Transfer of Academic Research – Uncovering the Grey Zone

Anna S. Nilsson, Senior researcher, Karolinska Institutet, Unit of BioEntrepreneurship, Nobelsväg 15a,

171 77 Stockholm, Sweden*

Annika Rickne, Associate Professor, Lund University and University of Gothenburg, Vasagatan 1, 405 30, Gothenburg, Sweden.

Lars Bengtsson, Professor, School of Economics & Management at Lund University,
PO Box 7080 , 220 07 Lund, Sweden and School of Management, Blekinge Institute of Technology, PO Box 520, 372 25 Ronneby, Sweden

Abstract In this study, we respond to calls for further investigation on why and how scientists choose to commercialize their research. Mowery (2005), in his criticism of the US-system, emphasizes the need for multiple channels between university and industry. His argument makes the case of Sweden interesting, where the researchers own the intellectual property of their research. Sweden thus constitutes a unique case where data can be found on which choices researchers make in a setting where a variety of channels for transfer are available. Our empirical data, collected through case studies, allowed for the expansion of the typology for mechanisms for transfer of academic research as well as the development of a typology for determinants for researchers´ choice to engage in transfer of research. Apart from those contributions to the theoretic discussion, the data also provided policy implications.

***Correspondent author** Anna.Nilsson@ki.se , tel +46 703 88 35 96, fax +46 8 462 02 92

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1 Introduction

The current policy discussion about commercialization of research seems to focus on two extremes. At one end of the spectrum the researcher in essence 'drops the discovery off' at the university's technology transfer office, possibly assisting in writing the patent application, but not engaging in the commercialization of the discovery. At the other end of the spectrum the researcher takes on an entrepreneurial role, creating and running a spin-off to pursue commercialization of the discovery. While the literature acknowledges that there are other ways that research is transferred, their outcomes are harder to measure and are thus not as policy-friendly as, for example, spin-offs. Our view in this paper is that the lack of insight to the variety of mechanisms of transfer and the dynamics behind the choices that researchers make, and consequently, the lack of both language and concepts, hampers constructive discussions about the processes. This, in turn, creates problems for policymakers when creating programs and incentives aimed to increase commercialization of research.

Indeed, Audretsch et al (2006, p 63) claim that "future research needs to further probe why and how scientists choose to commercialize their research, what commercialization route they select, what mode of commercialization is most effective, and how university governance and public policy can best promote such commercialization efforts". In accordance, we address the first of these points, by scrutinizing the choices made by the researcher. Our research questions are thus;

1) Why do researchers engage in commercialization at all? We aim to develop a typology of determinants that influence that choice.
2) If researchers do transfer research, how do they choose to perform that transfer? We aim to expand the existing typology of mechanisms of transfer of academic research.

This paper contributes to the academic literature as well as to the policy debate by uncovering some of the "grey zone" between academia and industry that is not visible through present-day technology transfer calculations, but in which some of the contributions of academic research to economic growth is likely to occur. The aim of the paper is develop the current framework regarding which mechanisms that are used to transfer academic research into social and economic value. We do this through a set of case studies where academic researchers have considered diffusing their research findings to be used in commercial settings.[1] The empirical cases let us further expand the typology of mechanisms for technology transfer – or knowledge diffusion - from academia to industry, and we also explore why specific mechanisms were chosen by the researchers. The viewpoint we adopt is thus that of the researcher. To do this we have focused on the case of Sweden and stem cell research. Current research is mainly based on data from countries where the intellectual property belongs to the university, not the researcher. That situation limits the researchers' choices with regards to transferring their research findings. Even if they find creative ways of following their own choices, it is difficult to find empirical data describing those undercover choices and the reason behind them. The case of Sweden allows us to add to current research by studying ways in which research findings are transferred when the researcher herself gets to choose. In the Swedish context the researchers in academia own the intellectual property stemming from their research and they may choose whichever way to transfer their findings they see as most attractive. Other countries with similar regulations are Finland, Iceland and Italy (OECD, 2003).

The paper is structured in the following way: Section 2 further lay out the details of the problem at hand, describing the current understanding of determinants that influence researchers´ choices to engage in commercialization and of mechanisms of transferring academic research. Section 3 presents the research design. The case studies are presented in section 4, highlighting researchers´ choices to commercialize as well as the mechanisms of transfer. Conclusions and implications are discussed in section 5.

[1] We do not focus on diffusion of results in the form of teaching, but on ways that, in accordance with previous research findings and our empirical data, relate closer to commercial contexts.

2 Conceptualizing determinants of choice and mechanisms of transfer

Several authors highlight that the literature has focused on 'what' universities do in order to contribute to economic growth and not 'why' certain ways to transfer research are chosen (Gunasekara, 2005; Audretsch et al., 2006; Bercovitz and Feldmann, 2006). We begin this section by focusing on why researchers engage in commercialization at all and search previous literature for determinants that influence that choice. We then move over to the question of how they choose to perform that transfer if they decide to engage in commercialization and search previous literature to identify mechanisms of transfer.

2.1 Determinants of choice

We have identified four sets of determinants that influence researchers´ choice to engage in commercialization, see table 1.

Table 1 Determinants for researchers´ choice to engage in commercialization

Determinant	Definition
Perceived role of the university	The role that a university is perceived to have in society, and how this in turn relates to the individual researcher's wish, and choice of mechanisms, for transfer of research.
Supportive infrastructure	University-based infrastructure, such as technology transfer offices, as well as infrastructure located outside campus.
Industrial actor set-up	Companies in a region that have receiver capabilities to further develop early stage research projects from academia.
Networks	Formal and informal links and level of trust between academic and industrial actors.

