University-industry relationship: From the perspective of small firms

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Abstract

This thesis investigates university-industry relationships from the perspective of small firms. Traditionally university-industry relationships research features large firms rather than small firms, which leaves the strategies applied by small firms to establish and develop relationships with universities poorly understood.

This thesis begins with a comprehensive theoretical review, which subsequently leads to the development of a research model and research questions. The review shows that small firms face a number of challenges when it comes to establishing and developing relationships with universities. Production and distribution of knowledge is increasingly taking place in reflexive systems of innovation and follow non-linear patterns. This suggests that small firms need to manage their relationships with universities in a similar dynamic way. Small firms are also subject to rapid technological progress and to constantly changing organisational forms. It is under these circumstances that this thesis proceeds with empirical studies on how small firms manage their relationships with universities. The empirical work of this study is based on an explorative research design involving interview data and secondary information from 30 small firms.

The findings from this study are presented in three research papers (chapters 8, 9 and 10). The first paper investigates how small firms choose which university to partner up with. The second paper examines how the increasing focus on research commercialisation forces small firms to rethink how they govern their university relationships. The final paper explores the relationship between social capital and value-capturing in university-small firm relationships.

This study contributes to existing research on university-small firm relationships by exploring how small firms can establish and develop relationships with universities from a dynamic perspective. Firstly, small firms' strategies to partner selection are affected by accumulation of collaboration, partner and technical experience. Secondly, small firms need to develop governance mechanisms towards technology transfer offices and the individual scientists simultaneously to ensure successful relationships with universities. Thirdly, small firms need to adjust their social capital over time to ensure continuing value-capturing in university relationships. These three contributions are combined at the end of this study to develop an analytical model to guide future research on university-small firm relationships.

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1 Introduction

The purpose of this chapter is to introduce the topic, provide an overview of prior research, identify a research gap and present the research questions and approach of this study.

1.1 Introducing the topic of this study

There is an increasing interest in collaborative relationships between industrial firms and universities among policy makers, managers and scholars. The interest is sparked by a general confidence among these groups that successful relationships between universities and industrial firms are vital drivers for economic growth, employment and competitive advantage in society (Debackere & Veugelers, 2005; Etzkowitz & Leydesdorff, 2000; Montoro-Sanchez, Mora-Valentin, & Guerras-Martin, 2006; Perkmann & Walsh, 2007; Rosenberg & Nelson, 1994).

Research usually considers university-industry relationships to be different to traditional relationships among industrial firms because: (1) the organisational structure, research culture and commercial focus at universities are distinct (Rosenberg & Nelson, 1994; Donald S. Siegel, Waldman, Atwater, & Link, 2004); (2) university knowledge and technology outputs are often fundamental and novel compared to outputs from other types of external sources such as suppliers and customers (Bierly III & Daly, 2007; R. Jensen & Thursby, 2001); and (3) it is only a particular set of firms that seek relationships with universities (de Jong & Marsili, 2006; Pavitt, 1984). Thus it has been argued that research on university-industry relationships should have their own space in the management literature.

While research on university-industry relationships is a distinct research area, it has been approached from different perspectives in the literature. Most commonly, scholars have examined how universities can use relationships with industrial firms as a mechanism to commercialise academic outputs (Debackere & Veugelers, 2005; Rosenberg & Nelson, 1994; Veugelers & Cassiman, 2005). This includes the creation of new ventures such as spin-offs (Clarysse, Wright, Lockett, Van de Velde, & Vohora, 2005; Lockett, Siegel, Wright, & Ensley, 2005) and academic founded firms (Krabel & Mueller, 2009). Within this approach, the actual university-industry relationship is regarded as the outcome of organisational setups and strategies to transfer knowledge and technologies from universities to industry.

Research on university-industry relationships has also been approached from the perspective of the firm. This approach focuses on how industrial firms can manage relationships with universities to

enhance their capacity to innovate; for example through partner selection strategies or choosing appropriate governance structures and mechanisms (Fontana, Geuna, & Matt, 2006; Fransman, 2008; Rappert, Webster, & Charles, 1999). This study will continue research within this approach.

A closer review of the research applying a firm perspective shows, however, that the majority of studies tend to feature large firms rather than small firms (J. E. L. Bercovitz & Feldman, 2007; Keld Laursen & Salter, 2004). The bias towards large firms can be explained by university-industry relationships usually being associated with long-term investments in scientific discoveries as it used to be believed that innovation proceeded in a linear manner (Godin, 2006). The requirements for long-term investment usually only attracted firms with abundant financial and human resources (Godin, 2006) - a luxury that did not apply to most small firms (Keld Laursen & Salter, 2004; Motohashi, 2005). During the last few decades the linear perspective on innovation has been replaced by the view that innovation benefits from science through an interactive process of combining knowledge in new ways (Freeman, 1987; Kline & Rosenberg, 1986; B-Å. Lundvall, 1992; Bruce S. Tether & Tajar, 2008). This view has been important for understanding why small firms are becoming increasingly involved in science-based innovation and often on behalf of large firms (R. Rothwell, 1989). Small firms are often pictured as being more flexible and adaptive to changes in the internal and external environment, which have proven to be important characteristics of the management of uncertainty in innovation (D. Audretsch, 1999; Narula, 2004). Small firms are also often more open to collaboration with external partners because they lack resources to establish in-house R&D activities (David Audretsch & Feldman, 2003). These differences between small and large firms prompt researchers to suggest that small firms are applying different strategies to manage their relationships with universities compared to large firms (Bierly III & Daly, 2007; Motohashi, 2005; Santoro & Chakrabarti, 2002).

This study is positioned within the area of research on university-small firm relationships. More particular, this study aims to extend our understanding of how small firms can establish and develop successful relationships with universities. This is an area that has only very recently started to receive more systematic attention from scholars in the literature but nevertheless is very relevant in today's society where small firms are becoming more and more important contributors to the economy.

1.2 An overview of prior research of university-small firm relationships

It is only within the past decade that research on university-small firm relationships has started to appear more systematically and frequently in academic journals. Thus our understanding of how small firms manage relationships with universities continues to improve. A review of the research field, however, shows that research on university-small firm relationships is far from exhaustive and several research opportunities within this topic still exists. The purpose of this section is to provide an overview of prior research and research gaps on how small firms manage relationships with universities.

Relationship logic

In contrast to large firms, small firms rarely engage directly with universities in basic research that may lead to new inventions in non-core technological areas (J. E. L. Bercovitz & Feldman, 2007; Santoro & Chakrabarti, 2002). Small firms are more likely to apply academic research when undertaking development of products or services new to the market (Bierly III & Daly, 2007). Hence small firms collaborate with universities to access and transfer knowledge that is related to advancing their core technology (Hu & Mathews, 2009; Santoro & Chakrabarti, 2002).

University-small firm relationships can take many forms with various levels of intensity and commitment; from arms-length to joint ventures or consortia involving one or multiple partners (Kleyn, Kitney, & Atun, 2007; Tödtling, Lehner, & Kaufmann, 2008). Small firms are more likely to engage in less cost-intensive relationship structures to facilitate knowledge transfer and learning, e.g. consultancy and collaborative and contract research (Bierly III & Daly, 2007; Motohashi, 2005; Perez-Perez & Sanchez, 2003). These structures are often supported by a myriad of informal relationships that are usually formed before more formalised structures are applied (Debackere & Veugelers, 2005; Rappert, et al., 1999). Moreover, small firms often attend seminars, supervise student projects/theses, hire students and co-author publications as part of the ongoing relationship they have with universities. In return university staff may take up positions in the firm's advisory board, provide assistance or allow firm access to equipment and facilities on an ad-hoc basis (Inzelt, 2004).

Forming relationship with universities

Another area of interest in research on university-small firm relationships is how these relationships are formed. Small firms often use their existing social network to form relationships with universities either directly or indirectly (Al-Laham & Souitaris, 2008). A firm can accumulate information about

potential partners from prior experiences of collaboration with an external partner or through one's social networks. Prior collaboration or partner experiences are valuable for reducing transaction costs and risk from information asymmetry when establishing new relationships (Al-Laham & Souitaris, 2008; Murray, 2004). In contrast, firms without prior experience often find the costs of establishing relationships with universities higher than the expected return (Motohashi, 2005).

It can be difficult to justify searching for new partners if a firm has positive experiences collaborating with one particular university (Izushi, 2003; Santoro, 2000). One study also referred to how similar institutional logics across the firm and university (e.g. culture, objectives, practices) supported richer interaction (Bjerregaard, 2010). If a firm has technical experience working with a particular technology from a specific university, then it is also more likely to continue collaborating with that university (Daghfous, 2004; Guan, Yam, & Chiu Kam, 2005).

Besides the relevance of prior experiences of collaboration with universities and technical experiences, several scholars have also found that small firms that are more open towards external knowledge are also more likely to consider universities as a source of knowledge (Keld Laursen & Salter, 2004). Openness is seen as a strategic choice made by the firm to actively search and share knowledge with existing and potential partners (Keld Laursen & Salter, 2004). For example, small firms that take part in patenting and publishing are more likely to attract universities as partners (Fontana, et al., 2006). It has also been well documented that small firms with a high level of absorptive capacity within scientific research are more likely to learn from universities, and hence, collaborate with universities (Bigliardi & Dormio, 2009; Busom & Fernández-Ribas, 2008; Schartinger, Schibany, & Gassler, 2001; Bruce S. Tether & Tajar, 2008; Tödtling, et al., 2008).

Close geographic proximity also influences which firms collaborate with universities because spatial closeness reduces travel time and cost (Scott Shane, 2002) and improves knowledge spill-overs (D. B. Audretsch, Lehmann, & Warning, 2004). To stimulate more small firms to collaborate with universities, several governments have made significant improvements to the surrounding infrastructure through establishment of science-parks, incubators and clusters in close proximity to leading science-based universities. Löfsten and Lindelöf (2002) and Quintana-García and Benavides-Velasco (2006) found that small firms located within science parks or clusters collaborate with universities more often. Yang et al. (2009) also found that new technology-based firms located in a science park experience higher externalities from universities in the form of access to equipment, knowledge diffusion and network opportunities. Other scholars also found that firms that receive public funding are more likely to collaborate with universities (Busom & Fernández-Ribas, 2008).

Funding can be directed towards the actual relationship (Montoro-Sanchez, et al., 2006) or to improve internal R&D competences in the individual firm (Inzelt, 2004).

Managing university relationships

In the existing literature, university-small firm relationships are pictured as dynamic constellations that require constant attention from management to ensure long-term success (Plewa & Quester, 2007; Santoro, 2000). A number of studies describe how small firms often need to develop additional skills to be able to collaborate successfully with universities. Izushi (2003) argued that small firms often lack the capacity to learn from universities to begin with. They can, however, compensate for this lack by first collaborating with universities around activities involving lesser information gaps. As the firm accumulates more capacity to learn from universities they can intensify the relationships. Small firms and university relationships are more likely to succeed as their organisational culture and objectives converge (Bjerregaard, 2010) or as they develop a mutual understanding over time (Gonard, 1999). Inzelt (2004) referred to small firms gradually increasing commitment over time in university relationships. These studies describe the university-small firm relationships as evolving gradually over time.

Another stream of research shows that small firms need to manage their relationships with universities according to their strategic focus. Small firms become gradually less dependent on knowledge and technologies from universities as their core technology matures and they become more business orientated (Gübeli & Doloreux, 2005; Perez-Perez & Sanchez, 2003). Other scholars argue that small firms are better off by forming weak ties with universities to allow university researchers freedom and autonomy to come up with new knowledge to solve the firm's problem. As the knowledge proves to have potential, then the firm can form stronger ties with the university researchers to exploit this new knowledge (Harryson, Kliknaita, & Dudkowski, 2007). Within these studies, the expectation is that small firms should develop their relationship according to their strategic focus.

In summary, research on how small firms manage their relationships with universities is beginning to substantiate and a number of specific themes are appearing with increasing frequency in the literature. In this overview, the literature has been divided into three sub-themes: (1) relationship logic; (2) formation of relationships; and (3) relationship management. These themes are all critical for understanding how small firms can manage relationships with universities successfully (Perkmann & Walsh, 2007).

The research gap

Existing research has mainly been descriptive in the sense that: (1) it describes common characteristics across the population, e.g. motives for small firms to collaborate with universities (Santoro & Chakrabarti, 2002) or common governance structure in university-small firm relationships (Fritsch & Lukas, 2001); or (2) identifies causal relationships between antecedences and certain relationship outcomes, e.g. prior collaboration experience leads to lower transaction cost (Fransman, 2008) or technical relatedness leads to more knowledge sharing (Daghfous, 2004). The descriptive studies are usually based on large quantitative data sets, which allows for generalisation and frequency counts (i.e. Keld Laursen & Salter, 2004; Lhuillery & Pfister, 2009). Based on these descriptive studies alone it is possible to answer a number of questions related to university-small firm relationships, for example: *Why do small firms collaborate with universities? What forms do university-small firm relationships take? What types of small firms are most likely to collaborate with universities? What firm antecedents promote knowledge sharing behaviour?* Although these descriptive studies enhance our understanding of how small firms can establish and develop relationships with universities, they suggest even more research opportunities.

The understanding from the existing research is that the success of university-small firm relationships is determined by their initial conditions (e.g. existing resources and competences). While this might be true in a stable context, it is more uncertain whether this applies in a situation where internal and external environments of small firms are constantly evolving. The type of innovation undertaken in university-small firm relationships usually involve high technological and market uncertainty (R. Jensen & Thursby, 2001). Technological advancements are not predetermined but occur more often through iterative processes or when knowledge is combined in new and creative ways across firm boundaries (Kline & Rosenberg, 1986). Knowledge production for innovation is also described as becoming more context dependent, which means that knowledge is never perfectly understood but has different meanings to different people depending on their background and the context in which it is applied (Gibbons, et al., 1994). As innovation does not follow a linear path, strategies of small firms pursuing innovation also exhibit strong non-linear properties (H. Chesbrough, 2003). Under these circumstances, success in university-small firm relationships is not necessarily determined by the initial conditions. University-small firm relationships are not static entities that produce constant return on investment for the stakeholders involved (Perkmann & Walsh, 2007). Rather success in university-small firm relationships comes down to how small firms manage their relationships on an ongoing basis. This is an area that has received only little attention in the existing literature and will be further explored in this study.

1.3 The research questions and approach of this study

This study intends to continue research on university-small firm relationships by investigating how small firms can manage their relationships with universities successfully. It is argued in this section that the purpose of this study is best pursued through explorative empirical studies of small firms.

The research questions of this study

The purpose of this study is to explore how small firms can establish and develop successful relationships with universities. This has been formulated into the following overall research question guiding this study:

How can small firms succeed in establishing and developing relationships with universities?

The research question is explored in the context of small firms using relationships to access and transfer knowledge from universities to enhance their capacity to innovate (Perkmann & Walsh, 2007; Santoro & Chakrabarti, 2002). Accessing and transferring knowledge is assumed to be fundamental for small firms to continue advancements in innovation and stay ahead of competitors (Joel A. C. Baum, Calabrese, & Silverman, 2000). Establishing and developing relationships is considered to be a dynamic process. The outcomes from this process depend on the ability of the firm to continuously develop new competences and learn from past experiences.

To be able to address the overall research question in this study, three sub-questions have been formulated. Each of these sub-questions will be addressed individually and presented in chapters 8, 9 and 10 respectively.

1. *How do experiences affect how small firms select which university to partner up with?*
2. *How does the increasing focus on research commercialisation at universities affect how small firms apply mechanisms to govern their relationships with universities?*
3. *How can small firms use their social capital to continue capturing value in the relationships with universities?*

A more detailed account of each of these sub-questions is outlined in chapter 6.

The approach of this study

Given the lack of research on understanding how small firms can establish and develop successful relationships with universities, this study is based on an explorative research design aiming at reconceptualising and extending theory (Dubois & Gadde, 2002). A total of 30 small firms were

included in this study representing various industries such as software, nanotechnology, robotics, bio pharmaceuticals, protein engineering and cell and tissue culture. The firms were located in some of the major cities of Denmark (Copenhagen and Odense) and New Zealand (Auckland and Dunedin).[1] A senior manager from each firm was interviewed at least once and additional information about each firm's innovation activities and relationships with universities was collected from websites and newspaper archives.

