four time intervals indicating. Blue nodes are companies and red nodes are board members. Node size corresponds to the number of relationships (Paper III)

The network was analysed for four different centrality measures; degree, betweenness, eigenvector and closeness. Explanations and interpretation of the four centrality measures are found in Table 9.

Table 9 Explanation and interpretation of network central measures

Centrality	Explanation	Interpretation
Degree centrality	Measured by calculating the number of ties maintained by each board director in the network. The actor with the most ties has the highest degree and is most central.	Has access to information from others and is well positioned either to forward or block information (Valenti and Horner, 2010). Are the influential or powerful individuals in a network (Nohria, 1992).
Betweenness centrality	Measure of the number of times a board director serves as a bridge along the shortest path between other board directors in the network (Freeman, 1978).	Can fill an important information role as a broker or gatekeeper, filtering and importing information to the network with a potential for control over others. Where opportunities for brokerage exist, but have not been capitalized on are called structural holes (Burt, 1992, Burt, 2004).
Eigenvector centrality	Identifies well-connected nodes that are connected to other well-connected nodes.	Can influence many others in the network either directly or indirectly through the connections of their well-connected neighbours.
Closeness centrality	Identify individuals with close contacts. It is defined as the degree a node is near all other nodes in the network. It is calculated as the shortest path between a specific node and every other node in the network.	Low closeness indicates a more central board director with the ability to access information. Nodes that are close to each other are able to efficiently transmit information. Are relatively independent since they do not need to seek information from actors that are far away.

3.3.3 Analysis of the 'small world phenomenon'

When Stanley Milgram first analysed the small-world problem he did it using field experiments to trace chains of acquaintance (Milgram, 1967) by randomly investigating the distance between any two persons from the population. A randomly generated network is characterised by being sparse, *i.e.,* low clustering and long path length. Surprisingly, Milgram (1967) found that this was not true for social networks. Each individual has a relatively low number of friends and acquaintances in relation to, for example the country or world population. However it is likely that an individual's friends are also acquainted with each other, giving rise to local clustering. Later, Watts (1999) showed that only a very small number of interconnected nodes are needed to transform a 'big world' into a 'small world'. The mathematical calculations used to for small world analysis is presented below.

To measure the small world variable (SW) we first need to calculate clustering coefficient (CC) and the average path length (PL) (Watts and Strogatz, 1998).

$$SW = {Clustering\ Coefficient\ (CC)} \big/ {Path\ Length\ (PL)}$$

Clustering measures the tendency of nodes to cluster together. The clustering coefficient (CC) can be calculated, at the level of an individual node or as an average for the whole network. The clustering coefficient measures the likelihood that two neighbours of a node in a network are connected to each other. For unweighted networks, the clustering of a node i is the fraction of possible triangles through that node that exist (Saramäki, et al., 2007).

$$C_i = \frac{2t_i}{k_i(k_i - 1)},$$

Where t_i is the number of triangles through node *i* and k_i is the degree of *i*.

After having calculated the small world variable, that result needs to be compared to a random graph in order to decide whether the actual graph is significantly smaller or not (Watts and Strogatz, 1998). A random graph is created by randomly reproducing a graph that have the same number of nodes as the actual graph and the same degree distribution (Conyon and Muldoon, 2004). The degree distribution is the statistical distribution for the degree centrality all individual nodes in the actual graph. We generate 100 iterations of random graphs for the full period-graph as well as the for time intervals. We used NetworkX[11] to calculate the small world measures. The final step is to calculate the value of the small world ratio. We followed the method employed in similar studies (Davis, et al., 2003, Uzzi, et al., 2007), namely;

$$SW = \frac{CC\ actual}{CC\ random} \Big/ \frac{PL\ actual}{PL\ random}$$

A network can be interpreted as having small world characteristics when CC ratio is much greater than 1, and the PL ratio is approximately 1. The small world ratio should be much greater than 1.

3.3.4 Content analysis

The interviews in ***Paper IV*** were analysed using qualitative content-analysis (Eisenhardt, 1989, Smith, 2000). It allows for subjective interpretation of the content in text by systematically identifying themes or patterns in the data through classification and coding Hsieh and Shannon (2005). The analysis process followed the grounded theory methodology and but was adapted to the circumstances in ***Paper IV***. For example, as can be noted in the interview guide in Appendix 1, the interview questions cover broader topics than the specific research question in ***Paper IV***. This is in line with grounded theory, but it was a long and challenging process of coding and interpretation. It was much longer than it is possible to describe in a schematic process description as in Figure 6.