Source: Compilation of previous literature

The first set of determinants relates to the perceived role of the university in society, and how this in turn relates to the individual researcher's wish, and choice of mechanisms, for transfer of research. In general, universities are set up to serve society with education and creation of new knowledge. They contribute to economic growth as "creators, receptors, and interpreters of innovation and ideas; as sources of human capital; and as key components of social infrastructure and social capital" (Lester, 2005, p 12). The so called third role of universities - i.e., to diffuse knowledge and value to society at large - has been discussed and researched for some time now (Sutz, 1997; Etzkowitz and Leydesdorff, 1999; Etzkowitz, 2002; Mazzoleni and Nelson, 2005). Clearly, the task of contributing to innovation and economic value through technology transfer is a rather new one for many universities, even in the US. There are therefore still questions on suitable organizational practices with regard to inventor incentives, legal issues, strategic objectives, and how to evaluate the contribution (Phan and Siegel, 2006).

The academic organization thus sets the framework for technology transfer by its policy and strategic decisions, and by the ways these are implemented. Researchers at universities or research institutes can be assumed to adjust the choice to commercialize and the way of doing so to social norms, organizational structure and incentives regarding e.g. promotion and tenure (Geiger, 1993). Culture and environment are found to affect the choices that researchers make because they tend to adopt the procedures of their peers. This can make researchers reluctant to engage in commercialization activities even though their university management may encourage it (Keck, 1993, Louis et al, 1998; Bercovitz and Feldmann, 2006). "We can incorporate the notion of prior losses or gains into the choice models (e.g. to faculty member's decision to disclose or not to disclose an invention, to license or not license a technology; or to launch a new venture or not) to the problem of opportunity costs faced by the scientists and transactions costs faced by the university and/or commercial enterprise" (Phan & Siegel, 2006, p. 41). The role of organizational practices has been highlighted by Siegel et al, 2003; Chapple et al, 2005; as well as Siegel et al 2007.

Also the more formal structures influence researcher's choices. For example, the reason to start a company may be to increase the value of the intellectual property related to a discovery, as well as adding ways of funding research projects (Bercovitz and Feldmann, 2006). Phan and Siegel (2006) note that research findings suggest that allowing the researchers a larger share of the intellectual property ownership royalties would increase their disclosures. There are also reasons as to why a researcher may not choose to engage in commercialization; she does not want to take time from other projects in order to work with applied research; she does not want to risk delaying articles due to patent procedures; or she does not think that researchers at universities should engage in commercialization at all (Thursby and Thursby, 2002).

For the individual researcher or research team, this translates to issues of how commercialization choices and mechanisms interact with career ladders and incentive systems, the need to secure financing of research, as well as requirements to excel in terms of teaching and PhD-supervision. At some universities or research institutes, these issues have been handled stringently, where in other cases the situation for the researcher may be unclear or even directed by contradicting university goals.

A second type of determinants is that of supportive infrastructure available for the researcher that wishes to move research findings into the commercial realm. Here we may include university or institute based infrastructure such as e.g. technology transfer offices, education in patenting or help in evaluating business plans, but also support-structures located outside the academic organization. Melese (2006, p. 2) claims that "many opportunities are lost due to the lack of a defined process by which researchers become aware of, and connected to, existing campus of external resources, including a) knowledge of potential collaborative research efforts, b) technology resources, c) corporate alliances, d) licensing opportunities.".

A third type of determinants is the industrial actor set-up, as well as their resources and strategies. Indeed, Mazzoleni and Nelson (2005) point out that contribution of universities are only effective in environments where there are users/companies that have a need and capability to improve their practices and to try new things. It is clear that most technologies from universities are licensed at a very early stage and they require significant additional investment from the licensees. It often takes years before the technologies enter the market (Jensen and Thursby, 2001). The cost of bringing a product to market varies depending on the characteristics of the product, but studies show that approximately 25 percent of the total costs are related to research (Schacht, 2003). Thus, the commercial actor has to be ready to face large expenditures e.g. developing a drug and getting it to market (Schacht, 2003). With regards to the field of life sciences, the number of development projects that companies can take on is limited, and there is also a limit to the number of companies developing life-science products. A lack of such companies in a region or country therefore constitutes another challenge to commercialization of university research, and is likely to decrease numbers of academic researchers engaging in commercialization.

Through a literature review, O´Shea et al (2008) develop a framework for the study of spinoffs and suggest that the creation of spinoffs should not only dependent on the characteristics of individual researchers. They bring forth three other factors of importance when studying spinoff creation: institutional characteristics, organizational resources, and environmental factors. This is in line with the three determinants we focused on here so far. Since our study focuses on the researcher and her choice to engage in any sort of transfer, we find it important to include a fourth determinant: networks and trust between academic and industry actors. Several studies point out that transfer of university research to commercial settings seem most successful when dedicated individuals engage one-on-one in the knowledge transfer (Zucker et al. 1998a, 1998b, 2002; Nilsson, 2001; Toole and Czarnitzki, 2005; Elfenbein, 2005). Interaction between researchers and market actors is not only shown to be a mechanism for transferring intellectual property rights, but also for the continued process of developing the discovery. According to Thursby and Thursby (2005), technology-transfer officers in a recent survey estimated that 71 percent of the inventions they licensed could not be successfully commercialized without further collaboration with university researchers.