Table 1-1: Overview of participating firms

Number of employees	
1-9 employees	19
10-49 employees	11
Type of company	
Direct university spin-off (based on university patents)	13
Indirect university spin-off (based on university know-how)	7
Independent (non spin-offs)	10
Location	
Denmark (Copenhagen and Odense)	18 (12 and 6)
New Zealand (Auckland and Dunedin)	12 (8 and 4)
Year of founding	
Oldest firm	1987
Youngest firm	2006

The data collection process was highly inspired by the existing research, but rather than testing or building on existing research, it uses existing research to inform the empirical process and provide insight that could contribute towards a more robust and rigorous analytical model on how small firms establish and develop relationships with universities (Dubois & Gadde, 2002). More specifically, the explorative approach of this study will pursue the following steps: (1) review prior research on small firms and university relationships; (2) develop a research model; (3) apply the research model to guide the empirical studies; and (4) use findings from the empirical studies combined with literature studies to develop an analytical model.

[1] Denmark and New Zealand provide a good context for studying the role of small innovative firms collaborating with universities because both countries are relatively similar in demographics and well integrated in the global economy despite their relatively small size. Both countries are politically stable with governments taking active part in coordinating innovation and formulate innovation policies and frameworks. Both economies are strongly dependent on the contribution from small firms. Furthermore, both countries are highly developed when it comes to the level of information and communication technology. This makes these countries highly suitable for studying small firms.

1.4 Overview of the study

This study comprises 11 chapters. The structure is illustrated in Figure 1-1:

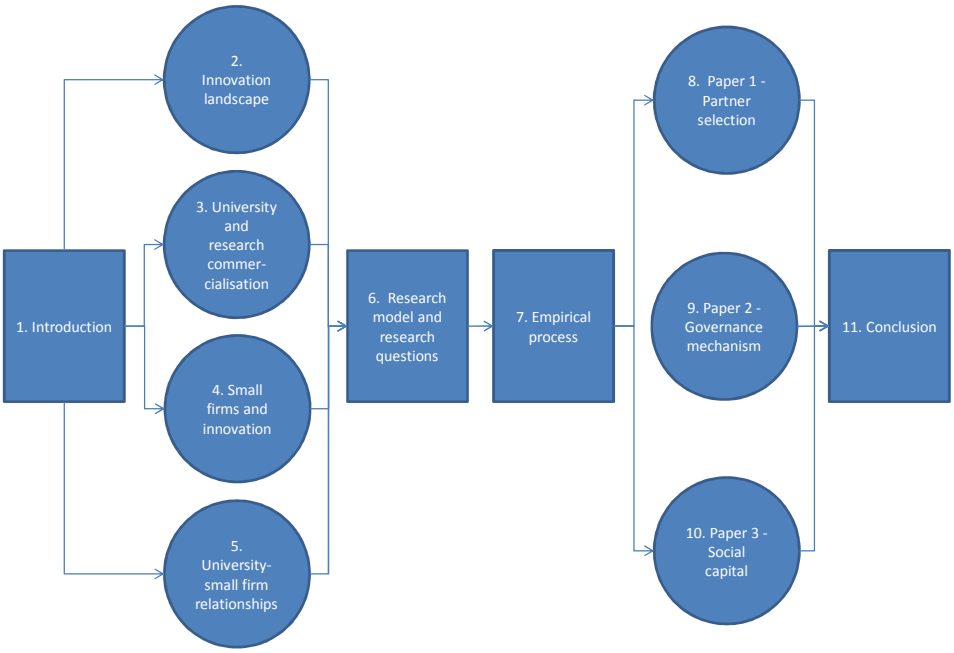

Figure 1-1: Structure of thesis

Chapter 1 introduced the topic and provides an overview of prior research on small firms and university relationships, which leads to the identification of research gaps. Also the purpose, approach and research questions are presented in here.

Chapters 2 to 5 review prior research related to university-small firm relationships from various disciplines such as innovation economics, innovation and strategic management, social networks and entrepreneurship. The first part of the review, *the innovation landscape*, describes how recent models of innovation have steered research scholars and policy makers to argue for the importance of inter-connectivity for the improvement of knowledge diffusion in society. Especially attention has been directed towards 'mode 2' knowledge production (1994), the Triple Helix framework (1995, 2000) and the National System of Innovation model (1987; 1992). The second part describes how the role of universities in society has changed in recent years as they have become more commercially orientated (Etzkowitz, Webster, Gebhardt, & Terra, 2000; P. H. Phan & Siegel, 2006). The third part of the review, *small firms and innovation,* focuses on identifying the unique characteristics of small firms but also the difference among them. It is argued that innovation processes in small innovative firms are very distinctive, especially when compared to larger firms. The final part of the review

contains a systematic review of prior research on how to manage university-small firm relationships. The systematic review includes more than 70 academic peer-reviewed articles.

Chapter 6 combines the reviews from the previous chapters into a research model and also outlines the specific research questions. Chapter 7 presents the methodological approach of this study including a more detailed description of how the empirical data was collected and stored. Chapters 8, 9 and 10 present the empirical research before chapter 11 concludes this study.

2 The innovation landscape

The purpose of this chapter is to critically examine the literature on knowledge production and distribution in society. While knowledge is required for innovation, research shows that knowledge production and distribution is becoming increasingly non-linear, context dependent and integrated in reflexive and dynamic systems of innovation. These characteristics of knowledge production and distribution have some implications in this study as it is assumed that the nature of university-small firm relationships follows some of the same trends as observed in knowledge production and distribution in society.

2.1 Introduction

In contemporary research, innovation is increasingly being viewed as a spiral movement that captures multiple and dynamic relationships between firms, universities and governments established to diffuse knowledge effectively and efficiently in society (Etzkowitz & Leydesdorff, 1995; Freeman, 1987; Gibbons, et al., 1994). This view challenges the notion that innovation is the result of successive organisations linked to a pre-determined chain of developments often referred to as the linear model of innovation (Bush, 1945; Godin, 2006). Rather, it creates the understanding that innovation is the outcome of combining knowledge, resources, skills and ideas in new ways within and across firm boundaries (Gibbons, et al., 1994; Kline & Rosenberg, 1986). With innovation moving outside the boundaries of the firm, researchers have increasingly emphasised the importance of the wider context to support knowledge production and distribution in society (Etzkowitz & Leydesdorff, 2000; Freeman, 1987). The wider context includes other organisations, physical infrastructures and institutional factors such as cultures, laws, values and norms (B-Å. Lundvall, 1992).

The purpose of this chapter is to gain insight into the relationship between production and distribution of knowledge and the wider context of small firms. This chapter aims at (1) identifying the main trends in knowledge production and distribution; and (2) investigating what role the wider context plays when it comes to production and distribution of knowledge in society. Overall, this chapter contributes to this study by outlining the possible links between the external environment and knowledge production and distribution affecting small firms and their relationships with universities.

The chapter is based on a critical review of central theoretical concepts and models in the literature describing knowledge and innovation in society (Huff, 2008). The chapter consists of two main topics: (1) knowledge production and innovation and (2) knowledge distribution and innovation. The exact content of each of these topics will be described in the separate introductions to each of these

sections. The chapter concludes with an overview of how each of these theoretical views on knowledge production and knowledge distribution in society contributes to the understanding of the context in which university-small firm relationships are embedded.

2.2 Knowledge production and innovation

The first part begins by introducing the linear model of innovation by Vannevar Bush (1945), which has been highly influential among politicians and academics and has dictated innovation policies and research for decades. Not until the 1980-90s did the linear view start to be challenged by some alternative theoretical models and concepts including the Chain-Linked Model by Kline and Rosenberg (1986) and Mode 2 Knowledge Production by Gibbons et al. (1994). Kline and Rosenberg's work is seminal in regards to rejecting the linear model of innovation and presenting innovation as an accumulated social process that take place continuously through vertical integrated relationships. Mode 2 Knowledge production by Gibbons et al. pictures knowledge production as transforming from Mode 1, characterised by autonomy, hierarchies and distance between pure science and application, to Mode 2, characterised by inter-disciplinarity, application orientation and socio-economic dominated.

The Linear approach, Mode 2 and Chain-Linked model are not only essential in describing a paradigm shift in our understanding on knowledge production but also appear as normative standards for enhancing knowledge production and the outcomes hereof. Each of these three models can be seen as separate theories surrounded by their own interpretations and assumptions to how knowledge production is best carried out. But they can also be viewed together to provide a more holistic overview of different trends and directions influencing knowledge production and innovation in society. The latter approach is applied in this study and the outcomes of this approach are to be summarised at the end of this chapter.

2.2.1 *A linear approach to knowledge production and innovation*

A linear model

One of the first models to conceptualise innovation has been the linear model of innovation. The model postulates that innovation goes through a set of well-defined stages: basic research → applied research → development (Godin, 2006). According to OECD (1962), basic research is the planned search for new knowledge; applied research is applying existing knowledge to problems that involved the creation of new products or processes; and finally development is applying existing knowledge to improve an existing product or process. The linear model was specifically endorsed by Vannevar Bush (1945) in 'Science, the endless frontier'. In the report Bush argued for the importance of basic

research in driving innovations. As the linear model of innovation found strong support among policy makers, especially in the time after World War II, Bush advocated for expanding public funding for basic research within universities. But long before the conceptualisation of the linear model, Carty (1916) argued for universities to be the home of basic research funded by the government because only university scientists, in contrast to industry scientists, had pure interest in the socio-economic benefits that could be derived from basic research. This perception was shared by Bush who articulated that "*[new inventions originated in advancing] basic research... creates the fund from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on the principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science. Today, it is truer than ever that basic research is the pacemaker of technological progress" (Godin, 2006, p. 644. Originally Bush [1945] reprinted in 1995, p. 19).*

Bush also put forward the argument that market imperfections kept industrial firms from investing in basic research. Therefore, relying on industry alone would lead to the level of new knowledge production to be far below what is socially required (Godin, 2006). The market imperfection rationale was subsequently developed by Nelson (1959) and Arrow (1962) who explained that industry investments in basic research will always be low because of market imperfections and the uncertain characteristics of outcomes of basic research. The research organisation may only appropriate a fraction of its total value because knowledge from basic research can be used by multiple actors without reducing its value. Knowledge from basic research generates external spill-over, which decreases the incentives for especially industrial organisations to invest in new knowledge creation (Arrow, 1962). For these reasons it was held that there was a serious problem as industrial firms did not have adequate resources and mechanisms for appropriating the benefits of the research to themselves (Rosenberg, 1990).

According to the linear model of innovation, innovation progresses in pre-determined sequences and industrial firms do not have incentives or interest in investing in basic research. Partly for these reasons it has been the practice for many years, and still is today, to fund basic research at universities or other public research institutions through tax payers money (Godin, 2006). Eventually outcomes from basic research may spill-over in society and be picked up by industrial firms undertaking applied research and development in the same sequential order as presented by the linear model (Rosenberg, 1990).

The limitations and implications of the Linear Model of innovation

Even though the linear model found its opponents soon after it was conceptualised by Bush, the model has been for a long time, and still is to some extent, recognised and applied by policy makers, journalists and members of the public to evaluate innovation performance across countries (Godin, 2006). Data on investments made in basic research, applied research and development at a country level have been relatively easy to collect and compare due to standardised definitions of the three terms developed in the Frascati Manual from 1963. The Manual was adopted by OECD to help countries measure their innovation effort by offering methodological conventions allowing for international comparison (Godin, 2006). As Freeman (1995) explained: "*Academic research on invention and innovation had amply demonstrated that many factors were important for innovative success other than R&D. However, the practical difficulties of incorporating these factors in international comparisons were very great. League table comparison of R&D were much easier and more influential" (Freeman, 1995, p. 10).*

While the number of critics of the linear model has continued to grow since it was introduced (i.e. Kline & Rosenberg, 1986; B-Å. Lundvall, 1992; P. Patel & K. Pavitt, 1994), it is only within the past 2-3 decades that scholars have managed to come up with alternative concepts and models to explain knowledge production and innovation processes. These include the concept of 'Mode 2 knowledge production' (Gibbons, et al., 1994) and the 'The Chain Linked Model' (Kline & Rosenberg, 1986) among others. While these various models and concepts will be discussed later in this chapter, it is interesting enough to mention that they all refer to the linear model of innovation as a motivational factor for developing more analytic and dynamic perspectives on knowledge production and innovation. Although it is recognised that some important innovations do originate from basic research (e.g. penicillin, DNA profiling and the Internet), there is a general understanding today among research scholars that a proportional relationship between investments in research and growth does not exist (Freeman, 1987; Kline & Rosenberg, 1986). Especially the postulates made in the linear model of innovation that science comes first and therefore is to be considered the most critical element in knowledge production and innovation and that science is automatically diffused in society have been scrutinised by contemporary research scholars (Etzkowitz & Leydesdorff, 2000; Gibbons, 2000; Gibbons, et al., 1994; Kline & Rosenberg, 1986).

2.2.2 *Context-sensitive knowledge production and innovation*

In a direct response to the lack of theoretical concepts to explain knowledge production and innovation in society, Gibbons et al. (1994) developed the concept of 'Mode-2 knowledge production'.

The emergence of Mode-2 knowledge production in society

The authors of the concept argued that the world is witnessing a dramatic shift both in the institutional context of knowledge production but also in the kind of knowledge that is being produced. This shift is conceptualised as a transformation from Mode-1 to Mode-2 production of knowledge (Gibbons, et al., 1994; Helga Nowotny, Scott, & Gibbons, 2001). Mode-1 knowledge production is described as being created within a context governed by the academic community and for the interest of this community. It is investigator-initiated and usually based in a single discipline (Gibbons, et al., 1994; Helga Nowotny, et al., 2001). In contrast, Mode-2 knowledge production is generated in a broader social and reflexive context and is application-driven. It is more trans-disciplinary, which refers to a movement beyond disciplinary knowledge production routines and where boundaries between pure and applied knowledge production and theory and practice become less important. Mode-2 knowledge does not necessarily derive from existing disciplines; nor does it always require the formation of new disciplines. Moreover, knowledge produced for one problem becomes the springboard to further advances. Exactly where this knowledge will be used next, or how it will be applied, is difficult to predict and control (Gibbons, et al., 1994; Helga Nowotny, et al., 2001).

Table 2-1: Key characteristics of 'Mode 1' and 'Mode 2' knowledge production

Key characteristics	'Mode 1'	'Mode 2'
Context governed by	Academic community	Application
Nature	Homogeneity	Heterogeneity
Organisational	Hierarchical	Heterarchical
Discipline	Single	Trans-disciplinary
Quality control	Less socially accountable and reflexive	More socially accountable and reflexive
Preferred research style	Single researcher	Collaborating researchers from different disciplines

Source: McLauglin (2007), 'Understanding social work research', Sage, London, p. 143

A society in transformation – towards Mode-2

Multiple sites for knowledge production

The transformation of knowledge production from Mode-1 to Mode-2 has been caused mainly by the increase in graduates from tertiary education who have found jobs outside academia in recent decades (Helga Nowotny, et al., 2001). As these graduates use their skills outside academia (for example in private laboratories, entrepreneurial firms or government departments) it drives the production of more diverse knowledge in society (Gibbons, et al., 1994). Multiple sites of knowledge production is also confirmed by several other scholars who have observed that universities no longer have a monopoly on producing knowledge; nor have universities a monopoly or control over the direction of research programmes (Etzkowitz & Leydesdorff, 2000; Gibbons, et al., 1994). As resources to undertake research, especially human capital, have become more widespread in society,

knowledge production is becoming increasingly heterogeneous (Gibbons, et al., 1994). At the same time, the sites for problem formulation have gradually been moved from academia to the public space where new issues are discussed, formulated and feedback is generated (Kline & Rosenberg, 1986; Rosenberg & Nelson, 1994; von Hippel, 1988). As a consequence knowledge production becomes reflexive and reverses knowledge production in fundamental ways (Helga Nowotny, et al., 2001).