[11] https://networkx.github.io/

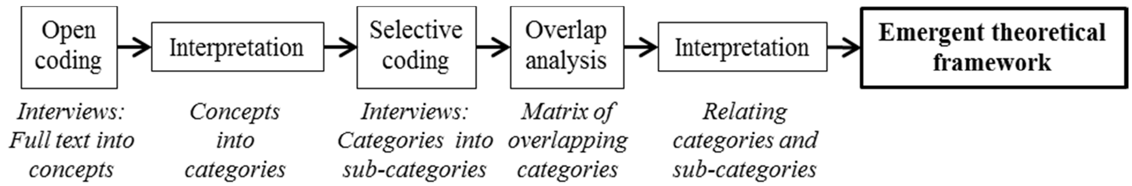

Figure 7: Data analysis process (Paper IV)

Data analysis was first performed through open coding in a combination of conceptual coding an in-vivo coding. (Glaser and Strauss, 1967, Strauss and Corbin, 1998). Important steps in the coding process were the workshops where it was possible to receive external feedback on the coding process.

4 RESULTS AND CONTRIBUTIONS FROM THE PAPERS

This thesis investigates how mapping hidden connections can provide insights into the management of knowledge transfer in the university-industry interface. This chapter presents the main results and contributions of the four included papers and demonstrates these papers addresses the overarching question of the thesis.

4.1 PAPER I

Paper I, *Investigating inventive productivity at Sweden's largest medical university* studied the extent to which university research is transferred into patents at one university during a time period of 15 years (1995-2010). In certain industries, such as the life sciences, patent protection is often a necessity for a company to invest in the development of an invention. Therefore, the filing of a patent can be seen an indication of an early step towards commercialisation of university generated knowledge. The paper demonstrated different ways to measure inventive productivity through patent counts in the academic setting.

Patents can be counted in a large number of ways and generate output measurements that affect the perceived productivity of academic patenting. Solely counting patents or inventions does not consider qualitative differences between patents. When only considering patent information it is not possible to foresee whether a patent will become a new product or if it will just stay on the office shelf of an academic inventor.

This is problematic since unless it is very clear exactly what is included in the calculation it is hard to know what is measured. Also, it becomes difficult to benchmark measures between different actors if the basis of the calculation differs. An output measure, such as the number of patents, is indicative of the inventive productivity, but does not tell us much about the actual impact of innovation activities.

To demonstrate the differences of perceived output of inventive productivity three ways of calculations are contrasted, namely number of patents, number of inventions and finally the KIIP-selection. The approach of the KIIP-selection is to select a patent family representative for each 1) patent application and 2) granted patent in 3) each jurisdiction. The rationale behind this selection method was to better reflect the commercial ambition and patent maturity of an invention. An invention was defined by the IMPADOC-family which clusters patent documents that are associated with one invention.

Table 10 Inventive productivity calculated in three ways using the same dataset (Dahlborg, et al., 2013)

No. of patents	No. of KIIP-selected patents	No. of inventions
4,176	3,313	703

Based on this logic and output measure, ***Paper I*** presents results of inventive productivity measured on the university level, faculty patenting and inventor level. The faculty patenting, defined as the ratio between inventors and all university researchers, yielded the 6.1% of the faculty had at least one invention (437 inventors/7,110 researchers). This result indicates a relatively high faculty productivity to be compared with available data on national level (4.1%).

The paper also reports the inventor productivity, defined as the ratio between inventions and inventors, for different sub-groups of the faculty and exemplifies those results based on inventions and the KIIP-selection. Unlike most prior studies, this paper includes junior researchers in the analysis and it can be concluded that this group's contribution to the overall patenting productivity should not be neglected. Moreover, results show that about half of the inventions originate from 35 inventors representing 8% of all inventors.

Table 11 Inventor productivity for different groups and subgroups of the faculty (Dahlborg, et al., 2013)

	No. of inventions/inventor	No. of KIIP-selected patents/inventor
All faculty	1.6	7.6
Senior researchers	1.8	8.3
Junior researchers	1.2	4.5
Postdocs	1.3	4.2
PhD students	1.1	4.9

4.2 PAPER II

Paper II - *To invent and let others innovate: a framework of academic patent transfer modes* traces the transfer of patent between multiple owners over time. This study extends previous research on academic commercialisation and knowledge transfer by investigating patent transfers from university inventors to third parties through a multitude of paths, simultaneously and longitudinally.

For the specific purpose of ***Paper II***, patent owners were identified at three time points, at the time of invention (*t0*), at the time of patent filing (*t1*), and last at the time of data download (*t2*). By connecting information on subsequent patent owners, the transfer of university derived knowledge could be uncovered, visualised and measured. Moreover, this analysis approach allows for continuous identification of patent owner status at any subsequent time point (*tn*). As patent ownership transfers have previously been identified as indicators of patent quality, the longitudinal approach makes it possible to, not only map the transfer pattern, but to map the value building process of academic patents.