Trust, developed through long-term relationships, plays an important role in initiating and facilitating transfers, making social capital a key issue. Social capital can be defined as aspects of social organization such as networks, values, and unwritten rules of conduct and trust that facilitate cooperation for mutual benefit. Social capital is created and sustained through the exchange of financial and human capital, but the network of relationships also works as a facilitator for reaching outcomes (Nahapiet & Ghoshal, 1998, Coleman, 1988, Burt 1992). Interaction is a prerequisite for obtaining and maintaining

social capital and thereby increasing the chances of realizing opportunities. Social capital increases with use and erodes if not maintained (Bourdieu, 1986, Aldrich, 1999, Powell et al, 1999). It is built and maintained through frequent contacts that enable bonds to develop and tacit knowledge to be transferred, which provides actors with more informal control over each other (Jones et al., 1997). This may imply joint decision-making and sharing and exchanging information. A high level of social capital can significantly reduce transaction and monitoring costs (Putnam, 2000). For example, in cases where a new company is created in order to commercialize a discovery, the social capital of the researcher decreases the probability of failure of companies and increases the likelihood of venture capital (VC) funding, according to a study of MIT start-ups (Shane and Stuart, 2002).

As an illustration of the importance of social capital, from a company perspective, university licensing is related to personal contact between the company's R&D personnel and university researchers (Thursby and Thursby, 2003). From a university researcher perspective, social capital increases the propensity to engage in commercialization, particularly for the ones choosing to start their own company rather than to license their technology through a technology transfer office (Audretsch et al, 2006). Audretsch et al (2006) find that US researchers who do not trust the capabilities of their technology transfer officers tend to choose to start their own firm, i.e. to take the entrepreneurial route, whereas researchers who perceive being helped by the officers rather choose licensing their discoveries through the technology transfer office (the TTO route). They go on to hypothesize that "social capital can serve as a mechanism to compensate for lack of technology transfer office help when starting a firm" (ibid., p.63).[2]

2.2 Mechanisms of transfer

According to many scholars the actual contribution of universities adds more to growth than present technology-transfer calculations show (Lester 2005; Bercovitz and Feldmann, 2006; Audretsch et al. 2006). One perceived reason for such lacks in the reporting of commercial outputs from universities is that not all results emanate from the technology-transfer offices, which is where data regarding transfers usually are recorded. Instead the output consists of both formal and informal processes taking place at various units within the university system. Moving over to our research-question of which mechanisms of transfer researchers choose if they decide to engage in commercialization, Bercovitz and Feldmann (2006) offers a typology of formal and informal transactional mechanisms of university technology transfer, see table 2. They created this typology in order to open up for a wider framework that would correspond better with actual contributions.

Table 2 Formal and informal mechanisms for transfer of research (Bercovitz and Feldmann, 2006)

Mechanism	**Definition**
Sponsored research	An agreement by which the university receives funding for conducting a research project
Licenses	Legal rights to use a specific piece of university intellectual property
Hiring of students	Recruitment of students from the university, especially those working on sponsored projects
Spin-off firms	A new entity that is formed around the faculty research or a university license
Serendipity	Simple luck or chance

Serendipity stands for the informal mechanism that seems to a large degree to be lacking in previous research on commercialization of university research. One reason is that informal mechanisms are hard to study and require qualitative research, often case studies, which are very time-consuming and costly to perform.

[2] Their study of the top-twenty percent of university researchers that had received research grants from the National Cancer Institute showed that 70 percent of NCI patenting researchers choose the TTO route, whereas 30 percent choose the entrepreneurial route.

Audretsch et al (2006) are also addressing the underestimation of the impact of university research on economic growth by focusing on what university researchers do, rather than what technology transfer offices do. They use five main measures of researcher commercialization: patenting, receiving SBIR awards, starting a firm, selling patents, and issuing licenses. They point out that although the different modes are linked, there are no exact linear relationships. They further add that additional modes that are important but difficult to measure still remain to be explored, including informal interactions, consulting contracts, mobility of researchers to industry, non-patenting researchers who start companies. Based on this background and state-of-the art of understanding, making use of Bercovitz and Feldmanns (2006) typology, we aim to use the Swedish case studies to further probe into the area of mechanisms of transfer.

Mazzoleni and Nelson (2005) argue that it is a mistake to assume that the contributions of universities flow directly from fundamental research. In their survey, industry respondents said that general research findings, instruments and techniques were far more important for their business than prototypes. This held true even for respondents within the pharmaceutical companies. Industrialist reported that their main use of university research was to solve problems in R&D projects, rather than to trigger new R&D projects. Although university patents are seen as an important vehicle for technology transfer, pharmaceutical industrialist rate publications, meetings and conferences as even more important vehicles of gaining access to university research results. In line with this, Lester (2005) argues that the focus on technology-transfer offices should be replaced with a more differentiated view: The universities need to be aware of innovation processes in local industries and, along with pursuing front-line research, identify which role to play in those processes. There are many types of interactions that may occur between a company and a university, sometimes they occur simultaneously and in other cases one mechanism is dependent on another.

3 Research design

Based on the gaps in the current literature regarding motives for engaging in commercialization and how researchers choose to perform the transfers, further research needs to be more exploratory. We used longitudinal multiple case studies to analyze our two research questions (Yin, 1984; Eisenhardt, 1989; Creswell, 1994). Multiple case studies typically yield more robust results than single-case studies (Eisenhardt and Graebner, 2007). The case studied in our seven cases is a project in early phases of commercialization or in pre-commercialization phases. The case studies each include a key researcher working with a stem cell project within academia in Sweden and other people and organizations with an interest in or impact on that specific project. Our design is embedded with two units of analysis: researchers' motivation and mechanisms of transfer.