From hierarchies to heterarchies

It has also been observed that innovation is becoming increasingly complex due to fiercer competition and shorter product lifecycles in many industries (Miotti & Sachwald, 2003). Innovative firms and organisations involved in innovation have responded to these increasing complexities by forming relationships with external partners as a means to reduce uncertainty and share cost related to knowledge production (Gibbons, et al., 1994; Håkansson & Johanson, 1992; Kreiner & Schultz, 1993; Pisano, 1991). These external partners are not only scientists or technical experts but people with social and personal perspectives such as customers and end-users (von Hippel, 1988). The popularity of inter-organisational relationships has been further accelerated by the advancement in information and communication technology that have drastically increased knowledge sharing behaviour in society but also have lowered the cost of pursuing such behaviour (Helga Nowotny, et al., 2001). Nowotny et al. (2001) argued that the increasing use of inter-organisational relationships have led to traditional hierarchies to be replaced by heterarchies, which is seen as a system of organisations with multiple overlaps, mixed ascendancy and co-existence.

Increasing complexity to input in innovation

The requirement to knowledge production in terms of diversity has also shifted as it has also been observed that the number of inputs technologies required to develop a commercial product has increased significantly over the years (Granstrand, Patel, & Pavitt, 1997). Gibbons et al. (1994) argued that knowledge production from a single discipline is no longer sufficient to satisfy the increasing complexity in innovation. Even within academia, several scholars have observed that knowledge production also is becoming increasingly trans-disciplinary and application-orientated, which makes it difficult to make clear distinctions between pure and applied science any longer (Etzkowitz, et al., 2000; Rosenberg & Nelson, 1994). Adler et al. (2009) also reported that more and more research activities at universities are organised as large projects with an increasingly diverse base of financing and participants from academic, government and industry.

As Mode-2 knowledge is produced primarily in the context of application, it increases the motivation of scientists to generate knowledge that accounts for social, economic and political interests (Gibbons, et al., 1994). In this sense, knowledge becomes more socially robust as it is reliable not only within academia, but also outside of the four walls where it is produced (Helga Nowotny, et al., 2001). Especially universities have been urged by governments and industry to make more academic research available to the public through public seminars, conferences, publications and patents (Etzkowitz & Leydesdorff, 1995; R. A. Jensen, Thursby, & Thursby, 2003; Rosenberg & Nelson, 1994). As a consequence of the transformation of knowledge production, Gibbons et al. (2000) described the knowledge production in society as "*an overall increase in complexity which embraces a pervasive uncertainty in social relations, greater institutional permeability, the emergence of new forms of economic rationality, the emergence of a greater degree of self-organisation amongst social actors, and a profound shift in our perception of time and space" (Gibbons, 2000, p. 160).* In such a society, discrete domains such as population, politics, culture, markets and science become inter-related and transgressive areas, subject to the same co-evolutionary trends (Helga Nowotny, et al., 2001).

The limitations and implications of Mode-2

While the Mode-2 concept of knowledge production has received considerable attention in contemporary innovation research, it has not been without criticism (Etzkowitz & Leydesdorff, 2000; Nathalie & Will, 2009; Weingart, 1997). Shinn (2002) argued that the popularity and diversity of the audience of Mode-2 stem in part from the fact that the argument touches on many subjects from science, education, politics, inter-organisational collaboration and the market for knowledge. However, Gibbons et al. (1994) and Nowotny et al. (2001) only claimed that Mode-2 is a description of knowledge production in contemporary society. They continue by explaining that their work is meant to be reflective essays rather than empirical studies, with the aim of conceptualising some of the observed new trends in how knowledge is produced in and with society (Helga Nowotny, et al., 2001; H. Nowotny, Scott, & Gibbons, 2003). This complicates using Mode-2 as a research framework as it does not articulate a research programmes or set indisputable limitations or opportunities for future research (Shinn, 2002).

Another point made by critics is to what extent Mode-2 has replaced Mode-1. Several scholars argue that Mode-1 and Mode-2 are not mutually exclusive and should in fact exist simultaneously (Huff, 2000; Mitev & Venters, 2009). But this comes down to one of the main assumptions made by Gibbons et al (1994) and Nowotny et al. (2001) that society is becoming increasingly transgressive and diverse. Other scholars argue for the opposite case and that division of labour is in fact

increasing because the demand for specialisation in innovation is going up (Weingart, 1997). For example, Huff (2000) argued that universities are increasingly hiring and promoting academic staff based on their academic merits. The emphasis is on knowledge production certified by a small number of academic peer-reviewed journal publications more than an ability to interact with industry or other external partners. The same trend is observed in industry where industrial firms are focusing on developing and sustaining core competences (Prahalad & Hamel, 1990). Mitev and Venters (2009) also found that much research from universities would not lead to Mode-2 without building on the results of pre-existing Mode-1 research. However, at the same time, these critics do not necessarily reject the Mode-2 concept, but rather suggest that the transformation from Mode-1 to Mode-2 is not a complete transition but more a case of balancing the two modes simultaneously.

Despite the lack of empirical research to support Mode 2, the concept remains very central in many studies on innovation as being an epistemological view on how knowledge is produced. This is also how it will be applied in this study. It helps to explain the importance of the underlying social aspects and the continuation of the knowledge production process that becomes more and more apparent in other theoretical approaches to innovation (Etzkowitz & Leydesdorff, 2000; Kline & Rosenberg, 1986; B-Å. Lundvall, 1992).

2.2.3 *Vertical integrated knowledge production and innovation*

In an attempt to develop a framework for the study of innovation processes, Kline and Rosenberg came up with the Chain-Linked Model (Kline & Rosenberg, 1986). The model challenges the linear model on knowledge production and Innovation by picturing innovation as a complex and iterative process. Rather than seeing innovation to be an outcome of science, Kline and Rosenberg (1986) considered innovation to be an outcome of a perceived need in the market and an attempt to fulfil this need.

Introducing the Chain-Linked Model

The Chain-linked model is structured around a set of key activities that form a central chain of innovation. A perceived market potential is identified and will be filled only if the firm can invent a technical solution to satisfy the need. The solution is turned into a technical design and tested before produced and finally distributed to the market. Yet, the chain-linked model views innovation as a continuous cycle as feedback loops (marked with 'f' in Figure 2-1) iterate the steps within and between each activity and also brings feedback directly from users to improve product performance in the next round of innovation "... *since each market need entering the innovation cycle leads in time to a new design, and every successful new design, in time, leads to new market conditions" (Kline &*

Rosenberg, 1986, p. 290). Especially in software development, feedback from customers have proven to be crucial for innovation speed (Heirman & Clarysse, 2007). Von Hippel (1988) also found that the users were the actual inventors in some industries. User-dominated innovations accounted for more than two-thirds of the first-to-market innovation in industries such as process machinery, scientific equipment and electronic sub-assembly manufacture. Firms within these industries specialised more in product engineering rather than R&D and in the ability to identify user solutions rather than ability to create user needs.

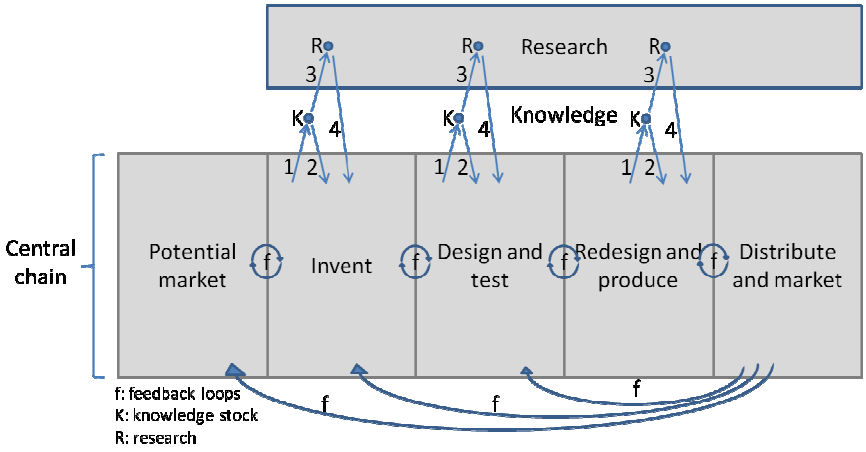

Figure 2-1: The Chain-linked model by Kline and Rosenberg; adapted from Kline and Rosenberg (1986), p. 290

Knowledge accumulation over time as innovation is a continuous process. As new solutions to problems are created, the processes, methods and know-how are stored in the firm's knowledge stock. As new problems occur, the firm will first search for solutions in their existing knowledge stock (marked with 1 and 2 in Figure 2-1). Notice that knowledge is not only limited to one area within one activity in the central chain, but can be combined across activities. In fact the chain linked model suggests that solutions to problems most likely come from combining existing knowledge across disciplines and individuals rather than from production of new knowledge through research. This puts pressure on firms to motivate collegial behaviour and knowledge sharing practices. For example, Laursen and Foss (2003) described how job design and incentives for R&D personal will result in improvements in knowledge accumulation. Shinton et al. (2006) argued that the requirement to human resources differ in respect to supporting idea generation and implementation activities. For example, idea generation required more focus on job rotation, increased customer contact and project work while implementation was achieved through training and goal orientated performance.

According to the Chain-Linked model, science plays a secondary role. Only if solutions cannot be solved by combining knowledge from the existing knowledge stock, will the firm invest in research

(marked with 3 and 4 in Figure 2-1). However, the outcome from this step is seen as very uncertain as there is no guarantee that the firm will find a solution through research. Also, the research process is resources consuming and may take a long time. While research is still considered very important in the chain-linked model, research is not usually the initiating step in the innovation process "*It is only when this knowledge fails, from all known sources, that we resort to the much more costly and time-consuming process of mission-oriented research to solve the problems of a specific development task" (Kline & Rosenberg, 1986, p. 291).*

The limitations and implications of Chain-Linked Model

The Chain-Linked model stands in sharp contrast to the linear model of innovation by picturing innovation as a continuous process involving accumulation of knowledge and vertical integration. In the Chain-Linked model, the accumulated knowledge base is the first resort for the firm to find solutions to specific problems. If this proves inadequate, other sources external to the firm are considered before research is undertaken since it is inevitably expensive and might not necessarily yield any useful results (Kline & Rosenberg, 1986). Yet, the Chain-Linked model has also been criticised by several scholars for: (1) only accommodating incremental innovation (R. Rothwell, 1992); (2) the indistinct role of science in the innovation process (Senker, 1995) and (3) providing too narrow an account for sources of knowledge (H. Chesbrough, 2003; Michelle & Bruce, 2003).

Incremental versus radical innovation

Rothwell (1992) argued that the Chain-Linked model only describes incremental innovation. Incremental innovation is described as ongoing refinements or improvements to existing products, services or processes (OECD, 1992). Firms that are successful at satisfying an existing market are more likely to pursue incremental innovation (Slater & Mohr, 2006). At least the use of feedback loops to and from the customers would imply that the firm is already operating in the market. While incremental innovations might well take place within existing structures and be based on existing knowledge stocks, radical innovations usually require more than established feedback loops and integrated vertical relationships to be accommodated. Radical innovation often requires the formation of more flexible and adaptable organisational forms such as matrix organisations, project teams or hybrid relationships that can be established ad-hoc and exceed a firm's current knowledge stock (Tidd, Bessant, & Pavitt, 2001). The need for a firm to manage both radical and incremental innovation is similar to the notion of exploration and exploitation that innovative firms need to balance short-term gains from incremental innovation with long term gains from radical innovation (March, 1991). A firm that only focuses on incremental innovation will eventually become trapped or locked-in. On the other hand a firm that only focuses on exploration will not be able to capture the

return on investments in R&D (Hansen, Podolny, & Pfeffer, 2001). Hence, the Chain-Linked Model can describe the innovation processes in innovative firms only partially.

The actual role of science in the innovation process

Several scholars have criticised the Chain-Linked model for over-emphasising the importance of the manufacturing processes over scientific knowledge in the innovation process (R. Rothwell, 1992; Senker, 1995). In contrast to the Chain-Linked Model several scholars found that technological advancements in some industries such as information technology and biotechnology tend to derive from science (McMillan, Narin, & Deeds, 2000; Michelle & Bruce, 2003; Stuart, Ozdemir, & Ding, 2007). Again this can be linked back to the notion of exploration and exploitation or radical versus incremental innovation discussed previously. While the linear model argues that science is the initiating step and the chain-linked model argues that science is only the last resort, Caraga et al. (2009) proposed that innovation is a multi-layer process that requires distinct forms of learning to take place.

Open versus closed innovation

Finally, scholars have challenged the narrow account of sources of knowledge in the Chain-Linked model (H. Chesbrough, 2003; R. Rothwell, 1992). It is generally recognised that the pace of technological progress and competition are increasing and no firm can rely on internal processes any longer to generate adequate knowledge to keep competitors at bay (R. Rothwell, 1992). Instead, they form relationships horizontally and vertically (B. Audretsch, 1998; Joel A. C. Baum, et al., 2000).

In summary, the Chain-Linked model shows that innovation is inherently uncertain and disorderly and requires the formation of different vertical relationships, feedback loops and processes to accommodate. Innovation does not take place only at one point in time but is to be seen as a continuous process involving knowledge accumulation and social interaction. While the Chain-Linked model also has weaknesses, it is important to point out that the model has its strengths in recognising the dynamic and non-linear aspects of innovation.

2.3 Knowledge distribution and innovation

The second part commences with the National System of Innovation model by Freeman (1987) who noted that innovation involved multiple actors (private and public) who were tied together in a system of innovation. Lundvall (1992) extended this view by describing how institutions such as laws, cultures, norms and routines affected the strength of the system of innovation and the motivation for actors to interact and collaborate around knowledge distribution. In an attempt to analyse the evolutionary aspects of systems of innovation, Etzkowitz and Leydesdorff (2000) introduced the

Triple Helix Framework, which pictures the innovation system to be in constant transformation as new relationships or organisation encompassing government, industry and universities emerge or dissolve. Recently, Chesbrough (2003) introduced the notion of open innovation, which contrasts vertical integration and proprietary models on innovation by suggesting firms should use both internal as well as external ideas, and look for internal and external paths to market, as they progress with their technology.

2.3.1 *The National System of Innovation approach*

In the wake of the linear model of innovation, the understanding among researchers continued to grow that innovations were influenced by many factors and occurred in interaction between organisations in a system of innovation (Ackoff, 1968; Gibson, 1964; OECD, 1958). But it was not until late 1980s that the idea of a system of innovation was conceptualised into an analytic framework, the so called National System of Innovation (NSI) as it is known today (Freeman, 1987). In short, the central idea in the NSI theory is the notion that innovation in society is a result of interactive processes among many actors at a micro level (Freeman, 1987; P. Patel & K. Pavitt, 1994). The NSI emphasises explicitly the importance of an infrastructure to support these interactions between actors and it brings to the forefront the central role of the government as the coordinator of this infrastructure (C. Edquist, 2005; B-Å. Lundvall, 1992). Since the NSI theory was introduced it has been seen by many researchers and policymakers as a useful tool to study innovation processes and the distribution of knowledge in the society (C. Edquist, 2005; Kodama & Suzuki, 2007; B-Å. Lundvall, 1992; P. Patel & K. Pavitt, 1994).

Introducing the National System of Innovation approach

The NSI approach emerged in the 1980s and was first introduced by Freeman (1987) to describe the success the Japanese economy experienced at that time. He described an NSI to consist of private (i.e. competitors, suppliers, consultants or customers, venture capitalists) and public organisations (i.e. government agencies, universities, research institutions), whose activities and interactions initiate, modify and distribute innovation (Freeman, 1987, p. 1). Freeman (1987) emphasised the specific role of policy making and corporate R&D in the Japanese NSI. He found that the Japanese government had contributed significantly to the economic growth of the country by making particular choices about what industries to support and build on to develop comparative advantages. Corporate R&D was used to assimilate knowledge and technologies from overseas and then used to develop new competences within their own system of innovation. He also emphasised that this process was driven by human beings and was dependent on their ability to communicate and interact. Finally he stressed the importance of conglomerates as a vital element in the economic

growth of Japan as these large firms were able to internalise externalities that were associated with improvements to supply-chains. Freeman's work was fundamental for the raise of the NSI approach and clearly stated the importance of linking innovation, policymaking, interaction and economic growth together.