A main result of ***Paper II*** was the ABC-framework of academic patent transfer modes that distinguishes between commercialisation initiated by researchers themselves (Autonomous mode), university support intermediaries (Bridge mode) or companies (Corporate mode) (see Figure 8).

The corporate mode, with 61% of the inventions, is the dominant transfer channel at the studied university (KI). The predominance of SMEs reflects that KI is a medical university and the characteristics if the Life science industry with small companies having a dominant role in early product development stages. While ***Paper I*** investigated the degree to which university knowledge have been converted into patented inventions, ***Paper II*** extends those results by tracing how that knowledge is transferred to entities downstream that have the ability to transform the inventions into commercial products. The university spin-offs studied in ***Paper III*** constitutes a sub-group of the SMEs in the autonomous mode and the bridge modes. The findings in ***Paper II*** have potential implications for benchmarking of universities and development of more targeted internal innovation support

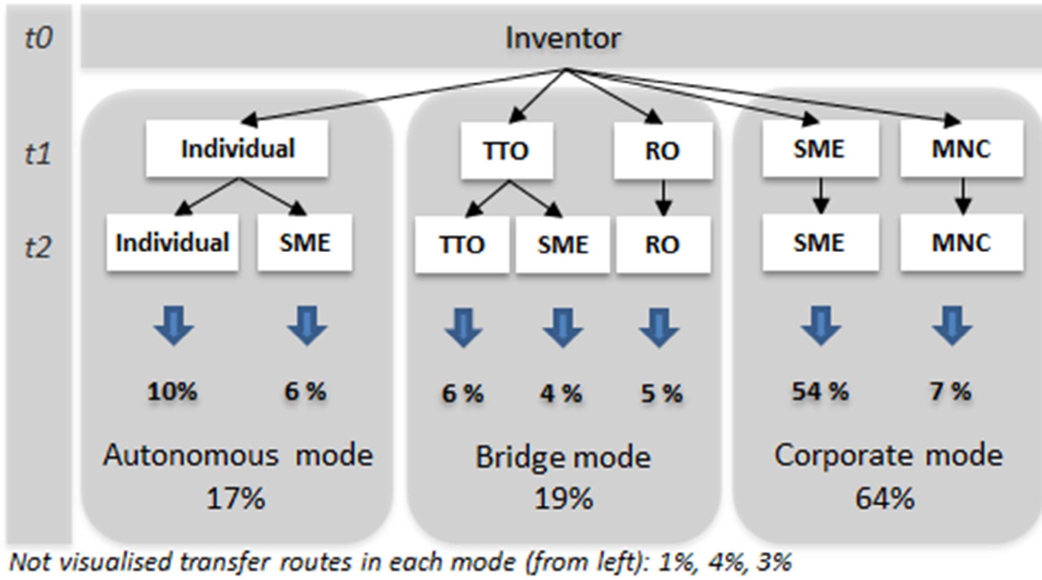

Figure 8 The ABC-framework of academic patent transfer modes illustrating the proportion of patents transferred from inventors at Karolinska Institutet to downstream entities (Dahlborg, et al., 2016).

4.3 PAPER III

Paper III, *The anatomy of a university spin-off network – a longitudinal study of company board interlocks and affiliations,* investigated the structure and composition of the BoD networks of 65 USOs derived from patented inventions at Sweden's largest medical university over a time period of two decades. Specifically it addressed the research question; *what does the network structure of the board of directors of university spin-off companies look like and how does it evolve over time?*

This paper extends the studies in ***Paper I*** and ***II*** by investigating the knowledge infrastructure through which knowledge and expertise in, for example, business development, strategy and product development, can flow to, and between spin-offs. Social network analysis is a powerful analysis method and tool as it uncovers 'hidden' social connections between individuals and firms. The analysis allowed for both network visualisations and calculation of the network centrality measures, degree centrality, betweenness centrality, eigenvector centrality and closeness centrality. The affiliation of the board directors as university researchers, type of investor and other in relation to their network position over time was investigated. Results showed that private and university investors held the most influential positions in the network over time.

Moreover, the small world quotient was analysed. A small world network is characterised by having a simultaneous high clustering and short path length. This gives an indication of the possible speed of diffusion of knowledge and practices throughout the network. The results indicated that the BoD-network of the university spin-off companies had the property of a small world in all time intervals. The small world ratio also indicate steady and increasing trend of small world characteristics over the years.