We chose researchers that already had commercial connections or were planning on making commercial exploitation in the foreseeable future. In both cases, our interest was to follow and analyze that pursuit, which we did over the period of 18 months. The history of each project was mapped initially through interviews with the key researcher and other involved persons and on related documentation. Interviews were in total performed on two to three occasions during the period, where the number of interviewees on each occasion was 2-5 per project and with recording and transcription of the sessions. Each interview lasted between 40 and 90 minutes. The same interview guide with open-ended questions was used for all projects, making for capturing a broad set of factors at the same time as all interviews contained the same basic elements.

The data was coded and analyzed with two specific issues in mind. First, the respondents' recollections about the motivation to pursue – or not pursue – the process towards application development were categorized and how and by whom the possibility of commercial applications were identified. A number of pre-formed categories were extracted from the literature, but additional ones were also added as needed. Second, the role of various types of actors in the process towards commercialization as well as how they interacted in the process were recorded, drawing on classifications from the literature as well as from the empirical data's own dynamics.

The case studies have been performed at three major Swedish stem cell research centers in Stockholm, Göteborg and Lund, being the three main centers of academic stem cell research in Sweden both in terms of quantity and quality (Rickne and Sandström, 2009). Moreover, these are the geographical regions where the stem cell related firms are located (Rickne and Sandström, 2009). While there are likely to be organizational differences for the three research centers in terms of e.g., the size of the universities, their detailed policies, etc., the institutional differences regarding laws and practices are similar.

The case studies constitute valuable empirical material for increasing the understanding of how certain determinants influence a researcher's choice to engage in commercialization to begin with. Through the case studies, we are also able to gain deeper insight to mechanisms of transfer found in both formal and informal interactions. As the cases are longitudinal and involve various actors, the material also contributes to the understanding of the fit between company strategies and research groups at universities, a piece of the puzzle which is relatively unexploited, according to Bercovitz and Feldmann (2006).

Two methodological choices were made. First, we aimed to gain a deeper understanding of early phases of commercialization on the frontiers of science. To this end, studies of stem cell research projects offered a unique opportunity to gain insights into the initial phases of the commercialization process, and how actors and institutions interact in a recently established scientific field where the commercial expectations are high and the governance structure is changing.[3] Second, our cases were selected in the Swedish setting. A background is that for example Mowery (2005) is critical of the current technology-transfer system in the US and claims that need exists for experimentation with alternative models for management and organization. He emphasizes the importance of having multiple channels between university and industry. His argument makes the case of Sweden interesting, since the researchers at universities in that system own the intellectual property of their research. Swedish universities have technology-transfer offices, but the researchers can choose to commercialize a discovery through whatever mechanisms they perceive as most appropriate for them. From an empirical point of view, Sweden thus constitutes a quite unique case where data can be found on which choices researchers make in a setting where a variety of channels for transfer are open to the choice of the individual researcher. Other countries with similar regulations are Finland, Iceland and Italy (OECD, 2003).

4 Uncovering the grey zone

Overall, our analysis shows that the determinants that influence researchers´ choice to engage in commercialization that we identified through literature review and developed a typology for (see table 1) work well when analyzing our cases. One determinant needs to be redefined however. "Industrial actor set-up" should not be restricted regionally, as we found that companies located in other countries may well learn about academic research through publications and contact researchers who may then be influenced to engage in commercialization. We therefore use the following definition for "Industrial actor set-up" instead: "Existence of companies that have receiver capabilities to develop early stage research projects".

With regards to existing literature on mechanisms for transfer of research we found, through our cases, that more mechanisms need to be included in order to uncover the grey zone. We have therefore developed a new version of the typology for mechanisms for transfer of research. There are forms of codified transfer mechanisms often acknowledged in the literature: publications, conference presentations, patents and licenses. However, these mechanisms have various types of outcomes which are not well penetrated in previous research and which we found important to include in our study. Along with our addition of the variety of mechanisms of transfer, we have therefore added "outcome" to the typology (see table 3).

[3] There are several potential areas of application and commercialization for stem cells; e.g., neurological disorders, tissue engineering and screening-processes for new drugs. For the purpose of this study, we have not made any limitations with regards to type of application.

Table 3 New typology for mechanisms for transfer of research

Mechanism	**Definition**	**Outcome**	**Case**
Publications and conference presentations	Researcher publishes or in other ways presents her research findings in a traditional academic way.	Knowledge diffusion Way to attract interest, which in turn may or may not go on to transfer mechanisms	Alpha Delta
Patents	Researcher agrees, or takes initiative, to patent research findings	Knowledge diffusion Way to secure intellectual property, independent of choice of transfer mechanisms that may follow	Gamma
Licenses	Legal rights to use a specific piece of university intellectual property	Transfer of Intellectual Property	Beta Delta Epsilon Zeta
Academic spin-off	A new commercial entity that is formed around faculty research or a university license	Firm creation	Beta Delta Epsilon Zeta
Sponsored research	An agreement by which the university receives funding for conducting a research project Divides into a) contract R&D/ R&D services/ clinical trials, b) testing of material or equipment, c) sponsored R&D with no commitments (relate to 'receiving SBIR awards'), d) sponsored R&D with first right of refusal or direct transfer of IP to financier, e) joint R&D, f) research collaboration through 3rd party sponsor.	Research and intellectual property that may e.g. result in corporate spin-out or a new corporate business unit or product	Beta Delta Epsilon
Informal and pre-formal discussions	For example: - Informal contacts between key researcher and company research director - Invitations to present research findings in non-academic settings - Discussions of possible partnerships and/or licensing deals (pre-formal interactions)	Knowledge diffusion	Gamma Delta

Shared personnel	Persons employed in academia temporarily work at a company through shared research projects, and vice versa	Knowledge diffusion	Beta Epsilon
Labor movement	Recruitment of students or other personnel from the university, especially those working on sponsored projects	Knowledge diffusion	Delta Eta

Source: Based partly on Bercovitz and Feldmann (2006) and Audretsch et al (2006), expanded through empirical data from our Swedish case studies.