Introducing institutions

Lundvall (1992) followed in the same line as Freeman, but shifted focus towards the institutional context (e.g. trust, norms and culture) within which organisations (private and public) operate and interact. Lundvall noted that successful innovation depends on diffusion of knowledge and learning as knowledge tends to be localised and not easily transferred from one context to the other. In fact, in a perfect world where organisations are rational and access and distribution of knowledge happens unrestricted and unlimited, the need for an NSI would not exists. Building on Polanyi (1966), Lundvall argued that knowledge contains a tacit element and it is something more than information. Knowledge becomes embedded in organisations (e.g. processes and routines), within the minds of individuals and not least in relationships among organisations and individuals. The existence of tacitness means that interactions taking place within a system of innovation are governed by the institutional context. Knowledge diffusion and learning appears to happen more successfully in a contextual setting where there are few institutional constraints and where relationships based on mutual trust and empathy can be developed easily (B-Å. Lundvall, 1992). Lundvall (1992) saw institutions being largely historically determined and contributing towards reducing risk and volatility in exchanging knowledge between organisations and individuals. The contribution by Lundvall (1992) to the NSI approach was also of fundamental character as he depicted the NSI as nationally specific, historically dependent and highly knowledge and learning-based.

Formal R&D systems

Nelson (1993) made another contribution to the NSI by focusing on formal R&D systems. Nelson was especially interested in the relationship between science and innovation, particularly in organisations that were directly involved in producing new knowledge. He found that some organisations, such as universities, were central to the performance of an NSI in terms of directing and dictating innovation in society. It followed that the structure and operations of universities were critical elements in an NSI. In a similar vein as lundvall (1992), Nelson also argued that it is almost impossible to identify an optimal system of innovation as such a system continues to evolve in a particular way dependent on its context and previous path (R. Nelson, 1993). Nelson's contribution complements those of Freeman and Lundvall by first of all capturing the importance of formal R&D and universities to the system of innovation. But perhaps more importantly, his contribution was based on a collection of

case studies which gave inspiration to many scholars to follow that empirical studies on NSI where possible by concentrating on a smaller part of the NSI. This will be elaborated on further in the next section.

In summary, within the NSI, innovation is closely linked to the activities carried out by organisations to stimulate productivity growth, continuous technological advancements and the central role of the government in organising and coordinating the various institutions dealing with science, education, policies, learning and competence development. The NSI approach also adopts a holistic and inter-disciplinary perspective. It is holistic as the system of innovation encompasses any factors that may affect innovation. It is inter-disciplinary as it combines social, economic, political and organisational perspectives (Charles Edquist & Hommen, 1999).

The boundaries of the system of innovation

While many of the earlier studies on NSI (i.e. Freeman, 1987; B-Å. Lundvall, 1992) aimed at conceptualising the idea of a system approach to study innovation, later contributions have been more focused on empirically testing this approach (i.e. Liu & White, 2001; P. Patel & K. Pavitt, 1994). However, one weakness of the NSI approach is that it does not provide any clear guidelines in terms of how to set the boundaries without compromising the integrity or diversity of the system to study (C. Edquist, 2005). The earlier contributions of NSI (Freeman, 1987; B-Å. Lundvall, 1992) seem to include everything that directly or indirectly impacts on innovation, which makes empirical studies an almost impossible mission to follow (R. Nelson, 1993). Freeman (1987) did argue that part of a system can be delimited if that part has a reasonable degree of coherence and inward orientation towards innovation processes. Edquist (2005) noted that a system can also be delimited based on the function of the system, e.g. economic growth or particular innovation project. But it is of course not self-evident what is meant by coherence, inward orientation or function. So far it has been up to the discretion of the individual researcher using NSI to study innovation processes to define the boundaries depending on the objectives of the study (C. Edquist, 2005). On the other hand, Lundvall (2002) argued that one of the advantages with the NSI approach is that the concept is broad and flexible enough to serve as a framework for studying, if not all, then at least most aspects of innovation in society. This creates some empirical challenges for researchers of NSI as it is necessary to be explicit in terms of how coherence and inward orientations have been defined to avoid ambiguity. Common ways to delimit a system of innovation in the literature have been: (1) geographically (national, regional and local) (e.g. Fornahl & Brenner, 2009; Fritsch & Franke, 2004; OECD, 2004b; P. Patel & K. Pavitt, 1994); (2) sectorally (most commonly biotech, information technology and other science-intensive industries) (e.g. Adeoti & Adeoti, 2005; Hall & Bagchi-Sen,

2001); or (3) a combination of the former two (e.g. Gallie & Legros, 2007; 1991; Smith & Bagchi-Sen, 2006).

Institutions, interactions and interactive learning

Since the pioneering studies from Freeman, Lundvall and Nelson, research applying a NSI has continued to grow very fast and in various directions due to the inter-disciplinary flexibility allowed by the approach. Some examples are:

- **Policy making**; e.g. OECD (e.g. OECD, 2004a; 2004b, 2004c) are mainly focusing on identifying bottlenecks in the NSI at a country level to guide policymaking.
- **Macro-economic**; e.g. Patel and Pavitt (1994) used the NSI approach to compare innovative performance across countries.
- **Regional development**; e.g. Lynskey (2004) studied knowledge flows within a system of innovation to identify if spill-overs are contingent on geographic proximity; Fernández-Ribas and Shapira (2009) studied the importance of regional innovation programmes to stimulate more cooperation in innovation.

It is not the aim of this section to review the rich and diverse literature on NSI, but rather to show how an NSI may evolve to provide opportunities for interaction and interactive learning in society. This is also of particular interest to this study as university-small firm relationships are assumed to be embedded in and affected by a system of innovation. Especially Lundvall (1992), Lundvall, Johnson, Andersen and Dalum (2002), Edquist (1997) and Edquist and Hommen (1999) have been prominent advocates for institutions shaping patterns of interaction and interactive learning within and between organisations in society.

Culture and policy making

One characteristic of an NSI is that the government can influence the behaviour of individuals and organisations in society through policy making, laws and authority. This has been exemplified through several studies in the literature. Liu and White (2001) described how the initial conditions for conducting innovation in China are fundamentally different from those in most western countries. The Chinese government is more in control of innovation activities in certain organisations and more in control of the transfer of knowledge among them and also between them and the government. The authors used the example to illustrate that knowledge diffusion and interaction can be influenced by how a government enforces power. Patel and Pavitt (1994) found that French firms were more likely to invest in person-embodied knowledge compared to the United Kingdom firms.

France had a compensatory levy system for training, which reduces the risk of losing the investment when staff leave the company. The studies showed that uneven performance across NSI can be explained by variations in institutions. Lehrer and Asakawa (2004) investigated how R&D reforms in Germany and Japan have helped in developing successful biotechnology sectors. At one point, the process of commercialising biotechnology in both countries could not be sufficiently accommodated by the existing system of innovation, thus prompting reforms in institutions, the venture capital market, entrepreneurship and the science base. In Germany the government implemented policies (the BioRegio competition of 1995) to encourage more biotech start-ups and also more collaboration with nearby universities. In Japan, the government implemented a different approach by changing the legislation to allow faculty members in national universities to: (1) take up management positions in biotech companies established to develop their technology: (2) work after hours with pay; and (3) take up to three years off to commercialise their own discoveries and still be able to return to their academic position (Lehrer & Asakawa, 2004). While the objective of the government in both Germany and Japan was identical, the study showed that each government followed different approaches to stimulate growth in their respective biotech sector.

Learning and education

Interactive learning and interaction have also been related to the educational level in society. The educational level is seen as an institution as it is often weighted differently from system to system. Patel and Pavitt (1994) found that tertiary education was more widespread in the Japanese and German systems of innovation than in the British system of innovation. More widespread tertiary education provides a better foundation for knowledge diffusion and cumulative learning. Lam and Lundvall (2007) noted that education and training vary across systems according to the relative importance given to academic knowledge over practical skills and the distribution and concentration of competence level throughout the workforce. They define a narrow education and training system as one that causes uneven competence development in society, e.g. lack of academically trained employees in rural areas, or academic training only affordable for a small exclusive faction of the workforce. A broad education and training system is characterised by a widespread and rigorous general and vocational education for a wide spectrum of the workforce. With regard to innovation, an even distribution of competencies among participants provides a better foundation for interactive learning. It is argued that the government should motivate a broad education and training system to promote learning and competence building in society.

Learning and labour market

Labour market institutions constitute another important dimension of interactive learning in the system of innovation. Lam and Lundvall (2007) differentiated between an occupational labour market and an internal labour market. An occupational labour market is characterised by a system where one's career consists of job shifts. In an internal labour market, one's career consists of internal advancements or promotions within a single organisation. The former offers a higher scope for job mobility. Knowledge and competencies are owned by and embodied in the individual and constitute personal assets for career advancement. The individual can signal the value of these assets through certifications or peer group recognition. Interactive learning tends to be centred on the individual and is rooted in the individual's career choices. This creates a greater degree of autonomy and latitude in the boundary and domains of learning. This can potentially extend the knowledge base of an organisation and stimulate more radical innovations (B.-Å. Lundvall, et al., 2002). In contrast, an internal labour market implies that the knowledge and competencies owned by the individual cannot easily be bundled into an occupation or codified in advance. In this case, signalling knowledge and competencies becomes unreliable and insufficient. The individual relies more on social professional networks based on shared industrial or occupational norms. Interactive learning tends to be organisation-orientated and self-reinforcing. The retention and accumulation of knowledge is suitable for incremental innovation and focuses on developing distinctive core competencies.[2] Another study found a positive relationship between knowledge spill-over and the mobility of knowledge workers. Some regions are more likely to attract skilled workers, which increases knowledge spill-over to those regions (P. Almeida & Kogut, 1999).

The studies mentioned in this section point towards the importance of more formal institutions and the role of the government to enforce, stimulate and control these institutions through policy making and designing frameworks on a continuous basis. However, it is important to remember that institutions such as education and career development are highly contextual, historically determined and cannot be changed that easily.

[2] It has been reported by the European Union that lack of mobility between academia and industries still remains one of the biggest barriers to knowledge diffusion in society. Several initiatives have been implemented in the European Union to strengthen staff mobility and networking between public and private organisations, e.g. the Marie Curie International Research Staff Exchange Scheme (IRSES) and the Industrial PhD scheme facilitated by the Danish Ministry of Science, Technology and Development.

Informal institutions, interaction and interactive learning

It is not only the formal institutions that matter for interaction and interactive learning. Research applying an NSI approach shows that informal institutions such as trust and social capital are equally or maybe even more important than formal institutions when it comes to knowledge sharing and learning across organisations (B-Å. Lundvall, 1992). This refers back to one of the main assumptions behind the NSI that knowledge required for learning often is tacit and therefore hard to transfer or share without the presence of trust and mutual understanding (B-Å. Lundvall, 1992; Polanyi, 1966). Knack and Keefer (1997) studied trust at a country level. They found that countries with higher levels of measured trust also turned out to be richer. They argued that this finding implies that high level of trust indicates high level of interaction, which has a positive effect on economic growth. Akcomak and ter Weel (2009) also noted that the stock of social capital in society has a positive effect on the accumulation of knowledge and innovation within regions. In both studies, trust and social capital was measured in similar ways as a percentage of people in a society who expect that the majority of others will act cooperatively in a prisoner's dilemma context. Bueno and Salmador (2004) found that social capital plays a central role in turning a society into a knowledge-based economy. Social capital draws individuals and organisations together and enhances the value of intellectual capital.

Impact of social networks

Other studies found that geographic areas with a larger extent of social networks tend to be more innovative. Asheim and Gertler (2005) argued that uneven distribution of innovation in society can be explained by: (1) the circulation of knowledge remains highly localised because knowledge diffusion (especially tacit and non-codified knowledge) occurs first, fastest and cheapest within already established social networks. Knowledge in these networks is often circulated among members before it is publicly available in patents, publications or on the internet. (2) knowledge workers are often concentrated in those geographic locations that offer the most attractive and diverse employment opportunities, e.g. larger cities. In more densely populated areas, there are also better opportunities for knowledge workers to find a critical mass of people working in the same or similar occupational categories, which stimulates more interaction and knowledge sharing. (3) knowledge workers seem to be attracted to those locations that offer a high quality of life in terms of social and cultural diversity. The conclusion from this study is that innovation activities are not randomly or uniformly distributed in the geographic landscape but determined by the extent of social networks. Myint et al. (2005) described how the development of social capital among serial entrepreneurs played a central role in the success of the Cambridge high-technology cluster. While social capital might be culturally determined, there is also evidence in the literature to suggest that governments or other interested organisations can stimulate the development of social capital by

motivating more interaction, e.g. through earmarked funding for collaborative research or through the increase of venture capital (Bueno & Salmador, 2004; Davidsson & Honig, 2003; Maurer & Ebers, 2006).

The theoretical and empirical evidence presented above supports the usefulness of the system of innovation framework to study innovation processes in society. It provides strong reasons for using a comprehensive innovation framework in future studies that give more attention to the external environment of innovative firms (Freeman, 1987; B-Å. Lundvall, 1992; R. Nelson, 1993). At the same time, it has become recognised that innovation is increasingly taking place through national and regional networks of organisations, stimulated by both formal and informal institutions (Fornahl & Brenner, 2009; Fritsch & Franke, 2004). Research applying an NSI approach shows that innovative performance in society can be managed or at least constructively influenced (Liu & White, 2001; B.-Å. Lundvall, et al., 2002). Consciously designed institutions may create new organisations or relationships to emerge which stimulate more knowledge creation and diffusion in society. But this has also to be seen as an evolutionary process that cannot be forced as institutions are historically dependent, cumulative and often mutually influenced by the evolution of individuals and organisations that are part of the system (C. Edquist, 1997; Charles Edquist & Hommen, 1999; B.-Å. Lundvall, et al., 2002). The NSI approach argues that historical and context analysis plays a more important role than economic theory (Charles Edquist & Hommen, 1999).

Limitations and implications of the National System of Innovation

The NSI approach emphasises the importance of inter-connectivity and interactive learning to stimulate the creation and utilization of knowledge in the society. However, critics argue that the NSI approach is overly optimistic about the outcome of interactive learning by considering it as a purely positive sum game in which everybody involved will gain (B.-Å. Lundvall, et al., 2002). Several studies show that interactive learning is not without cost or risk. Interactive learning may be obstructed because a partner behaves opportunistically or the learning environment is hostile and based on rivalry (Dickson, Weaver, & Hoy, 2006; Kale, Singh, & Perlmutter, 2000; Park & Ungson, 2001). Other studies also show that interactive learning is often geographically localised and difficult to facilitate with partners outside the region (P. Almeida & Kogut, 1999; Fritsch & Franke, 2004). This adds some limitations to the idea of NSI as certain regions might not be relevant enough to be included in a system of innovation as no innovation takes place there. This also leads to another critical issue with the NSI approach as it has been argued that the approach has been applied mainly to studies of systems of innovation in 'rich' countries (often referred to as the North in the literature) where systems already are strong and diversified and with well-developed institutions and infrastructure

(Fagerberg, Mowery, & Nelson, 2005). The NSI approach has proven harder to apply to system building. For example, what kind of institutions should be introduced first in poor developed countries or regions to stimulate more innovation? (B.-Å. Lundvall, et al., 2002). The NSI approach does not argue for best practice or an optimal system but for a system that evolves over time in a largely unplanned manner (C. Edquist, 2005). This is one limitation of the NSI approach as it does not provide any guidelines on how to optimise innovation in society or where to start when trying to build up a system of innovation (Etzkowitz & Leydesdorff, 2000). However, in the context of this study, it is safe to say that university-small firm relationships are embedded in a system of innovation and highly affected by this context. Therefore it is important to understand at least how different institutions may explain variations in patterns of interaction and learning behaviours across systems or even in parts of the same system of innovation.