Table 12: Small world analysis of four time intervals and full time period (Paper III)

	N (% in interval)	Average degree	PL Actual	PL Random	PLr	CC Actual	CC Random	CCr	SW (CCr/PLr) >>1
1994-2003	155 (26%)	12.00	2.53	2.34	1.08	0.84	0.17	4.94	4.57
2004-2007	317 (53%)	13.69	2.86	2.49	1.15	0.85	0.10	8.50	7.39
2008-2011	371 (62%)	12.67	2.93	2.59	1.13	0.87	0.08	10.38	9.19
2012-2015	398 (67%)	12.23	3.06	2.63	1.16	0.90	0.07	13.70	11.79
1994-2015	594 (100%)	18.97	2.91	2.48	1.17	0.90	0.07	13.10	11.15

4.4 PAPER IV

Paper IV *- Searching inside and outside – how individuals find knowledge through formal and informal social networks* addressed the question of how individuals search for knowledge to solve problems in product development processes. The first aim was to contribute to the theory development of individual-level knowledge search processes and the second aim was to relate the findings to previous studies and to discuss implications.

Most research on knowledge transfer and knowledge search has focused on processes at an organisational level and often in inter-organisational arrangements. One rational behind ***Paper IV*** was the importance of individual social interactions and networks in knowledge exchange. Even though prior literature has stressed that importance the role of the individual in search processes was found to still be under-researched. Therefore, the unit of analysis of ***Paper IV*** was the individual. ***Paper IV*** investigated where and how individuals seek knowledge. Specifically, this paper explored if knowledge is sought internally or externally of the firm, and whether the individual's informal or formal social network is used. This study brings new insights into the search behaviour of the individual and how individuals contribute to knowledge creation in firms. The study was based on empirical evidence from interviews with representatives in four biotechnology firms. The interview transcripts were analysed following grounded theory methodology by applying content analysis. A knowledge search typology is developed consisting of four knowledge search paths; Strategic, Formalistic, Social exploration and Social exploitation. Based on grounded theory methodology an emergent theoretical framework of individual level knowledge search processes (Figure 9) is suggested that emphasises the importance of social networks. The findings suggest that the knowledge search process is highly iterative and that individuals need to employ a combination of knowledge search paths to find relevant knowledge, expertise and skills to solve a current problem. Findings also indicate that there seems to be a need for mechanisms that can facilitate the individual's use of the formal social network

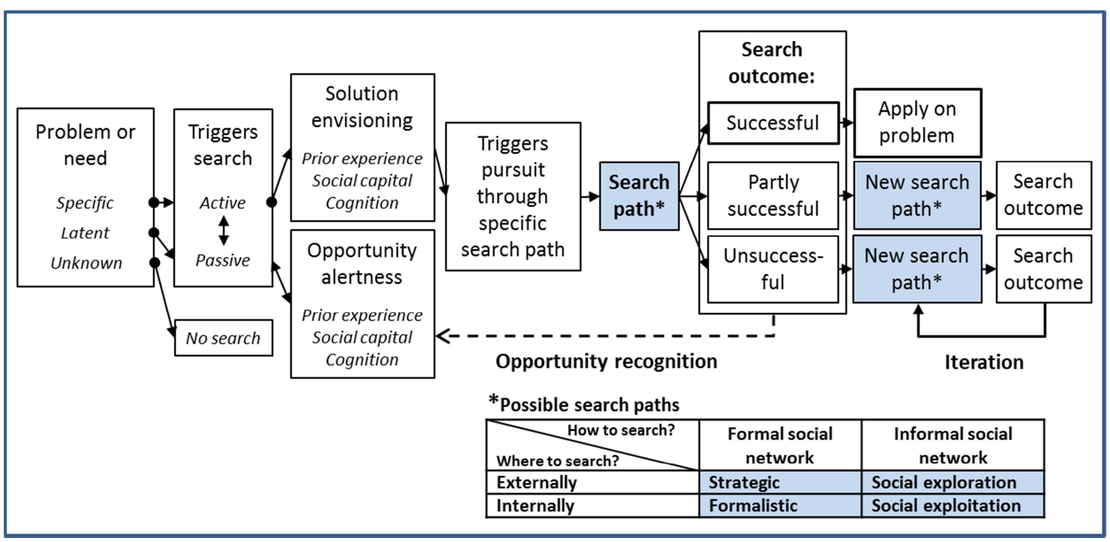

Figure 9 Emergent theoretical framework of individual-level knowledge search in firms (Paper IV)