In the brief case descriptions below, the actual mechanisms of transfer that took place are highlighted, along with the determinants that influenced the researchers´ choice to engage in commercialization.

4.1 Alpha: No personal network, but supportive infrastructure

In this case the key researcher had talked to a colleague at another university for several years about the possibilities of combining their research to pursue an area that they thought would have commercial potential. They had different science backgrounds which they felt could be very exciting if combined. The opportunity for formally collaborating came in 2002 when our respondent hired a post doc whose scientific background overlapped the two research areas. The project did not have dedicated funding initially, but survived on money from other ongoing projects in the same research group. In late 2004 they hoped to have the first patent within a year, but problems of receiving funding for the project came in the way of that plan. In June 2005, our respondent received a tenure track position and associated research funding. This was a turn-around for the project that had lacked dedicated funding for a long time. The first publication came in December 2005, exemplifying the *transfer mechanism: "Publications and conference presentations".*

The key researcher in this case provides an example of an academic who looks for commercial value in his research, but acknowledges that he does not have the knowledge, nor the network to pursue commercialization on his own. Nor does he have any interest in building a company, all of which supports Audretsch et al's (2006) hypothesis and is an example of how a lack of a commercial network influences a researcher to use supportive infrastructure at the university to arrange for patenting and future licensing, rather than starting a spin-off on their own. The fact that the researcher considers his university to have a well-functioning technology transfer office exemplifies the *determinant "Supportive infrastructure"* as it influenced the researcher to engage in commercialization, since he feels that he can transfer his results and still keep focusing on his research at the university.

With regards to choice of *mechanism of transfer*, our respondent provides two reasons for using the *technology-transfer office* at his university: 1) He does not have confidence in his own competence when it comes to judging the commercial potential of research, 2) part of his research money goes to pay overhead at the university anyway, so he should take advantage of the services provided.

4.2 Beta: Supportive infrastructure and perceived role of the university

The key researcher in this case had found a way to reduce the time for expanding X-cells. He was contacted by the technology-transfer office at his university, because they knew that he and his research group might have interesting projects with commercial potential. The technology-transfer office already had some projects that could become a part of a company, but they were not enough to form a company. Eventually the office managed to connect ten researchers who brought in different projects and in return got shared ownership in a spin-off. It was funding from a university initiated fund, started especially to invest in university spin-offs, which enabled its creation, exemplifying *the spin-off mechanism* along with the *determinant "Supportive infrastructure*", i.e. that the existence of an active support system that has a good reputation can encourage researchers to engage in commercialization.

For the researcher in this case, the involvement in the spin-off is a way of getting more resources to his research group at the university, which supports Bercovitz and Feldmann´s hypothesis (2006). It also exemplifies the *determinant "Perceived role of the university",* i.e. that both university management and peers consider involvement in spin-offs to be politically correct and allows for the researcher to secure financing for

her academic research. This case exemplifies the *mechanism of sponsored research*, more specifically the "first right of refusal", which means that the spin-off has the option to acquire the researcher's intellectual property from any finding associated with the specified project. *The mechanism of licensing* can also apply, instead of aquisition. There has also been funding for the project from Swedish Cancer Society, enabling a phase 1 trial, an example of the *mechanism of sponsored research through a third party*. The people involved in the company are to a majority researchers that work at the university, providing an example of the *transfer mechanism where a company and a university share personnel*.

4.3 Gamma: Combination of perceived role of the university, supportive infrastructure, personal networks, and industrial actor set-up

This case is really about two, rather than one, key researchers. Both are researchers at the same university and they work as a team in their pursuit of commercialization. They hope to earn substantial amounts of money through their commercial pursuit, exemplifying the *determinant "Perceived role of the university"*, where the organizational and regulatory set-up of the university allows for such incentives and influences early thinking of commercialization opportunities.

The researchers decided not to engage the technology-transfer office at the university, because they believe that they would loose too much control in terms of giving up a part of the company. The researchers have tried to get as much "free" advice as possible from colleagues or other people in their network with experience of commercial activity. The fact that they have a network of their own in the area of commercialization influenced their decision to use that network instead of working with the technology-transfer office. This also exemplifies how the *determinant "Networks"* influences researchers´ engagement in commercialization, thus supporting the hypothesis of Audretsch et al (2006). At the same time, none of them wants to spend too much time on a future company.

Because the want to stay independent, the researchers have chosen the *transfer mechanism of filing a patent application of their own.*. The two researchers turned to a non-commercial organization outside campus for help with the patent application. This exemplifies how the *determinant "Supportive infrastructure"*, e g the existence of such an organization, influenced them to take the first steps towards commercialization. They received financial support from this organization to cover initial costs of the patent and have an option of taking back the patent as long as they pay that money back. The contact with that organization came from one of the researchers, who had been involved with the organization before.