2.3.2 *Triple Helix and the dynamics of systems of innovation*

Introducing the Triple Helix framework

In an attempt to analyse the evolutionary aspects of systems of innovation, Etzkowitz and Leydesdorff (1995, 2000) developed the Triple Helix (TH) framework. While Etzkowitz and Leydesdorff often referred to the NSI approach as an inspiration for continuing research on innovation from a system perspective, they argued that innovation is not a product of a system, but the system is in fact a product of innovation (Etzkowitz & Leydesdorff, 1995, 2000). The argument here is that innovation is becoming more complex and inter-disciplinary which has required the system of innovation and the organisations within the system to adapt to these new circumstances (Etzkowitz & Leydesdorff, 2000). The TH framework concentrates on the dynamics in relationships between governments, universities and industries rather than the actual structure of the innovation system. The TH framework is described to complement the NSI approach because the framework works as a tool to analyse and understand the evolution of a system of innovation (Etzkowitz & Leydesdorff, 2000) - one aspect that the NSI approach has been criticised for failing to do (Etzkowitz & Leydesdorff, 2000; Giesecke, 2000).

Triple Helix and dynamic evolution

Etzkowitz and Leydessdorff (1995, 2000) argue that governments, universities and industries are the main three organisational domains involved with innovation in society. Traditionally each of these domains was separated and only little interaction occurred between them (Etzkowitz & Leydesdorff, 1995). Universities were mainly concentrating on research and education; industries on development and production; and governments on policy making and funding (Etzkowitz & Leydesdorff, 2000). But during the early 1990s Etzkowitz and Leydesdorff (1995) observed that these traditional roles of

governments, universities and industries as outlined above were changing. Innovation was becoming more complex and requiring input from an increasing number of organisations throughout the process. These observations were much in line with similar observations described by Gibbons et al. (1994), Kline and Rosenberg (1986), Freeman (1987), Lundvall (1992), Chesbrough (2003) and more. To accommodate these changes, the organisational domains (governments, universities and industries) have been forced to adapt and work more closely together (Etzkowitz & Leydesdorff, 1995).

To describe these changes in the organisational domains, the TH framework draws on evolutionary theory (Andersen, 1994; L. Leydesdorff & Meyer, 2006; R. Nelson, 1994; Richard R. Nelson & Winter, 1982). While organisations are trying to adapt to the increasing requirements for collaboration, they are at the same time limited by their historical continuities in terms of how organisational structures, objectives and competences have evolved over time (Richard R. Nelson & Winter, 1982). Given that organisations are limited by historical continuities, it is argued in the TH framework, that this has only increased the need for creating and combining resources and competences in society through re-organising government-university-industry relations in new ways (Loet Leydesdorff, 2005). This includes creating complete new hybrid organisations (e.g. jointly owned ventures and projects) and tri-lateral networks (e.g. science-parks, incubators consortia and clusters) (Etzkowitz & Leydesdorff, 1995, 2000).

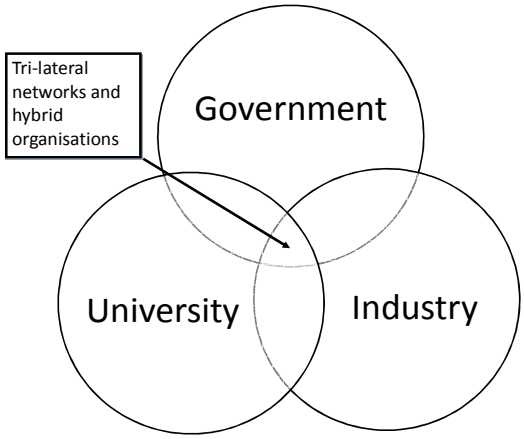

Figure 2-2: Triple Helix Framework; adapted from Etzkowitz and Leydesdorff (2000), p.111

Evolution in the TH framework is seen as a spiral movement that is enhanced as existing organisational domains are transformed and new hybrid organisations and tri-lateral networks emerge (Etzkowitz & Leydesdorff, 2000). Within the TH model, tri-lateral networks and hybrid organisations generate reflexive sub-dynamics that cause the system of innovation never to be stable or in optimum (Etzkowitz & Leydesdorff, 2000).

The system of innovation to sustain, is the one that shows the most courage to make changes to the underlying infrastructure and allows organisations to adapt to new opportunities (L. Leydesdorff & Meyer, 2006).

Dynamics within a system of innovation

Different from the NSI approach, the TH framework does not refer to a closed system (e.g. geographic space), but to multiple systems existing simultaneously. These multiple systems are competing for resources in society, and over time some of these systems will erode while others will continue to prosper and succeed (L. Leydesdorff & Meyer, 2006). In this relation the government also play a central role as they are to some extent in control of distributing resources in society through policy making and funding (Etzkowitz & Leydesdorff, 2000).

The TH framework has been applied widely in the innovation literature to analyse and evaluate the effects of institutional domains being transformed or restructured (e.g. Ernø-Kjølhede, Husted, Mønsted, & Wenneberg, 2001; Etzkowitz, 1998; Van Looy, Ranga, Callaert, Debackere, & Zimmermann, 2004) or how new or existing organisational forms, hybrids and networks have influenced innovation and economic prosperity in society (e.g. Etzkowitz, 2002; Johnson, 2009).

Institutional transformation

Within the TH Framework it is argued that institutional transformations are a natural element in driving evolution in a system of innovations (Etzkowitz & Leydesdorff, 2000). Transformation is seen as the process of replacing organisational routines, processes, forms and cultures with new institutional order, which redirect orientation and actions of these institutions within the system of innovation (Benner & Sandström, 2000). Existing research that studies institutional transformation within the TH framework focuses on the transformation or co-transformation of governments, universities or industries.

Towards the entrepreneurial university

The majority of research within institutional transformation has been conducted in relation to the ongoing transformation taking place at most universities in the western world since the 1980s (Boardman, 2009; Etzkowitz, 2003; Van Looy, et al., 2004). The role of universities in the system of innovation has been subject to an ongoing public debate as it is argued that universities can and should play a more active role in stimulating innovation than what is currently the case (Etzkowitz, et al., 2000). A more detailed account for the role of universities in the system of innovation will follow in the next chapter. In this particular section, the focus will be more on providing some evidence that

the transformation of universities has played a major role in improving systems of innovation over time.

Etzkowitz (1998) described the ongoing transformation of universities to have taken place in two major revolutions. The first revolution was when research was made an academic function in addition to teaching in the early 20th century, and the second revolution, currently taking place, being incorporation of economic and social development as part of their mission. Etzkowitz (1998) argued that universities are increasingly focusing on capitalisation of knowledge, which establishes universities as an economic actor in its own right. Universities are increasingly involved in commercialising their own research through entrepreneurial activities, building stronger relationships with users of academic research, teaching and educating new talents not only in theoretical but also a more applied sense. As universities have been transforming, Etzkowitz (1998) found that the gap between academic research and the practical application of academic research is diminishing. This conclusion was based on an observed increase in the number of faculty members engaged in starting up their own business and collaboration taking place between universities and industrial firms. The increasing focus on application of knowledge at universities was also used by Godin and Gingras (2000) to suggest that universities are becoming more central to knowledge production in society. The author based their findings on an observed growth in co-published university papers between academics and industrial researchers in Canada between 1980 and 1995.

Yet, Etzkowitz (2003) argued that the transformation of universities is not unproblematic but sometimes may delay the transition from a production to knowledge-based economy. Ernø-Kjølhede et al. (2001) argued that as universities are becoming increasingly involved in Mode 2 over Mode 1 research, the management practices surrounding research at universities need to be changed. Traditionally Mode 1 research at universities tends to be managed by the individual researcher as a discrete laissez-faire activity. In Mode 2, knowledge production is becoming socially and economically dependent and therefore increasingly complex and involving more stakeholders. For universities to continue their transformation according to TH, the authors suggested that new management practices need to be developed at universities that ensure a better alignment and integration of various stakeholders but at the same time balance the need for researchers' independence and autonomy. Etzkowitz (2003) found that many controversies over academic entrepreneurship exist within universities themselves, because it can be difficult if not impossible to draw a clear line between internal university values and external economic values. For example, when is an academic researcher/entrepreneur conducting research for academic and social purpose versus attempting to make money out of it? The author calls for a system that does not prohibit

conflicts of interest but regulates and adjudicates potential conflicting interests. This includes integrating business and research activities under a broader university mission (Van Looy, et al., 2004).

Government interventions in transforming the Triple Helix society

Studies have also showed that national governments are transforming to meet the increasing need for networking among governments, industries and universities to promote innovation in society (Etzkowitz & Leydesdorff, 1995). De Castro el al. (2000) illustrated through a case how the Portuguese government played an active role in supporting the development of an emergent local industry. Policy formulation was decentralised and involved local stakeholders from universities and industries alongside government bodies to ensure enhanced relevance and improved implementation. The authors stated that policies formulated by central governments were not sufficiently adapted to support regional specificities, thus unable to generate the preferred synergies. In another study of Triple Helices in Wales, it was found that the government played an active role in eliminating bottlenecks in the system of innovation through policymaking (Huggins, Jones, & Upton, 2008). The government had the authority and resources available to change the infrastructure to allow knowledge to flow more freely in-between users and producers of knowledge. This involved creating intermediates and new research institutions to close the information gap between universities and local industries. Giesecke (2000) found that indirect policies enabling economic ecology had better effect on science and technology development than interventionist policies. Governments cannot force actors into collaboration or innovation, but need to promote such behaviour through stimulating social and economic dispositions accordingly and in a continuous manner.

Some studies also described how governments are increasingly changing their practices for allocation of funding to science and technology as the positive effects of triple helices have become more recognised (Etzkowitz, 2002; Giesecke, 2000). Governments are increasingly having specific expectations to outputs sought from public funding to science and technologies at universities and industries (Martin, 2003). Yet, Benner and Sandström (2000) found that despite university funding from the government had been reformed to encompass more applied science and research collaboration with industry, there were counteracting tendencies among some of the agencies allocating funds to universities. Some of these agencies were more orientated towards the reputation of the receiving institution/researcher and social connections. Another study found that conventional government funds (block grants) towards university research could potentially delay

the transformation of a society towards a TH, because they only created minimum incentives for academic researchers to consult and interact with industries (Razak & Saad, 2007).

Emerging organisational forms in Triple Helix

In the TH framework, new organisational forms that promote and regulate innovation are seen as important vehicles for transforming the system of innovation (Etzkowitz & Leydesdorff, 2000; Johnson, 2008). New organisational structures may take the form of new organisations or firms or any forms of new collaborative arrangements or networks (Etzkowitz & Leydesdorff, 2000). In the TH framework focus is in particular on new organisational forms that involve members or inputs from industry, universities and government combined. Marques et al. (2006) used the University of Coimbra in Portugal as a case to show how the formation of triple helices and hybrid organisations helped in strengthening entrepreneurship in a Portuguese region. Dynamic relations between the University of Coimbra, local companies and local government authorities led to the emergence of a tri-lateral network and the formation of hybrid organisations. In particular, the formation of a local business incubator and subsequent technology park had a significant positive impact on the rate of local entrepreneurship. Yet, despite the support by local government and local industry, the authors claimed that the crucial factor for this development was that the local university (Coimbra) recognised that they had the capacity, in the form of students, scientists and knowledge, to lead the transformation of the local environment for innovation.

In a recent study, Johnson (2008) was particularly interested in exploring the role of intermediaries in facilitating tri-lateral relationships and networks. The study is based on a single case study of Precarn, which was originally conceived as an industry-led consortium to support industry R&D projects, but during the time the study took place, it included 33 universities, 66 firms and 10 associate members. Precarn provided overall support and managerial direction to the members involved in tri-lateral relationships, including managing the intellectual property (IP) that might be developed in the relationships. The role of Precarn in facilitating contacts between university-industry-government was evident in a number of areas. Precarn acted as: (1) the mediator/arbitrator, to solve conflicts arising in the relationship; (2) the sponsor or fundraiser, to ensure the projects were carried through; (3) the legitimator, especially to smaller firms or to reduced search costs for larger firms looking for smaller firms; (4) the technology broker, by selling technologies to or buying them from outside members of the consortium; and (5) the management provider, in the form of advice and support regarding how to manage tri-lateral relationships. While there exist many examples of other types of intermediaries that may differ in terms of scale and scope, Johnson argued that high set-up and coordination costs are a threat to the formation of tri-lateral networks. Giesecke (2000) also stated

that university start-ups are important new organisational forms that stimulate knowledge transfer and commercialisation in society effectively in both the United States and Germany. These start-ups were typical examples of hybrid organisations that drew on elements from all three spheres: university (patent and know-how), industry (relationships and venture capital) and government (changes in regulatory practices defining risky investments). Academic founded start-ups command tacit knowledge and sometimes patents that no one else are able to exploit. Academic founded start-ups were more common in the United States than in Germany. The author argued that the relative low number of academic founded biotech firms in Germany could be seen as a missing trajectory in the German system of innovation as fewer options for reciprocal interactions of the TH were created and exist.

Limitations and implications of the Triple Helix

The TH framework is a useful tool to study the dynamics within systems of innovation in forms of institutional transformations and emerging organisational forms. The framework emphasises the roles of universities, governments and industries in forming triple helices that act as sources of progressing innovation in society. However, as most empirical studies on TH also suggest, the evolution of a system of innovation is very context-dependent and highly complex. It can be difficult to compare and contrast systems of innovation across countries and regions or suggest best practices as systems of innovation evolve differently based on past structures and development paths (Etzkowitz & Leydesdorff, 2000; Giesecke, 2000). For the purposes of this study, the TH framework provides support for the assumptions that university-small firm relationships can be seen as emerging and transforming organisational forms, which affect the shape of the system of innovation and vice versa.

2.3.3 *Open innovation*

A recently proposed model of knowledge distribution and innovation is based on the need for firms to open up their innovation processes to allow for internally developed technologies to be commercialised externally and external technologies to be commercialised internally. The notion of Open Innovation was first introduced by Chesbrough (2003, p. 128) and has quickly attracted interest among innovation scholars (i.e. Buganza & Verganti, 2009; H. Chesbrough, 2003; Keupp & Gassmann, 2009; Joel West & Gallagher, 2006). Based on observations of innovative firms in the beginning of the twenty-first century, Chesbrough (2003) concluded that firms no longer can afford to rely entirely on their own ideas to succeed; nor can they restrict their innovation to a single path to market. As a consequence they are increasingly practising open innovation. To illustrate, what has been named a shift from ‘closed’ to ‘open’ innovation, these two concepts will be described and discussed below.

'Closed' innovation

During the last century, innovation in industrial firms was believed to originate mainly from internal research departments within large diversified corporations of the United States and Europe (Chandler, 1977). Diversification together with vertical integration into production and distribution provided these corporations with a competitive advantage over new competitors in terms of economies of scale and scope (Chandler, 1977, 1990). Rivals that sought to challenge the established firms had to raise considerable resources to create their own R&D labs. Strategies of that time were focused on standardisation and mass production to ensure effective and efficient operations and distributed to a large customer base to keep marginal cost as low as possible (Pine, 1993). Vertical integration made a firm in control of the innovation processes as it was the custom to generate and develop their own ideas, protect, produce, market and service them, which earned the firm profits to reinvest in conducting more research (Chandler, 1990). This approach called for self-reliance as "*if you want something done right, you've got to do it yourself*" (Chesbrough, 2006a, p. 128). This view on innovation has been referred to as 'closed' innovation as innovation projects are initiated, proceeded and distributed to the market internally by the firm (H. Chesbrough, 2003).

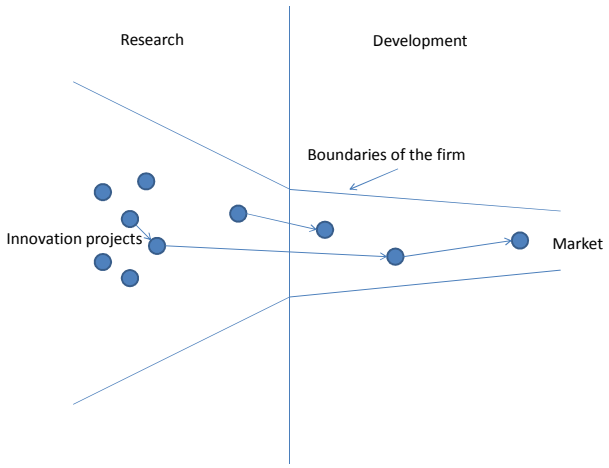

Figure 2-3: Closed innovation model; adapted from Chesbrough (2003, p. xxii)

Closed innovation is comparable with an internal focus on innovation in which the firm tries to keep control of all innovation processes through internal vertical integration. Closed innovation is guarded by strong IP management which aims at reducing negative spill-over effects (H. Chesbrough, 2003). Up until the end of the 20th century, closed innovation seemed to have worked well and has also been used to argue for the success and prosperity of many large corporations (Chandler, 1990). Today, however, the leading industrial corporations are facing increasing competition from many

new start-ups. These new upstarts do not have large internal R&D labs; nor do they invest heavily in basic research. They rely on external sources for inspiration and market access (Chesbrough, 2006a).