4.5 SUMMARY OF THE RESULTS OF THE PAPERS

The four included papers address the overarching question in different ways with different methodological approaches (see Figure 10). Based on the problem of lacking statistics on university patenting, ***Paper I*** investigates how inventive productivity can be measured in the academic setting. ***Paper I*** also introduces the Karolinska Institutet Intellectual Property (KIIP) project which included a description of the construction of the KIIP database. The KIIP database contains comprehensive statistics on patented inventions derived from Karolinska Institutet between 1995 and 2010. ***Paper II*** introduces the ABC-framework of patent ownership transfer modes that is a longitudinal study of knowledge transfer paths from the university to third parties. Using social network analysis, ***Paper III*** investigates the board network structure, composition and evolution of 65 university spin offs. Findings show that investors hold central network positions in the network over time and are therefore in a position to both facilitate and hinder knowledge transfer. Results also show that the board network has a stabile 'small word' feature over time indicating dense clustering and short transfer distances across the network. ***Paper IV*** takes an individual level perspective and addresses the question of how individuals search for knowledge to solve problems in product development processes. Based on grounded theory methodology an emergent theoretical framework of individual level knowledge search processes is suggested that emphasises the importance of social networks.

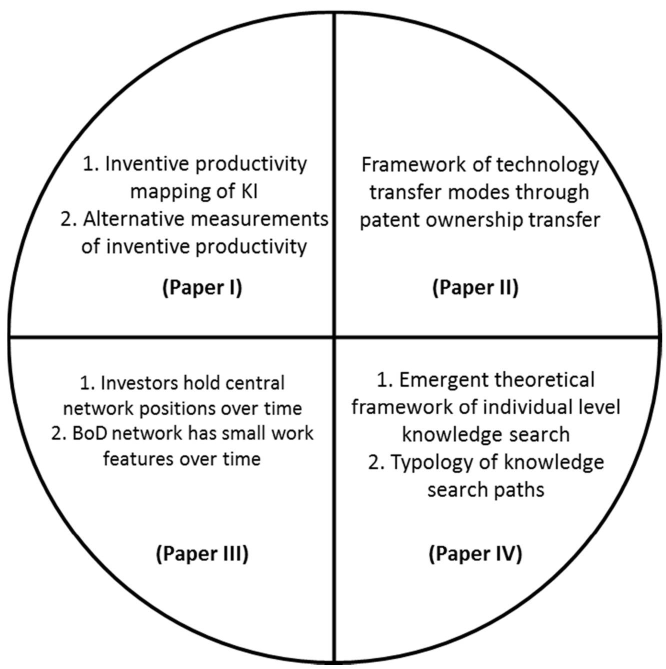

Figure 10: Results of Paper I-IV

5 DISCUSSION AND IMPLICATIONS

According to the knowledge based view, knowledge is the most important resource and the basis for competitive advantage in organisations. By that follows a need to understand, and measure knowledge transfer in order to be able to manage it more efficiently. However, to cite Thursby et al. (2009) 'Despite extensive research, there is still much that we do not understand, in large part because knowledge flows do not always leave a publicly accessible "paper trail."'.

This thesis addresses the question of *how mapping of 'hidden' connections could provide insights into the management of knowledge transfer in the university-industry interface.* Four independent studies address this overarching question in different ways. The thesis draws mainly on three research fields; university-industry relations, knowledge transfer and social network analysis. The results of the thesis mainly have implications for university managers, firm managers and policy makers.

This thesis contributes to previous research by suggesting new perspectives on how knowledge transfer can be mapped and measured to provide; 1) a better foundation for theory development, and 2) a basis for decision making for practitioners.

5.1 THEORY DEVELOPMENT

The thesis offers three contribution to the research and literature on knowledge transfer, university-industry interactions and social networks.

First, the findings in the four independent papers provide insights into multiple pathways that knowledge is transferred between actors in the university-industry interface throughout the commercialisation process of university knowledge. In doing so, various 'hidden' connections were needed to be uncovered to be able to trace the knowledge flows. Thus, this thesis contributes to previous research that has studied the many mechanisms through which knowledge can be transferred between universities and industry (D'Este and Patel, 2007, Perkmann, et al., 2013). However, the present thesis limits the focus to knowledge transfer for the purpose of innovation.