In early 2006 the two researchers were interacting with companies in three different ways, all of which are examples of *the transfer mechanism of pre-formal discussions.* Moreover, they all exemplify the *determinant "Industrial actor set-up"*, that is, how company strategies and information through networks or publications lead companies to researchers in academia who, once contacted, are influenced to engage in commercialization.

i) The researchers started negotiating with an American company in the beginning of 2005. The company had shown an interest in the use of the cells as a screening tool to help decrease development time, rather than to find a new research project, which is in accordance with Mazzoleni & Nelson´s (2005) argument about how universities contribute to industry. The contact was taken by the company who received information of the researchers, their research and potential product, through a mutual contact to one of the key researchers. The researchers did not have any experience of negotiations prior to the contact with the company, but relied on getting help from friends with experience from Swedish biotechnology companies. The initial thought was to use these contacts in order to maintain a professional contact with the company. However, at a much later stage in the negotiations the researchers had not yet taken any external help. They plan to start a spin-off, if they would finalize a licensing deal. They would then license the methodology to other companies as well.

ii) In January 2006, an American biotech company, contacted the researchers after noticing an article of theirs in The Cell. The company has invited them to come to California to present their findings.

iii) A number of distinguished researchers in the US are planning to build a stem cell biotechnology company, backed up by a large American venture capital firm. The American researchers, of whom the Gamma-researchers know one personally, have contacted them and are interested in

having their gen-therapy project, which has not developed as far as the scanning project, as a part of the company. The Gamma-researchers would get a partnership in the firm in return. It is too early to know what will become of this, but the Swedish researchers will keep in touch with the American researchers.

Although the above shows various possible future transfer possibilities, no formal agreements had been formed at the time of the last interview. This case does contradict Mazzoleni & Nelson´s (2005) point that universities' contribution is only effective when users are nearby, since all three companies that are interacting with the Gamma-researchers are not located in Sweden, not even in Europe, but in the US. Apart from changing the definition of the determinant "industrial actor set-up", this case also highlights the fact that when foreign companies are more active or have a better match in terms of research areas, the contribution from universities will to a large part fall into the hands of another nation, which certainly has policy implications.

4.4 Delta: Industrial actor set-up and the perceived role of the university

The researcher in this case works on the causes of Parkinson's disease and how to restore the production of dopamine in the brain. In the end of the 1980's he and his research group managed to transplant human brain cells into patients suffering from severe Parkinson. The researcher became very well known in the medical field at large because of those experiments. He has published more than 600 articles and also worked as a consultant for several pharmaceutical companies interested in various neurological diseases. A researcher in one of those companies contacted our respondent in 1999. After some discussions, the company researcher and our respondent proposed to start a *spin-off* were research was performed in various neurological diseases using knowledge regarding stem cells, genes and brain cell transplantation techniques. This is thus an example of how the *mechanisms of publishing leads to the determinant "Industrial actor set-up"*, where a company looks the researchers up and through a fit in interest, the researchers get interested in commercialization.

The proposal was put to the company's management and board and received a positive response, given that enough venture capital could be raised from other sources. Several venture capital companies were approached through the company researcher's network. Our respondent took part in these presentations, endorsing the proposal for a new company and the research that was going to be performed. Six different venture capital companies agreed to invest. Our respondent is regarded as the spin-off's scientific founder but he does not have any shares in the company. Through the years he has never applied for a patent, even though he had several opportunities to do so. He explains his interest in the spin-off and for assisting in raising venture capital and recruiting key staff by stating: "I want more research to be performed in this area and this is a way to get more funds for the research and hopefully progress both scientifically and in practice". This is another example of the *determinant "Perceived role of the university"*, which ties nicely into the hypothesis of Bercovitz and Feldmann (2006).

The spin-off and our respondent interacted extensively in the beginning, performing several stem cell research projects together and researchers from our respondent's group took up work in the spin-off, showing how one *mechanisms of transfer can give rise to another. In this case labor movement and licensing.* The *mechanism of sponsored research*, specifically through a third party, is exemplified in this case, by the initiative that our respondent and the research director in the spin-off took to apply for EU-financed programs regarding Parkinson and stem cell differentiation. After a couple of years it became clear that stem cell research had a long way to go before it could be used in cell transplant therapies. The management of the spin-off decided that the stem cell research should be limited only to the areas which are EU-sponsored. Almost all research in the area is now performed within our respondent's research group within the university. At present there are mainly contacts within the EU-sponsored program. Our respondent has informal contacts with the management of the spin-off, mainly for exchanging information about what is happening in the Parkinson research field, exemplifying the *mechanism of informal and pre-formal discussions.*

4.5 Epsilon: Industrial actor set-up and the perceived role of the university

In this case, the researchers was a pioneer into human stem cells and responsible for isolating and characterizing several human stem cell lines that research could be performed on. He chooses to engage in commercialization because he wanted a way to finance the academic research, which provides us with another example of the

determinant "Perceived role of the university". The *transfer mechanism he chose was to create a spin-off* together with some fellow researchers.

The company strategy is to develop stem cells into screening tools for the drug development companies, making use of the research made in the researcher's laboratory. His research group also assists the company in developing xenofree stem cells, which may be important in the screening procedures. The researcher is bound by contract to disclose any interesting research results that come up through his research at the university to the spin-off. If someone in his research group comes up with commercially interesting results, our respondent can offer that researcher stock options in the spin-off against the right to that intellectual property, exemplifying the *mechanism of licensing.* Again we see an example of how the close strategic fit between company and research in academia may influence researchers to engage in commercialization, the *determinant "Industrial actor set-up*".