'Open' Innovation

In the beginning of the twenty-first century, Chesbrough (2003) studied why some innovative firms such as Intel and Cisco grew more rapidly than other traditional successful firms like IBM, Philips and Xerox. These more successful firms had started to adopt a more 'open' strategy to innovations replacing the 'closed' innovation model. According to Chesbrough (2003) there are many reasons for this shift.

Firstly, there has been an increase in mobility of staff that leave one firm to join another firm and bring with them knowledge and experience. In relation to mobility of staff, it has also been observed that more people are becoming highly educated which increases the opportunities for knowledge to be shared among employees across organisational boundaries. These observations are very similar to those concepts of heterogeneity and heterarchical knowledge described in Mode-2 (Gibbons, et al., 1994).

Secondly, the private venture capital market has been growing, which has advanced innovation and entrepreneurship to new levels. Today individual staff face better opportunities to raise capital to initiate and commercialise innovation on their own (H. Chesbrough, 2003). Therefore it is not self-evident anymore that it is necessary for the employing firm to realise the potential from inventions. The employee (inventor) might pursue the opportunities on their own by starting their own business (Byckling, Hameri, Pettersson, & Wenninger, 2000; Stankiewicz, 1994).

Thirdly, the arguments of global competition and shorter product lifecycles have also been referred to as explanations for the shift from 'closed' to 'open' innovation. Firms are becoming more specialised and choose to outsource non-core activities to key suppliers leading to multiple sources of innovation (Mol, 2005). Finally, markets have also changed from being formerly mass-production to mass-customisation or niche market orientated. It was found that firms could speed up and reduce the cost of their innovation processes by developing more flexible processes allowing for quick and efficient adaptation to changing market demands (Pine, 1993).

Open innovation is a paradigm that contradicts the closed innovation paradigm by suggesting that firms can and should use both internal and external ideas and paths to the market. A firm can bring internal ideas to the market through external paths (e.g. through corporate spin-offs, licensing

agreements) and can as well bring external ideas to the market via internal paths. False positives are not necessarily shelved anymore but can be sold to external partners as a natural part of bringing down risk in the innovation process. Chesbrough (2003; 2006b) argued that one strength of open innovation as a business model is the way IP is treated. In closed innovation, IP that is not internally commercialised all too frequently is shelved and risks never to be exploited. In that case, the firm may miss out on opportunities of actually generating value based on their less useful inventions.

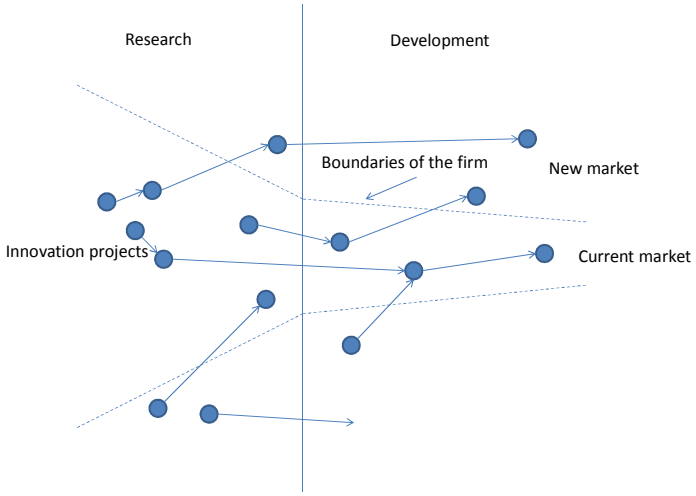

Figure 2-4: Open innovation model; adapted from Chesbrough (2003, p. xxv)

Managing open innovation

Boundaries

Chesbrough (2003) argued that open innovation is a business model that has two functions related to creating and capturing value from innovation: *"the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. Open innovation is a paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology (Chesbrough, 2006b, p. 1)"*. West and Gallagher (2006) referred to open innovation as a process of systematically searching and integrating knowledge from a wide range of internal and external sources and applying this knowledge through multiple channels, e.g. inter-organisational arrangements, license agreements, corporate spin-offs. External knowledge has a great effect on the innovation performance of firms and organisations in the era of open innovation (H. Chesbrough, 2003). The open innovation literature suggests that the porosity of the boundaries of the firm is necessary in order to enable absorption of external knowledge (Joel West & Gallagher, 2006). When firm boundaries become porous, the firm can then establish and develop networks of inter-firm relationships (Ahuja, 2000; Gulati, 1998; Johanson & Mattsson, 1987). Networks allow the firm to

access and share knowledge with external partners to cover needs without having to spend enormous amounts of resources to develop that knowledge internally or acquire it through vertical integration (Williamson, 1991). At the same time, networks are opportunities for the firm to commercialise internal knowledge which would otherwise be shelved and not utilised (H. Chesbrough, 2003).

Determining openness

According to Chesbrough (2003) the term 'open' is relative which can be described as a continuum between a low and high degree of openness. Laursen and Salter (2006) argued that openness can be measured by 'breadth' (the variety of external knowledge sources) and 'depth' (the variety of important external knowledge sources). West and Gallagher (2006) noted that the degree of openness depends on what type of knowledge is actually shared with external partners. Firms that are highly focused on proprietary knowledge are less likely to be open. Jacobides and Billinger (2006) discussed how permeable vertical architecture leads to openness. Increased permeability enables more input from external partners to be integrated into the firm's innovation processes. Other scholars have studied the industry structure and dynamics to determine openness. Fontana et al. (2006) proposed that the degree of openness is a decision making challenge for management. Christensen et al. (2005) argued that early stage technologies needed input from more diverse sources compared to mature technologies. The important point here is that openness is relative and depends on a number of internal and external factors.

Open innovation and networking

An important aspect of open innovation is the formation of external partnerships which includes seeking and evaluating partner opportunities, recruiting partners and capturing value through partnerships (Elmquist, Fredberg, & Ollila, 2009). Within open innovation relevant partners include customers, competitors, suppliers , consultants, industrial associations, universities, other public research organisations, governments and non-profit organisations (H. Chesbrough, 2003). Chiaromonte (2006) pointed out that within the Open Innovation paradigm partnerships are seen as peers rather than suppliers. Based on open source software, Jeppesen and Frederiksen (2006) and Dahlander et al. (2008) referred to firms and individuals being part of the development as members of an integrated community. In such communities its members may share same the objectives, beliefs, preferences, needs, risks and resources, which affect the identity and the degree of cohesiveness.

It has also been argued that managing external relationships and networks is a dynamic process. Christensen et al. (2005) argued that a firm's position in a network changes as the technology evolves. During early stages, the firm may play a more central role in the network, but as the technology matures this role may become more peripheral as other competences are required to produce and market the technology. Simard and West (2006) built on Granovetter's (1985) strong and weak ties by referring to deep and wide ties. Deep ties enable a firm to capitalise on existing knowledge and resources while wide ties provide access to new technologies and markets. The outcome of deep ties is usually related to incremental innovation and wide ties to more radical and advanced innovation. The firm needs to balance both deep and wide ties. The logic behind the open innovation framework is that the firms use external relationships (vertical and horizontal) to increase the value of their innovation processes (H. Chesbrough, 2003). However, these relationships take time and resources to establish and also need to be managed on a continuous basis to ensure a match between internal requirements and external opportunities (Joel West & Gallagher, 2006).

Open innovation and intellectual property

According to the closed innovation paradigm, intellectual property is seen as a by-product of innovation and was used mainly as a defensive strategy to keep competitors at bay (H. Chesbrough, 2003). In the open innovation paradigm, intellectual property is managed proactively to provide opportunities for integrating external knowledge or exploiting external paths to markets (H. Chesbrough, 2003). However, even within the open innovation paradigm it is still a challenge how much of the firm's intellectual property should be revealed. Firms that pursue open innovation strategies have to consider the importance of their intellectual capital before sharing it with an external partner or the public (Alexy, Criscuolo, & Salter, 2009). Intellectual property such as patents, trademarks and copyright can be protected, but know-how and trade secrets are becoming more difficult to secure as the open innovation environment is characterised by high labour mobility (H. Chesbrough, 2003).

Von Hippel and von Krogh (2006) argued that revealing intellectual property to the network might be worth considering: (1) when others know something close to the firm's intellectual property; (2) when profits from exploiting their own intellectual property is low; and (3) if incentives to reveal intellectual property are positive. Henkel (2006) observed how software companies practiced 'selective revealing'; the more support needed in the development, the more software code is revealed to the community. Alexy et al. (2009) developed different scenarios for when it is worth revealing intellectual property in open innovation environments. In industries with high concentration and with slowly evolving technologies the benefit of revealing intellectual property is

limited and considered risky. In industries with high concentration and with fast evolving technologies, firms are more likely to benefit from collaborating closely with other experts within the field. Often these types of collaboration are undertaken in formal structures such as consortia or clusters and with clear guidelines and regulations in terms of ownership of joint developed intellectual property. If industry concentration is low and the technology evolves slowly, the authors suggest using open innovation to spread the problem but secure the solution. In this scenario, the firm uses open innovation to find solutions through the wisdom of the crowds. In a setting with low industry concentration but fast evolving technological development, firms are more likely to reveal most of their intellectual property to accelerate innovation speed and gather an audience for their technology. In conclusion, proactive IP management is important among firms operating after an open innovation strategy. Revealing too much will lead to competitors or followers taking over; revealing too little will lead to competitors slower innovation speed and reduced technological diffusion.

Open innovation and entrepreneurship

Open innovation implies that a firm can choose from a number of entrepreneurial strategies to commercialise internal IP. These strategies include, among others, corporate venturing, intrapreneurship and spin-offs (H. Chesbrough, 2003). Corporate venturing refers to the process of investing in start-ups or smaller firms that are expected to grow fast. Corporate venturing is a method to keep control and integrate potential external opportunities (H. Chesbrough, 2003). Intrapreneurship is known as the practice of allowing internal employees a degree of freedom and autonomy to explore new opportunities often unrelated to the existing activities of the firm. Intrapreneurship can be motivated by stimulating the employees to socialise externally and through internal activities such as idea competitions (van Dijk & van Den Ende, 2002). Spinning off new ventures is seen as a method to commercialise internal technologies that do not fit well with the current business portfolio or competences of the firm (H. Chesbrough, 2003). A spin-off is created by internal staff, who acquire the intellectual property from the parent firm on which a new firm is founded. The parent firm can combine spin-offs with corporate venturing or they can choose not to get involved further in the development process. In both cases, the parent firm gets the opportunity to benefit from internal inventions that either do not fit into the business portfolio or is expected to have only limited commercial value (G. D. Markman, Gianiodis, Phan, & Balkin, 2005; O'Shea, Allen, Chevalier, & Roche, 2005).

Limitations and implications of Open Innovation

There are two key aspects of the open innovation concept that are of particular relevance to this study and complementary to the various models of innovation described in this chapter. Firstly, innovation processes are increasingly taking place outside the boundaries of the firm through inter-firm relationships and within networks. Firms are active participants in the market for technology and knowledge. They establish relationships and networks with the purpose of acquiring and selling technologies and knowledge between firms. Secondly, open innovation is a business model where outputs from internal or external R&D are turned into commercial value. A firm selects to commercialise those R&D outputs that fit with the strategy of the firm and sell those outputs that do not. This helps towards identifying those outputs that should be licensed in and those that should be licensed out or spun-off.

2.4 Chapter summary

The purpose of this chapter was to examine the relationships between production and distribution of knowledge and the wider context of small firms. This examination was intended to identifying main trends to understand what role the wider context plays in knowledge production and distribution for small firms. The examination was based on a critical review of dominant theoretical models within innovation.

Trends in knowledge production and distribution

The review revealed the following trends that are summarised in detail in Table 2-2.

- Linear knowledge production is decreasing;
- Knowledge production is becoming more context dependent;
- Knowledge production takes place in vertical links and via feedback loops;
- Knowledge distribution is becoming more integrated into systems of innovation;
- Systems of innovation are constantly evolving and never reach equilibrium;
- Innovation in organisations is increasingly moving from closed to open.

Table 2-2: Main trends in knowledge production and distribution

author(s) and (year)	Main trends
	Knowledge production
Linear model of innovation by Bush (1945)	**Linear knowledge production is decreasing** – For many decades the linear model of innovation has been the most recognised theoretical model to explain successful innovation in society. The assumption was that innovation went through a pre-determined chain from basic research → applied research → development (Bush, 1945). While the linear model of innovation has been heavily criticised in the contemporary innovation literature, major scientific breakthroughs have then derived from basic research over the years. However, as more resent models on innovation show, innovation is increasingly deriving from combining existing knowledge across individuals

	and organisations rather than investing in basic research.
Mode-2 knowledge production by Gibbons et al. (1994)	**Knowledge production is becoming more context dependent** – Gibbons et al. (1994) distanced themselves from the liner model of innovation by arguing that knowledge production is increasingly application driven and context sensitive constituting a move from Mode-1 to Mode-2 knowledge production. Context sensitive knowledge refers to knowledge not being fully understood but has different meanings to different people depending on their background and the context in which the knowledge is applied. The consequence is that knowledge production is becoming more heterogeneous, which makes it harder for knowledge producers to produce relevant and socially robust knowledge without conferring the public space.
Chain-linked model by Kline and Rosenberg (1986)	**Knowledge production takes place in vertical links and via feedback loops** – Kline and Rosenberg's (1986) chain-linked model of innovation is build up around a vertical chain of activities. Innovation begins with an identified need in the market which the firm seeks to fulfil with an invention. The firm uses different sources of knowledge to develop the invention to cover the need in the market. Firstly the invention is created by combining existing knowledge across individuals and internal departments through established feedback loops. Only if existing knowledge is not adequate will the firm seek external knowledge and as the last resort undertake new research. As the invention hits the market, the firm will engage in continuing innovation based on feedback from customers. The chain linked model is diametrical to the linear model in which innovation begins with investments in basic research. On the other hand, the chain-linked model has been criticised for over-emphasising market-pull as the driving force behind innovation and for only considering investment in science as the last resort. However, the model is important as it does recognise that new knowledge is not a product of research only but to a large extent derives from combining existing knowledge in new ways.
	Knowledge distribution
National system of innovation by Freeman (1987)	**Knowledge distribution is becoming more integrated in systems of innovation** – As it was observed that knowledge production increasingly dependent on social relationships and context, several scholars in the late 80s and early 90s began picturing innovation as a product of firms and organisations organised in a system of innovation (Freeman, 1987) under influence of institutions such as laws, culture, norms and routines (B-Å. Lundvall, 1992). It was observed that governments through policy making and interventions also played an active role in stimulating innovation in society. The system approach inspired researchers to study how changes to the system of innovation infrastructure could stimulate more interaction and knowledge to flow more freely between users and producers of knowledge. What is important about this approach from the perspective of this study is that a system supporting innovation activities is assumed to exist but it varies from country to country and even from region to region.
Triple Helix by Etzkowitz and Leydesdorff (2000)	**Systems of innovation are constantly evolving and never reach equilibrium** – Continuing building on a systemised approach to innovation, Etzkowitz and Leydesdorff (2000) conceptualised the evolution of such system to take place in as a continuous process through institutional transformation of governments, universities and industries and through the emergence of new organisational forms. They argued that a system of innovation never reaches equilibrium but will constantly evolve.
Open Innovation by Chesbrough (2003)	**Innovation in organisations is increasingly moving from closed to open** – Based on observation of innovative firms in the beginning of the 21st century, Chesbrough (2003) noted that firms were increasingly engaging in open innovation in contrast to closed innovation. Closed innovation is a paradigm describing how firms gained control of their innovation processes through vertical integration and proprietary intellectual property regimes. Within an open innovation paradigm, firms are increasingly seeking to commercialise both internal and external ideas but also seek internal as well as external paths to market. Within the open innovation framework firms are seen as active participants in the market for technology and knowledge. This framework explains the increasing use of vertical and horizontal relationships external to the firm but also how firms can be based solely on intellectual property produced externally.