Paper I, investigates how knowledge originating in the realm of the university is transferred and formalised into patent applications and granted patents, which can be considered an initial commercial step. The transferred knowledge usually have a codified part and a tacit part that is hard to transfer without social interaction (Nonaka, et al., 2000). For instance, the knowledge embedded in patents which are the focus of ***Paper I*** and ***II*** is, to a large degree, codified. However, as the interviews with firm representatives in ***Paper IV*** indicated, firms tend to engage the academic inventors in the innovation process to facilitate transfer of tacit knowledge related to patents, as well as to gain access to the university researchers' social and human capital (Murray, 2004). ***Paper II*** traces the patents from the university to various external recipients of knowledge and uncover three modes of technology transfer. University spin-offs is one mechanism of knowledge transfer that is part of the corporate mode introduced in ***Paper II***. ***Paper III*** continues by investigating how knowledge can be transferred to spin-offs by mapping social networks of board-of-directors. Finally, ***Paper IV*** shifts the perspective and explores how firm employees search for knowledge, often at universities, to solve product developemnt related problems.

Second, this thesis provides unique empirical insights from the KIIP-database. The thorough methodological effort to compile comprehensive longitudinal data on inventor-patent connections from one university makes it possible to, in ***Paper I,*** report inventive productivity measures of high validity**.** When contrasting the results on inventive productivity in ***Paper I*** to similar studies on European (Lissoni, et al., 2008, Lissoni, et al., 2009, Lissoni and Montobbio, 2015) or national level (Ejermo and Lavesson, 2012, Göktepe, 2008) the results indicate a high inventive productivity.

A third contribution relates to the integration of multi-dimensional multi-level and analysis to better understand knowledge transfer in the university-industry interface. For once, multi-dimensional analysis involves combining quantitative and qualitative perspectives in the analysis. For instance, ***Paper I***, proposes the 'KIIP-selection' of patent records that takes into account the maturity of a patent as well as the market breadth. The idea behind this selection method was that the market breadth, *i.e.,* the number of markets that a patent is filed in indicates a commercial ambition, and the patent maturity indicates how far into the patenting process the patent has progressed. Together, these measures indicate quality and the amount of investment that the stakeholders have invested in an invention.

Another multi-dimensional approach is the use of longitudinal data and analysis, which is present in all four papers. In ***Paper I***, inventive productivity is studied by using a longitudinal data set uncovering detailed new insights into the patenting activity at a university governed by an inventor-ownership regime. ***Paper II*** extends previous research that has investigated patent ownership at one time point by tracing patent ownership at multiple time points. In ***Paper III*** all generations of board-of-directors were mapped using social network analysis providing a dynamic map of a knowledge infrastructure that infuse knowledge to the university spin-offs. Finally, the longitudinal case studies in ***Paper IV*** make it possible to follow knowledge search practices over time as the case firms evolve. This thesis shows that the application of longitudinal data and/or the analysis of the data at multiple time points bring value by providing a more dynamic analysis and stress the need of more longitudinal research. This is supported by Phelps et al. (2012) that note that only 35% of the studies on knowledge networks were longitudinal and of which half were based on panel regression estimations.

Stakeholders in the university-industry interface request and apply information on different levels of analysis. For instance, on a macro-level, policy makers view university-industry knowledge transfer important to spur innovation that, in turn, is considered as a driver of national and regional economic growth. On a meso-level, universities increasingly view knowledge and technology transfer to the industry as a potential source of revenue, while firms need tangible and intangible knowledge as input into their innovaition processes. On a micro-level individuals' social connections can generate valuable resources. For example, the mutual interaction of academic researchers and firm employees are a means to gain access to complementary resources, knowledge and expertise that could increase the quality of their daily and long term work activities and ability of problem solving. One approach to bridge different levels of analysis is through qualitative studies (Phelps, et al., 2012). ***Paper***

IV provides an example of a qualitative, case-based study that explore processes on an individual level which can provide insighs on an organisational and inter-organisational level.

Based on the findings in ***Paper III*** and ***IV,*** another suggestion of how to bridge different levels of analysis is through the study of social ties. It is argued in this thesis that social ties, on an aggregated network level, are characterised by being multi-level in the sense that interactions between the individuals in the social network can simultaneously be analysed on micro-, meso- and macro-levels (Wasserman and Faust, 1994). For example, in ***Paper III*** the board network can be analysed on an inter-personal level (micro), an inter-firm level (meso) and on a structural level (macro). Similarly, the findings in ***Paper IV*** call for simultaneous analysis of multiple social networks, formal and informal, both intra-firm and inter-firm. Such parallel social networks interact at certain nodes as they, in part, involve the same individuals participating in multiple networks. The view that there is a need to integrate multiple levels of analysis and their casual relationships interplay is supported by several researchers in the field (Coleman, 1990, Felin and Foss, 2005, Kim, et al., 2016, Phelps, et al., 2012).