The research is carried out almost 50-50% between the company and the research group. Our respondent is also a member of the spin-off's board, which gives him a good position to coordinate research between the company and his own group. Researchers are often exchanged between the company and his group, providing an example of the *transfer mechanism of shared personnel*. Some of the research is sponsored through EU-programs on diabetes research were our respondent is one of the coordinators in European network of diabetes researchers and the spin-off is one of the commercial partners, exemplifying the *mechanism of sponsored research through a third party*.

4.6 Zeta: Perceived role of university

In this case, there were four factors influencing the researchers' choice to engage in commercialization and they all fit within the *determinant "perceived role of university":* First, the financial means for embryonic stem cell research within the specific university were small at the time, and to place the research activities within a corporate setting was a feasible way to continue along promising research avenues. Second, the researchers had an ambition to provide solutions to patients' needs. At the time there were high hopes from a number of patient groups – e.g. relating to Parkinson's disease – and an urge to move research from the lab to the clinic. Third, the Swedish regulation stated that the university was prohibited to sell its research results based on stem cells from fertilized eggs, and the solution with a corporate legal unit was thereby a way to handle that situation. Fourth, there was an interest within the group to explore the commercial potential of their research results, with the possibilities of economic returns.

The researchers considered a *spin-off to be the best mechanism for transfer*. The firm's intellectual property and business ideas were based on the joint efforts of this group of academics, sharing similar research goals. They agreed that a major part of the development should take place within academia, drawing on the facilities, equipment and research teams of the founding researchers. The scientific founders brought intellectual property, knowledge, a wide range of ideas as well as the initial capital, but their competence base was also matched by the recruitment of industrially highly experienced individuals into the management team. There were not very distinct borders between the academic and the corporate sphere and the focus was to collect all the intellectual property into one organizational unit.

The majority of the founding researchers have kept their positions at their universities and simultaneously retained a close link to the business development. They are involved as scientific experts in several corporate projects, and perform research on the firm's stem cells with resulting intellectual property being offered to the firm with a 'first right of refusal' as a *licensing* deal. In cases where the intellectual property is of less commercial value to the firm, its ownership is transferred to the individual researcher. Moreover, the company's facilities are accessible for the researchers and the cell lines can be acquired at a low cost.

4.7 Eta: Industrial actor set-up

In this case, the researcher had a PhD in biology and, after a post doc period in the USA during which he had gained both academic and industrial experience, he was more tempted to use his experience in industrial projects than to return to the Swedish academic setting. He found it especially interesting to work

in a small firm where a young researcher possibly could get responsibility for a larger part of the development process. This exemplifies the *determinant "industrial actor set-up"* where the existence of a company with a similar research field influences a researcher to engage in commercialization. In this case the researcher went as far as to leave academia for a position in the company. The *mechanism of transfer was thus labor movement* and it was facilitated by a public policy initiative, in the form of financial support, which made it beneficial for the young firm to employ a returning expatriate researcher.

The researcher was involved in developing a method needed for the quality assurance of the company's products. This method showed such large potential that the company management decided to place it within a new company, which would be managed by the researcher and two colleagues. This spin-off developed successfully and was acquired a few years down the line. The researcher then returned to the mother company for a period before moving on to another start-up company.

What is interesting to our research questions is that the three companies have all been tightly linked to academia. This has meant that the researcher has continuously kept a close link with both the university research as such, and with his former department in particular. In this way the knowledge transfer from the labor movement has not been an end to the university-industry connection, nor a one way path. Instead it is characterized by continuous knowledge flows back and forth.

5 Conclusions

The actual contribution of universities adds more to growth than present technology-transfer calculations show (Lester 2005; Bercovitz and Feldmann, 2006; Audretsch et al. 2006). Scholars have therefore started to focus on what researchers do (rather than what technology transfer offices do) and to include informal mechanisms for transfer of research in their studies. In this study, we respond to Audretsch et al´s (2006) call for further investigation on why and how scientists choose to commercialize their research. Mowery (2005) is critical of the current technology-transfer system in the US and emphasizes the need for multiple channels between university and industry. His argument makes the case of Sweden interesting, since the researchers at universities in that system own the intellectual property of their research. Sweden is one of few countries with this regulation and thus constitutes a quite unique case where studies can be made on which choices researchers make in a setting where a variety of channels for transfer are open to the choice of the individual researcher. We have made use of this empirical setting through seven longitudinal case studies. The cases were from three different centers in Sweden, which may effect the results. The centers are, in major ways, very similar: they follow the same regulations regarding intellectual property, the leadership encourages transfer of research, quality of research within the stem cell area is high and there are industrial actors in the nearby area. The informal attitude at the different institutions regarding engaging in transfer of research is bound to vary. Such variations are known to be found between institutions at the same center and do not necessarily constitute a difference between the three centers per se.

Based on the Swedish cases we can conclude that the ways in which, and reasons why, academic research is transfused into society is much more diverse and multi-facetted than what is covered by common measures of academic research transfer or by public policy. Our empirical material allowed for the expansion of the typology for mechanisms for transfer of academic research (see table 3) and the development of a typology for determinants for researchers´ choice to engage in commercialization (see table 1). It thus contributes to the theoretic discussion on transfers of academic research by uncovering some of the "grey zone" between academy and industry.

Regarding the determinant "Perceived societal role of the university", a similarity between the cases is that the organizational, regulatory and working environment not only allows, but also encourages engagement in technology transfer. In our open-ended interviews there have been no signs of obstacles or hesitations relating to negative effects of the researchers' engagement in commercialization issues. Moreover, the feeling of owning their own intellectual property and being in control of how to transfer it, seems to work as an incentive for some of the researchers. The key researchers do not want to leave academia in any of our cases, but are to different degrees involved in commercialization (or plan to be) because they want to secure funding for their research-projects, have their research put to practical use for the benefit of patients and/or gain private financial benefits.