The role of the wider context for knowledge production and distribution for small firms

As knowledge production and distribution of knowledge is becoming increasingly non-linear, context dependent and integrated in reflexive and dynamic systems of innovation, it has become more important than ever before to look outside the boundaries of the firm to understand innovation. Knowledge production and distribution is increasingly becoming an outcome of interplays between

the specific system of innovation and internal abilities of the firm to engage with external forces. Knowledge production and distribution are increasingly becoming integrated in systems of innovation. Systems of innovation have become a national matter with government trying to intervene in innovation through policymaking, allocations of funds and creation of triple helices (Giesecke, 2000; B.-Å. Lundvall, et al., 2002). Giesecke (2000) and de Castro et al. (2000) pointed out that knowledge production and distribution in society requires a combination of top-down and bottom-up initiatives, e.g. establishment of incubators, improved availability of venture capital, polices directed at increasing interaction and allocation of funds to reduce bottlenecks.

At the same time, there are numerous accounts in the literature that it is not government interventions alone that accounts for advancements in innovation. Universities are seeking new methods on their own to promote research commercialisation and are strengthening revenue streams (Craig Boardman & Ponomariov, 2009; Etzkowitz, 1998). Industrial firms are aiming at developing competitive advantage by exploring new models for combining and accessing knowledge residing externally (H. Chesbrough, 2003; Kline & Rosenberg, 1986).

The contribution of this chapter to the overall purpose of this study

This chapter contributes to the overall purpose of this study in many ways. Firstly, competences related to interaction and learning are becoming increasingly important for small firms to stay innovative and competitive. The various models presented in this chapter (see Table 2-2 for an overview) all suggest that complexity in innovation is growing and innovative firms are increasingly searching for new practices of accessing and transferring knowledge externally.

Secondly, small firms cannot rely on developing relationships with universities in a linear fashion. The fact that knowledge production and distribution progresses dynamically and non-linearly suggests that small firms are not only users but also produces of scientific knowledge. Small firms cannot only rely on accessing knowledge from universities in one-dimensional ways. Knowledge from universities is neither complete nor perfect. Progression in innovation happens when small firms combine knowledge from universities with their own knowledge or knowledge from other external parties in iterative and creative ways.

Thirdly, competence development and learning in small firms can be accelerated through systems of innovation but is not given beforehand. Governments are becoming more active in formulating policies and improving the infrastructure to encourage more interactions and research commercialisation in society. This study is not focusing at how these government initiatives are affecting the opportunities for small firms to engage in university-small firm relationships. What is relevant to this study is to understand how small firms take advantage of these new opportunities

through competence development and learning. It is argued in this study that small firms are not equally competent to take advantage of external opportunities, e.g. apply for funding, take part in establishing and developing clusters and utilise locations in science parks to enhance growth.

3 Universities and research commercialisation

This chapter aims at identifying the most important dimensions at universities that affect their engagement in research commercialisation and interaction with industry. Through a review of prior research on universities and research commercialisation it has been found that incentive structures, technology transfer abilities and surrounding network structures are most likely to affect opportunities for university-small firm relationships. The development and implementation of these dimensions across universities are not universal. Hence it is argued in this chapter that the opportunities for small firms to engage with universities may in fact be determined by the degree of research commercialisation taking place at the respective university.

3.1 Introduction

Universities in most developed countries have become increasingly commercially orientated (Etzkowitz, et al., 2000; Rosenberg & Nelson, 1994). This shift in orientation is caused by a number of external factors including moving from closed to open innovation (H. Chesbrough, 2003), a growing recognition of social robust knowledge (Gibbons, et al., 1994), increasing pressure from governments (Debackere & Veugelers, 2005) and a growing number of industrial sectors involved in science-based innovations (Giesecke, 2000). As a result of these external factors, universities are going through an organisational transformation which involves many dimensions including university mission, incentive structures, capability development and supporting network and infrastructure (F. T. Rothaermel, Agung, & Jiang, 2007).

The purpose of this chapter is to explain how the ongoing transformation of universities is affecting the opportunities for industrial firms to collaborate with universities. It is assumed in here that this transformation is in fact ongoing but not identical or following the same pace for all universities. This may create discrepancy in the ways small firms approach universities. In short, this chapter aims at identifying those organisational dimensions at universities that are likely to explain variation in how small firms establish and develop relationships with universities.

This chapter builds on the existing literature on universities and research commercialisation (e.g. Debackere & Veugelers, 2005; Rosenberg & Nelson, 1994; Donald S. Siegel, et al., 2004). Through a review of this literature, the chapter begins with a description of the ongoing transformation of universities towards research commercialisation. This is followed by an examination of the most

important organisational dimensions at universities and how they affect the opportunities for small firms to establish university relationships. The chapter concludes with a summary of these dimensions including a discussion on how they are to be applied further on in this study to explain university-small firm relationships.

3.2 The ongoing transformation of universities

The traditional role of universities

The role of universities in the national innovation system has changed dramatically over the past few decades (Etzkowitz & Leydesdorff, 1995; Gibbons, et al., 1994; Donald S. Siegel, et al., 2004). Historically, universities concentrated on basic research, which occasionally would spill over to industrial firms. Knowledge spill-over was seen as an unexpected consequence or by-product of academic research (Rosenberg & Nelson, 1994). But during the 1940s, led by the logic of the linear model of innovation, governments in developed countries started to become more aware of the potential economic and social benefits of basic research for innovation and economic growth in society (Godin, 2006). Governments realised that an increase in basic research would not happen without government interventions (Rosenberg & Nelson, 1994). It was argued that private investments in basic research would always be low due to market imperfections and the uncertain nature of outcomes of basic research (Arrow, 1962; R. R. Nelson, 1959). Vannevar Bush (Godin, 2006; originally Bush [1945] reprinted in 1995) strongly advocated that basic research needed government funds to accelerate. At the same time, it was argued that universities were the most appropriate recipient of these funds as only university scientists had pure interest in socio-economic benefits deriving from basic research combined with the required competences and mindset to undertake such a task (Carty, 1916; Godin, 2006).

One of the consequences of Vannevar Bush's influential linear model of innovation was that universities earned a central position in the innovation system by being the dominant producer of basic research in society. This position was sustained as universities almost entirely absorbed all government funds allocated to basic research in society and were assigned a great amount of autonomy to decide what research served the public best (Rosenberg & Nelson, 1994). Thus the role of universities in the system of innovation after World War II became more established and was grounded in education and undertaking basic research (Etzkowitz, 1998).

The new role of universities

Even though universities became the primary centre for basic research after World War II, it was still the expectations among policy makers who funded this research, that research from universities

should yield practical benefits (Rosenberg & Nelson, 1994). While the linear model argued for a clear distinction between basic and applied research (Godin, 2006; originally Bush [1945] reprinted in 1995), top universities in America already in the first half of the 20th century began to establish more applied science disciplines such as chemistry, electronic and engineering within the university curriculum (Rosenberg & Nelson, 1994). It was argued that this trend was sparked by a decentralised funding system in which government agencies with particular fields of interest had power to dictate new discourses at universities; e.g. The Department of Defence, NASA and Department of Energy (Rosenberg & Nelson, 1994). The introduction of more applied disciplines at universities also meant an increase in the use of industry trained scientists and engineers to educate and train new graduates and the establishment of professional organisations and associated academic journals within these disciplines (Gibbons, et al., 1994). The link between university research and applied research received further attention by policy makers around the world when breakthrough inventions from universities favoured the emergence of numerous new industries and commercial applications (Etzkowitz, et al., 2000). Especially the early steps towards the computer (numeric control of machines in 1952 at MIT) and the generic engineering revolution in the mid 1970s, were convincing examples of how applied research could strengthen industry prosperity and economic growth (Rosenberg & Nelson, 1994). Today, disciplines such as computer science, robotic engineering, business, and art and design have been added to the curriculum of most western universities. An indication that universities are becoming more practical and responsive to the needs of emerging industries and also that the traditional boundaries between basic and applied research has become looser (Etzkowitz, 1998; Gibbons, et al., 1994).

Another radical alteration to the role of universities in the innovation system was caused by changing legislation. In the 1970s, US universities started lobbying the US government to change the ownership structure of intellectual property deriving from government funded research (Scott Shane, 2004).[3] At that time the current system was seen as an obstacle for research commercialisation as there were only limited incentives for universities and the individual researcher to engage in such activities (Scott Shane, 2004). As a consequence the US congress attempted to remove potential obstacles to university research commercialisation by passing the Bayh-Dole Act in 1980. The Bayh-Dole Act served to simplify the existing patent system and give autonomy to those that were best motivated and prepared to undertake research commercialisation. The Congress anticipated that

[3] The Act permitted public research institutions, small business and non-profit organisations to pursue ownership over output from government funded research. In this study, focus will be on how the Act affected research commercialisation at universities only.

handing over ownership and management of intellectual property to universities would accelerate research commercialisation and promote economic growth and entrepreneurial activities. The US government was the first country in the world to introduce legislation that gave universities ownership of scientific research accomplished with government funding. Today, most western countries have implemented their own version of the Bayh-Dole Act (D. C. Mowery & Sampat, 2005).

While the Bayh-Dole Act and similar national legislation handed over the ownership of IP generated from government funds, the issue remains somewhat unsettled and left to the discretion of the individual university to distribute the actual ownership and eventual revenue from successful commercialisation among the inventor, the faculty and the university (Debackere & Veugelers, 2005). For example in some countries, such as Germany and Sweden, researchers have long had ownership rights over the IP deriving from their own work. In Japan, the ownership rights are determined by a committee and may be awarded to the inventor (Debackere & Veugelers, 2005). However, intellectual property from universities is most commonly owned and managed by the university from which it originates (Debackere & Veugelers, 2005; D. Mowery & Rosenberg, 1993). As a consequence of the passing of ownership of IP to universities, most universities established dedicated technology transfer offices (further elaborated below) to assists with managing and protecting their IP.

One consequence of the increasing focus on application orientated research is that governments are increasingly regulating funding to universities in terms of their intrinsic scientific merit and their possible contribution to practical problem solutions (Martin, 2003; Rosenberg & Nelson, 1994). Targeted (earmarked funding) and competitive funding have become increasingly widespread, replacing the simple block grant funding that gave universities the autonomy to decide how to spend it (Martin, 2003). Particularly throughout the OECD, it has been observed that targeted and competitive funds are directed, to a large degree, towards applied research or joint research programmes between universities and industries (OECD, 2008). In some countries, government funding has even dropped to some extent to give way to more private investments in R&D (David, Hall, & Toole, 2000; Godin & Gingras, 2000). For example, in the US, government funding per full time researcher dropped by 9.4 percent in real terms from 1979 to 1991 (W. Cohen, Florida, randazzese, & Walsh, 1998).

The transformation from the old to the new role of universities has not been without an intense debate among policy makers and research scholars. On the one side, several scholars argue that universities are responsible for undertaking fundamental research and serving public interests that are either neglected by or irrelevant to profit-orientated firms (Carty, 1916; Rosenberg & Nelson,

1994). Commercial orientation may aggravate conflicts between advancing knowledge and generating revenue and thus interrupts academic freedom (Magnus Gulbrandsen & Smeby, 2005). Other scholars suggest that economic incentives among faculties and academic scientists create more secretive behaviours (less publishing), which may generate more patenting (revenue streams) but less advancement in knowledge and technological development. As a result, academic freedom and integrity may be compromised (Rosenberg & Nelson, 1994). On the other side, scholars found that applied research did not necessarily occur at the expense of basic research because the two types of research are in fact converging (Etzkowitz, et al., 2000; Van Looy, et al., 2004). Engagement in commercial activities may also provide new insight that can stimulate fundamental research or additional funding to develop the research area further (Etzkowitz, 1998, 2003; Gibbons, et al., 1994). While research on research focus at universities presents conflicting views as to what extent universities should conduct research on behalf of commercial interests, a number of scholars have reconciled these opposing opinions by arguing that the mission of universities today requires a balance of traditional and commercial roles to best serve the interest of the government and complement the skills of the industry (Etzkowitz, et al., 2000; Rosenberg & Nelson, 1994).

In summary, universities have been going through a transition since the beginning of the 20th century. They have become more integrated into the system of innovation both in terms of their link to governments but also their contribution to industry and commercial interests (Etzkowitz & Leydesdorff, 2000; Freeman, 1987; Godin & Gingras, 2000). This also corresponds with the Mode 2 knowledge production perspective where science is firmly located in a mode of application, interdisciplinarity and user/stakeholder involvement (Gibbons, et al., 1994). Etzkowitz (1998) refers to the transformation of universities as a revolution in which economic development through research commercialisation, industry interaction and entrepreneurship is integrated into the academic function along with teaching and research. It is the capitalisation of knowledge and technologies that is the heart of the new mission of universities, which also establishes universities as an economic actor on its own right in the system of innovation (Etzkowitz, et al., 2000).

3.3 The organisational dimensions at universities and research commercialisation

Today, most governments around the world have asserted that knowledge and technologies from universities are important contributions to national and regional economic growth (Etzkowitz, et al., 2000; R. Nelson, 1993). At the same time, policy makers and university management also point to the possibilities that knowledge and technologies can provide substantial income for universities (G. D. Markman, Phan, Balkin, & Gianiodis, 2005; Donald S. Siegel, Waldman, Atwater, & Link, 2003). These

possibilities have become even more essential to universities as constraints on public funding and continuing cost pressures within their operating budgets have become tighter (Rosenberg & Nelson, 1994). Today universities are becoming more aggressive in promoting their research locally and internationally and in seeking closer relationships with industries as a means of raising funds, generating value of intellectual property rights through contracting, patenting and licensing and creating spin-off companies (Debackere & Veugelers, 2005; G. D. Markman, Phan, et al., 2005; Donald S. Siegel, et al., 2003). These commercial activities are increasingly becoming integrated into university curriculum (Etzkowitz, 1998; Etzkowitz & Leydesdorff, 2000). To reach that stage, universities have undergone radical organisational restructuring which can be divided into three broad areas affecting their interface towards industry (P. H. Phan & Siegel, 2006):

- incentive structures to encourage participation of academic researchers in the commercialisation process (Goldfarb & Henrekson, 2003; R. A. Jensen, et al., 2003);
- establishment of technology transfer offices to build organisational capabilities within research commercialisation (G. D. Markman, Phan, et al., 2005; Donald S. Siegel, et al., 2003); and
- creation of wider network to support entrepreneurial activities including incubators (Aaboen, 2009; Clarysse, et al., 2005), science parks (Hansson, Husted, & Vestergaard, 2005; Löfsten & Lindelöf, 2002) and venture capital markets (Myint, et al., 2005).

Most of these organisational developments at universities have also been supported by national governments in many countries via legislation (e.g. The Bayh-Dole Act of 1980) alongside economic support from both governments and industries (Andréosso-O'Callaghan, 2000; Colombo & Delmastro, 2002; Marques, et al., 2006). This ongoing organisational restructuring at universities fits well within the NSI approach (Freeman, 1987) and the Triple Helix Framework (Etzkowitz & Leydesdorff, 2000) in which universities are becoming increasingly integrated and inter-dependent on other parts of the NSI.

3.3.1 *Incentive structures*

The increasing focus on research commercialisation at universities is often argued to cause potential conflicts between commitment to commercial (e.g. patenting, consultancy and contract teaching) and traditional academic activities (e.g. publishing and teaching) (Etzkowitz, 2003; Magnus Gulbrandsen & Smeby, 2005). The conflict is essentially there because academic researchers today will have to share their time and resources between academic and commercial activities, while in the past they only had to concentrate on the first part (Magnus Gulbrandsen & Smeby, 2005). It has been

a challenge for most universities as well as policy makers to develop and implement appropriate incentive structures to optimise research capacity at universities while at the same time take the motives and interests of the individual researcher into consideration (R. A. Jensen, et al., 2003). The solution, however, is not straight forward as there are conflicting views among research scholars and policy makers in terms of what the objectives of universities should be - undertaking fundamental research and serving public interests or produce application orientated research with commercial prospects (Carty, 1916; Etzkowitz, 1998; Gibbons, et al., 1994; Rosenberg & Nelson, 1994). Current research on incentive structures at universities often deals with this potential conflict between the interests of the university versus those of the individual scientist.