As a final conclusion, this thesis argues that a holistic approach to study knowledge transfer and innovation is needed, where multi-level and multi-dimensional analyses are used to address the same research question with the same data-set. This view is supported by Adams et al. (2006) that also stresses the absence of a holistic framework. The connections between individuals are emphasized in a holistic approach. It should simultaneously consider the importance of the whole, *e.g.,* social structure, and the interdependence of its parts, *e.g.,* individuals exchanging knowledge.

5.2 IMPLICATIONS FOR PRACTITIONERS

This thesis offers several practical implications.

A first implication for policy makers and university managers that intend to support university knowledge transfer is to be aware that university knowledge can take many different paths to recipients outside the university. The results from this thesis indicate that the knowledge transfer modes used are context specific and depend on both the technological areas of research and the characteristics of the industry absorb the knowledge (***Paper III***). This means that in order to develop a knowledge transfer support system that is adapted to a specific university context; an analysis of that university's inventive productivity is needed as well as an assessment of the knowledge transfer modes used at that university.

Second, in line with applying a holistic approach, a more integrated innovation-related statistic is needed. It should preferably be collected on a national level and compiled in an innovation statistics infrastructure. Such an infrastructure could serve multiple purposes. It could allow for university benchmarking on a national level, provide individual universities with innovation related information, and provide statistics to policy reports and international university rankings. Moreover, it could be used for universities to strategically connect and match patents with similar or complementary technologies for commercialisation or to sell to firms.

During the work with this thesis the term 'Innometrics'[12] has been used to refer to integrated innovation statistics and multi-level, multi-dimensional analysis. The KIIP project is a first effort in the direction of national innovation statistics initiative. Moreover, the KIIP project is a validation of previous patent mapping studies that have applied a name matching methodology (Göktepe, 2008, Lissoni, et al., 2006, Meyer, 2003) and confirms the importance to compile comprehensive university patent statistics to eliminate underestimation of university-industry knowledge transfer (Lissoni, et al., 2008). For instance, the KIIP-methodology used to identify university inventor-patent pairs could be further developed to be applied in large-scale data collection. Today, technological developments in 'Big data analytics' have opened up for further advancement.

A third implication is directed toward firm mangers and concerns the use of social network analysis to gain insight into the 'hidden' social structure of their organisations. Such insights could be used to support and manage knowledge transfer and collaboration (Cross, et al., 2002). Findings in ***Paper III*** exemplify how inter-organisational relationships and knowledge transfer channels can be analysed and visualised through the board-network. Similarly, the inter- and intra-organisational context explored in ***Paper IV*** could be analysed to uncover formal social networks in relation to informal social networks.

Finally, knowledge transfer infrastructures are constructed as social networks bridge individuals, organisations, industries, countries and technological areas. Like other types of infrastructures, such as traffic, a thorough mapping of bottlenecks and seldom used routes is important for efficient management and resource allocation. Without a map, one gets easily lost. A better analogy than a map, given the speed of today's computational power and 'Big data' opportunities, would rather be an advanced GPS-system.

5.3 LIMITATIONS AND FUTURE RESEARCH

While this thesis suggests new approaches to study, map and evaluate knowledge transfer in the university-industry interface, there are some limitations.

First, the sample used in the first three papers originate from one single university which most likely influenced the results, especially the specific levels of inventive productivity, the distribution of transfer between the three transfer modes, as well as the context of the university spin-offs. Even though the specific measures most likely are university specific, they are not believed to have affected the overall results and conclusions of the thesis. Still, future research should increase the number of universities studied and perform a comparative analysis that could take into account contextual differences.

Second, the patent related data that was compiled and connected in the KIIP project offers many opportunities for future research. For instance, to analyse the many social networks that the different, but parallel activities of research, invention and innovation give rise to in

[12] Building on the term 'bibliometrics', Innometrics use a combination of data related to research, technology transfer, innovation and business to measure 'input', 'output' and 'impact' of individuals, research teams, institutions, organizations and countries. It can be used to identify national and international networks and to map emerging scientific and technological fields as well as to trace societal impact of innovation.

the university-industry interface. These different layers of networks are interconnected through common denominators (interlocked nodes), when inidviduals wear multiple hats (for example as researcher, inventor, board director and collaborator). Granovetter (1985) refer to this as social embeddedness, which is a multidimensional aspect of social networks. The individuals in such multidimensional networks are especially interesting when they hold central positions as brokers between social network of different charactar (Fisher and Atkinson-Grosjean, 2002, Forti, et al., 2013, Lissoni, 2010). Future research studies could investigate the role and activities of these brokers through a combination od social network analysis and qualitative studies.