Regarding the determinant "Supportive infrastructure", the choice of whether to make use of a technology-transfer office on campus or not relates to whether researchers believe that office to be competent or not, and to whether the individual researcher has enough social capital to transfer without the support system. Worth noting is, however, the importance of an active support system, since the researchers can not be expected to be occupied with thoughts of application nor able to value potential commercial use.

Regarding the determinant "Industrial actor set-up", our cases are located in areas with local biotechnology companies nearby, so we cannot make statements regarding potential difficulties if there had not been companies around. What we do find, however, is that both local and non-local companies are interacting with the researchers in our cases, with purposes of transferring research. This leads us to redefine the "Industrial actor set-up"- definition: "Existence of companies that have receiver capabilities to develop early stage research projects". The policy implication is that even though local companies are important, companies located far away from the researchers may well be informed of and interested in their findings. Adding to the discussion about the role of local resources in technology transfer, we would like to bring in the observations that non-local companies may be just as important as local companies for the transfer dynamics as such. From policy-makers point of view, looking at contributions to local economic growth and realizing that transfer takes place with the company that has the best strategic fit no matter where it is located, the question should be how to increase the likelihood that the value created from university research is being harvested at home, rather than abroad.

Our material contributes to the understanding of the fit between company strategies and research groups at universities, a piece of the puzzle which has been relatively unexploited. The informal interaction that occurs between companies and researchers in academia, and a potential strategic fit, give rise to an interest in transferring research that the researcher otherwise may not have had. We propose that concrete discussions of potential practical use and research collaborations that will bring money into the research projects in academia work better as incentives for researchers than general advice to disclose findings to the technology-transfer office. Related to that proposal is the value of direct interaction between academic researchers and companies for increased technology transfer to occur, which we have seen in our cases. Such interaction can be facilitated through policy-initiatives.

Regarding the determinant "Networks", our cases contain examples of researchers that lack social capital related to commercialization, as well as of researchers that have plenty. In the cases where the researchers lack that social capital, they are inclined to turn to the support system in terms of university technology-transfer offices, unless there seems to be a better support alternative available. Where they do have social capital, they seem to interact directly with companies, using a variety of mechanisms for transferring research. Based on a few case observations it thus seems likely that, in a situation where a researcher can choose herself, a technology-transfer office serves a purpose for researchers that lack social capital related to commercial settings, because they have not interacted with companies so far. Researchers with frequent contacts with companies and where trust has been established, make their transfers (both formal and informal) directly with the companies, independent of to which degree the researcher herself chooses to engage in commercial activities. Social capital thus seems to indicate whether or not a researcher uses a technology-transfer office, but not which choice of mechanism for transfer that is chosen.

The study is based on a limited number of case studies, and as such has restricted external validity. The typology developed needs to be further tested and validated on different sets of projects and in different institutional circumstances. In particular, as the projects relate to a science driven field (stem cell research) the findings should be validated for other knowledge areas. Also, given the IPR-ownership structure of Swedish university based research, other institutional set-ups should be contrasted in further research. We would argue though that the difference may in practice be less that seen at face value: The reason is that even though the regulations regarding ownership of intellectual property differ, researchers in other countries find ways of taking "the back door" to exploit their research outside of the formal channels (Audretsch et al., 2006; Bercovitz and Feldman, 2008). In essence, we believe the conclusions and typology developed through the Swedish cases likely to be relevant beyond this specific national context.

By using the method of longitudinal case studies we could follow researchers' pursuits and expectations with regards to transfer of research. Across the cases, the researchers tend to underestimate the time needed for their projects to develop into something useful for industry. One aspect, touched upon briefly in this paper, is outcome of transfers. Our cases are early stage and it will take some time before

actual outcome can be analyzed. In future studies it would, however, be interesting to see how expected outcome relate to actual outcome. It would also be relevant to investigate whether the intensions of the researchers were fulfilled and/or if they have changed along the way. Related to that is the question of how the ups and downs of the process impact the researchers´ interest in engaging in future transfers of research. Such knowledge would be important for policymakers who aim to keep researchers engaged in transferring their findings.

A lesson from our cases is that key researchers and their teams contribute to companies in ways that would not be visible by licensing or spin-off data. This variety in transfers and their contribution to economic growth through company advancements, so far to a great deal unnoticed by policy-makers, makes us inclined to agree with Lester (2005) in the need for a more differentiated view of technology transfer, focusing on a variety of roles that the academic research play in companies' innovation processes. Our journey into the "grey zone", with the typologies we provide, will hopefully be of use in future quantitative studies that aim to present such a differentiated view. Future quantitative studies, based on our typology on mechanisms for transfer, may be able to present a more accurate picture of the extent of transfer activities, compared to previous statistics limited to patents and spin-offs. If such studies would show that a large percentage of university researchers in some ways are involved in transfers it would send important signals of the actual contribution to growth made by universities. It would further allow for comparative studies between different types of universities or different regions/countries. Do researchers at universities in one region engage more in transfer than in another? What then are the differences between the regions compared? To move forward with the latter question, we expect the typology on determinants for researchers´ choice to engage in transfer of research, presented in this paper, to be useful.

The typologies presented here may be an important input to policymakers´ expectations regarding universities' contribution to economic growth. It will also provide a base for policy-decisions with regards to regulations and support to technology transfer processes, taking into account how researchers act. Increased knowledge will also provide input on how to identify and reward different types of contributions to growth that researchers in academia make.

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