Third, building on the results in ***Paper III***, an complementary study should investigate the actual knowledge contribution of the board directors through qualitative studies and relate the results to their network positions. Would it be possible to find relationships between network position and board room behaviour? Moreover, social network analysis of board directors could be extended to include their connections to organisations outside the university spin-off cluster.

6 CONCLUSION

In conclusion, the findings of this thesis suggest the there is a need to apply a more holistic and multi-level methodological and theoretical perspectives to gain better understanding of knowledge transfer in the university-industry interface. This includes building comprehensive innovation statistics, applying analysis methods, such as social network analysis on micro-, meso- and macro level, developing qualitative impact oriented innovation measures, and using pedagogical strength of social network visualisations. By bringing such ‘hidden’ connections to the surface a more tailored management of knowledge transfer and innovation support systems could be developed.

7 APPENDIX 1: INTERVIEW GUIDE

RESPONDENTENS BAKGRUND

Tidigare utbildning:
Tidigare forskning:
Tidigare arbetslivserfarenhet:
Antal år på nuvarande företaget:
Tidigare positioner/arbetsroll på företaget:

A) INLEDANDE FRÅGOR

1. Vilken roll har du inom företaget?
2. Hur gick det till när företaget startade?
3. Vilka mål fanns då?
4. Hur ser företagets utveckling ut sedan start?
5. Nämn och beskriv de viktiga beslut som har påverkat företagets tills idag.
6. Hur ser företagets samarbetsrelationer ut?
7. Vilken vikt har dessa?
8. Vad är ursprunget till företagets produkter? Hur ser uppdelningen ut mellan ”in-house”-projekt och tex inlicensierade projekt?

B) PRODUKTUTVECLING

9. Beskriv ert företags olika produktutvecklingsstegen
10. Vilken är projektledarens roll?
11. Vilka problem har ni stött på under en varje delstegen? Kan du ge konkreta exempel
12. Hur löste ni det problemet?
13. Vem vänder ni er till om ni saknar kunskap på ett område?
14. Vilka resurser krävs?
15. Hur får ni tag på dem?
16. Varför gjorde man de prioriteringar man gjorde?
17. Hur ser beslutsgången ut vid kritiska beslutssituationer?
18. Finns det något tillfälle som man kan hoppa över de formella beslutsleden?
19. Hur har sammanslagningen av produktutvecklingsprocesserna påverkat det dagliga arbetet i ett projekt? Ge konkreta exempel.
20. Hur många projekt drivs parallellt på företaget?
21. Hur många personer brukar det vara i ett projekt?
22. Hur ofta är en och samma person involverad i fler projekt?
23. Hur samarbetar ni med andra företag i projektet? Vilka/När?
24. Vilka möjligheter att påverka projektet/produktens inriktning har en specifik individ i ett projekt?
25. Vilket inflytande upplever du att styrelsen har på inriktningen på ett projekt?

C) SAMARBETEN

26. Har ni idag några relationer/samarbeten med kunder?
27. Samarbetar ni med något annat företag? Hur?
28. Vad förväntar ni er att få ut av dessa samarbeten?
29. Har ni planer på framtida samarbeten?
30. Vad förväntar ni er att få ut av dessa samarbeten?
31. Har ni några interna vidareutvecklingsprogram för anställda?
32. Hur ser ni till att företagets kunskap växer och stannar inom företaget?

D) KÄNSLIG INFORMATION

33. Hur hanterar ni spridning av (känslig) information inom företaget?
34. Inom vilka kategorier finns denna känsliga information?
35. Hur många personer på företaget har tillgång till den informationen?
36. Vilka åtgärder har företaget tagit för att skydda affärshemligheter?
37. Hur hanterar man känslig information i samband med samarbeten med andra företag?
38. Skriver man på ett sekretessavtal som anställd på företaget? (Kan jag få se ett sådant kontrakt?)
39. Har ni några erfarenheter på försök till intrång eller dyl.
40. När/Hur diskuterades detta senast inom företaget?

E) PROJEKTFRÅGOR

41. Vilken typ av teknologi är projektet baserat på?
42. Kan du ge en bakgrundsbeskrivning av projektet.
43. Hur många personer är involverade i projektet?
44. Vad är speciellt med detta projekt?
45. Var befinner ni er idag?
46. Samarbetar ni med andra företag i projektet?
47. Hur ser det samarbetet ut?
48. Använder ni er av olika typer av outsourcing?
49. Hur ser ”kunden” ut för produkten?
50. Har ni idag några relationer/samarbeten med kunder?
51. Vad gör ni för att ”kundanpassa” produkter?
52. Hur ser ni till att företagets kunskap växer och stannar inom företaget?

8 ACKNOWLEDGEMENTS

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