Conflicts in incentives to engage in research commercialisation

Jensen et al. (2003) saw the process of disclosure and licensing as a principal/agent game-model, with university scientists and TTO offices being dual agents who maximise expected return and the university being the principal. The inventor has to make a decision to disclose his or her invention. If an invention is disclosed, the TTO decides whether to find a buyer or not. The university is responsible to put forward incentive structures that control both agents. University scientists are motivated to produce new knowledge that is useful input into other scientists' research. Scientists wish to have their work cited by other researchers to build up their reputation in the academic community (Goldfarb & Henrekson, 2003). As explained by Siegel et al. (2004), university scientists and TTOs have different motives that are not necessarily conflicting but that need to be accommodated in the university incentive structure. An overview of the primary and secondary motives for university scientists and TTOs to engage in technology transfer from universities to industry is presented in Table 3-1:

Table 3-1: Key stakeholders and their motives in the transfer of technology from universities to industry; adapted from Siegel et al. (2004), p. 115

Stakeholder	Actions	Primary motive	Secondary motive	Perspective
University scientists	Discovery of new knowledge	Recognition within the scientific community via publications and grants	Financial gain and a desire to secure additional research funding (mainly for graduate students and lab equipment)	Scientific
Technology transfer office	Works with faculty members and firms to structure deals	Protects and markets the university's intellectual property	Facilitates technological diffusion and secures additional research funding	Bureaucratic

According to Siegel et al. (2003, 2004) the root to potential conflict in the incentive system is often caused by university scientists claiming that TTOs are too bureaucratic to deal with. At the same time, TTO offices postulate that academic scientists often neglect or give low priority to the

commercial aspects of science. Siegel et al. (2004) conclude that universities not only need to adjust their incentive structure but also need to: (1) educate and train academic scientists to think more commercially; and (2) allocate more resources to competency development in TTOs.

The table above could also be extended to include the faculty level. Louis et al. (1989) found that faculty level support had a significant effect on the individual scientist's commitment to research commercialisation. Faculty is more in charge of developing appropriate career opportunities for the individual scientists and to make sure that he/she is compensated or released from academic activities when being engaged in commercial activities. For example, academic staff may use external funding to reduce their teaching load or hire research assistants (Magnus Gulbrandsen & Smeby, 2005).

Conflicts of interests among university stakeholders towards research commercialisation can affect the opportunities for industrial firms to interact with universities. Too many conflicts between the individual scientists and university management can discourage commercial focus and affect the opportunities for industrial firms to collaborate with universities negatively.

Incentive structures promoting research commercialisation

Another challenge to the incentive structure of universities derives from the nature of academic research. It is argued in the literature that university inventions are more likely to be commercialised successfully if the inventor takes part in the continuous research and development of the initial patent (R. Jensen & Thursby, 2001). The reason is that only a small fraction of knowledge associated with a licensed invention from universities is codified. Incentive structures (economical as well as reputational) often reward the inventor for codifying only certain types of knowledge. Failed experiments or second rank results are normally not included in a patent application or publication. However, knowledge learned as part of the process of arriving at the final results may be valuable in developing intuition regarding how the invention might behave under alternative circumstances (Agrawal, 2006). Access to this type of knowledge has proven to speed up the commercialisation process and save time and resources when replicating experiments (Agrawal, 2006; R. Jensen & Thursby, 2001). The creation of incentives for the academic inventor to direct effort towards taking part in the further research and development of early stage inventions and share non-codified knowledge is generally necessary for successful technology transfer. For this reason, a number of scholars recommend providing incentives directly to the inventor to encourage disclosure and commercialisation of activities (Debackere & Veugelers, 2005; Goldfarb & Henrekson, 2003; R. Jensen & Thursby, 2001).

Jensen and Thursby (2001) found that academic inventors preferred to receive research grants from the licensor as a means of continuing providing support in the commercialisation process. A research grant allowed the academic inventor to continue research in his/her labs which often combined both academic and commercial interests. When academic inventors are involved directly with the company as consultants or board members, they often perceive their academic freedom to be more constrained than when receiving research grants. However such activities are often compensated quite generously and therefore still considered attractive among many academic researchers (Goldfarb & Henrekson, 2003). When intellectual property rights have been asserted, a royalty arrangement between licensor and licensee may also be applied to engage the inventor (R. Jensen & Thursby, 2001). In this situation the inventor would have an interest in supporting the licensee to optimise the commercial success and royalty payments. Finally the inventor may find a new firm based on university IP or his/her know-how. In this case the inventor, as the founder, will have a significant equity share in the new firm with other shares been allocated between the university and investors (Bray & Lee, 2000; R. Jensen & Thursby, 2001).

In summary, incentive structures at universities affect the behaviour of the faculty and inventor when it comes to engaging in commercial activities. If universities do not offer incentives for the faculty to be involved in commercialisation, it may drastically affect the opportunities for industrial firms to collaborate with universities around research commercialisation. At the same time universities are facing a challenge as they will have to balance commercial activities with the individual academic researcher's interests. In relation to Mode-2 and the Triple Helix framework, incentive structures also have some direct implications in terms of steering universities closer towards application-orientated and social robust research (Etzkowitz & Leydesdorff, 2000; Gibbons, 2000). Incentive structures can also be linked to the notion of institutions which refer to norms and research culture at universities that can be difficult to change (B.-Å. Lundvall, et al., 2002). For incentive structures to be effective it is most likely they will require time to be fully accepted and understood in the university context. They may also require constant modification to match the ever-changing system of innovation (Etzkowitz & Leydesdorff, 2000).

3.3.2 *Technology transfer*

As a direct result of the passing of the Bayh-Dole Act, most universities saw a need to develop organisational capabilities to support research commercialisation (Lockett, et al., 2005; Donald S. Siegel, et al., 2003). Such capabilities include intellectual property assessment and protection (Goldfarb & Henrekson, 2003), networking (Nicolaou & Birley, 2003b), business and entrepreneurial

development (Etzkowitz, 1998). While these skills may occur in different parts of any university organisation, most universities have decided to concentrate these capabilities in dedicated technology transfer offices (Debackere & Veugelers, 2005). After the implementation of Bayh-Dole in 1980, it was reported that the number of TTOs increased eight-fold in the US, which led to a six-fold increase in the volume of patents registered, and university revenues from licensing IP went up from US$220 million to US$1,385 million over a 15-year period (P. H. Phan & Siegel, 2006). While growth in research commercialisation from universities is caused by many other factors, as described earlier in this and previous chapters (Gibbons, et al., 1994), it is generally believed among research scholars and policy makers that the establishment of TTOs have been highly influential in making universities more commercially capable (Debackere & Veugelers, 2005; Goldfarb & Henrekson, 2003; R. A. Jensen, et al., 2003).

Most TTOs are established as specialised units embedded in the university system. TTOs provide administrative support to the faculties and individual researchers in the form of legal (patenting and contract preparation), financial (due diligence) and marketing (identifying buyers and negotiating terms of transfer) support (Debackere & Veugelers, 2005). Common performance measures for TTOs are: patents registered, licences sold, spin-offs created, research contracted, industry collaboration established, utilisation of university equipment and resources, university staff engaged in commercialisation. TTOs are often the formal gateway for the establishment of relationships between universities and industrial firms (Debackere & Veugelers, 2005). TTOs are still considered as a relative novel extension to the traditional organisational structure at universities. Current research on TTO usually focuses on the (1) organisational structure and (2) organisational capabilities of TTOs (J. Bercovitz, Feldman, Feller, & Burton, 2001).

Technology transfer offices

Bercovitz et al. (2001) analysed how different organisational structures of TTOs mediate the relationship between inputs and revenue generated. Their study was based on data from three universities in the US.

- **H-form**. At the first university studied, the TTO aligned with an H-form, which is characterised by a centralised TTO with limited control and decentralised research units. The strengths of the H-form are autonomy of individual research units, optimised unit-level information-processing capacity, and unit-level incentives. The shortcomings of the H-form are the difficulties with coordinating activities across units.
- **M-form**. The second university applied an M-form, which is characterised by a centralised TTO with stronger control and decentralised research units. This led to more cross-unit

coordination and incentive alignment but also to more bureaucracy and less unit-level incentives.

- **MX-form.** At the third university, the TTO followed an MX-form, which allowed for better cross-unit coordination and incentive alignment. This led to more customers being shared across research units, but longer information-processing time. Bercovitz et al. (2001) argued that the structure of the TTO is a product of the history and unique characteristics of the host university. In a study of TTO structure at Belgian universities, Debackere and Veugelers (2005) found that decentralised management styles (like H-form or MX-form) gave better commercialisation results. They allowed the universities to perform well in scientific inventions as well as more applied research. The MX-form, in particular, led to more research being coordinated across research units.

TTO has also been related to bureaucracy at universities. Inflexible university bureaucracy might prevent academic scientists from establishing contact with industry through TTOs and might cause them to rely on informal contacts, thus bypassing the TTO (Donald S. Siegel, et al., 2004). Styhre and Lind (2010) argued that universities with ambitions towards becoming entrepreneurial need to soften their bureaucracy. Entrepreneurial activities, such as new venture creation, are usually highly ambiguous and uncertain and their success depends on staff's ability to react quickly to new internal and external opportunities. This can be difficult to do in highly bureaucratic organisations.

Technology transfer capabilities

Organisational capabilities are usually thought of as an organisation's ability to develop, reconfigure and integrate internal and external competences to address rapidly changing environments (Eisenhardt & Martin, 2000; Lockett & Wright, 2005). Capabilities reside within the staff of an organisation (P. H. Phan & Siegel, 2006). The primary tasks of TTOs are to protect, manage and commercialise IP from universities, which also require interaction with industry and new venture creation (P. H. Phan & Siegel, 2006). Several scholars have observed a mismatch between the primary tasks and the competencies held by most TTO officers (G. D. Markman, Phan, et al., 2005; Donald S. Siegel, et al., 2003, 2004). Siegel et al. (2004) found that TTO officers tend to specialise in patent laws and regulations rather than relationship management skills. This is problematic in terms of establishing contact between scientists and industrial firms and reducing cognitive and cultural distance between academia and industry. It was reported in the same study that those TTOs that did hire officers with substantial business and negotiation experience had a much firmer grasp on how to assess the market potential of a particular invention and create linkages with industrial firms. Markman et al. (2005) noted that the process of actually finding a buyer for university IP was one of

the most critical elements of successful commercialisation, but TTO officers often did not have the proper network contacts or skills to identify a buyer. Some scholars have also pointed out that TTOs often experience a high rate of staff turnover, which makes it difficult to maintain long-term relationships with firms and scientists (D. S. Siegel, Westhead, & Wright, 2003). High turnover rate of staff also makes it difficult to maintain a culture and accumulate organisational capabilities over time (D. S. Siegel, et al., 2003).

Research has also found a relationship between a specific set of capabilities of TTO officers and preferred technology transfer methods. Siegel et al. (2003) and Markman et al. (2005) argued that many TTOs preferred an up-front payment (lump sum) rather than accepting an equity stake in a start-up or royalty payments (G. D. Markman, Gianiodis, et al., 2005; Donald S. Siegel, et al., 2004). The authors argued that royalty arrangements and equity stakes often require a broader set of skills and a broader understanding of commercial issues compared to selling a patent and receiving a one-off payment. In another study, Markman et al. (2007) also found that TTOs that focused more on business development and less on IP rights tended to create more university spin-offs. Lockett et al. (2005) described the problem being that TTOs officers had poor due diligence skills and therefore they were not capable of actually leading the commercialisation process. This was especially a problem when the TTO officers had to cover several academic disciplines or technological fields. The recognition of different due diligence strategies according to the disciplines did not appear in general (Lockett, et al., 2005). Tendency towards selling patents rather than take equity positions or royalties, have also been linked to how TTOs are evaluated and rewarded. TTOs are typically focused on short-term gains and appear less interested in taking risk to secure long-term success (G. D. Markman, Phan, et al., 2005). This is especially problematic for smaller firms that do not have available funds to pay for university inventions up-front but rely more often on giving up equity or future royalty payments (G. D. Markman, Phan, et al., 2005; Donald S. Siegel, et al., 2004). Universities that do aim at becoming more entrepreneurial need to modify their commercialisation strategies to suit smaller and new ventures (Etzkowitz, 1998; G. D. Markman, Phan, et al., 2005)

In summary, most universities have established dedicated TTOs to support commercialisation of their intellectual property. TTOs can appear in various organisational forms each with their own strengths and weaknesses. However, as knowledge production is becoming increasingly inter-disciplinary and application-orientated, Debackere and Veugelers (2005) argued that a decentralised structure allowed for better coordination and collaboration across disciplines. TTOs need a variety of capabilities to support research commercialisation. Several studies found that TTOs often lacked essential business development and relationship management skills, which often made them prefer

simple license agreements or selling patents for an upfront payment rather than take equity in new ventures or choose royalty arrangements. This is a problem that affects new and small firms mostly and jeopardises the entrepreneurial role of universities in society (Etzkowitz, et al., 2000).

3.3.3 *Network and surrounding structures*

Another key factor underlying technology and knowledge transfer to industries is the supporting network surrounding universities. In particular, supporting networks in the form of science-parks/incubators (Hansson, et al., 2005; Löfsten & Lindelöf, 2002) and venture capitalists/mentors (Myint, et al., 2005) have received considerable attention in the literature for their positive effect on research commercialisation in general.

Incubators and science parks

Incubators and science-parks are often defined as organisations, private or public, that provide resources and support to enhance the establishment and growth of new ventures (Löfsten & Lindelöf, 2005). Often these types of organisations have also been referred to as hybrid organisations in the Triple Helix framework as they usually require the involvement from both governments, universities and industry to succeed (Etzkowitz & Leydesdorff, 2000).

The expectations of incubators and science-parks with regard to the economy are primarily to stimulate the formation of new science or technology-based ventures with high growth potential, and if the park is associated with universities, to stimulate research commercialisation of academic output through spin-offs and entrepreneurial activities (Phillip H. Phan, Siegel, & Wright, 2005). Rothaermel and Thursby (2005a) showed that incubators may foster stronger links between universities and new ventures. This is useful if the new venture is working with more advanced technologies. Link and Scott (2005) found that science-parks located geographically closer to universities attracted a greater number of university spin-offs. Also science-parks with a biotechnology focus hosted more university spin-offs. Incubators and science-parks are also seen as means of fostering regional economic development (Clarysse, et al., 2005; Colombo & Delmastro, 2002). Bakouros et al. (2002) showed that science parks had a significant role to play in strengthening the innovation system in less developed countries like Greece.

As the number of incubators and science-parks has increased in the past few decades in most countries, Hansson et al. (2005) pointed to the fact that building institutions such as science-parks may in fact institutionalise a low interaction between universities and industry over time. This is particularly the case if the mentality among university management is that academic output can be

'parked' in the science-parks for entrepreneurs and venture capitalists to commercialise. A science-park itself does not stimulate research commercialisation. For research commercialisation to succeed, the university still needs to be the driving force by continuously engaging with the industry. The science-park is only an instrument to strengthen entrepreneurial activities and university-industry engagement (Westhead, 1997).

For universities, incubators and science parks can be important instruments to promote research commercialisation but it does require the formulation of clear objectives and strategies to achieve (Link & Scott, 2005). According to Etzkowitz and Leydesdorff (2000) these types of hybrid organisations are also important to assist in driving the system of innovation towards a Triple Helix, but they need to be modified and adapted on a continuous basis to accommodate the ever-changing entrepreneurial opportunities that arise in the space between universities and industry.

Social networks and venture capital markets

A key factor underlying research commercialisation is an effective network of relationships that stimulates knowledge sharing and inter-organisational learning (B-Å. Lundvall, 1992; Pittaway, Robertson, Munir, Denyer, & Neely, 2004). Within a network, the proximity of universities and firms in one location foster better coordination and trust (Löfsten & Lindelöf, 2005).

Myint et al. (2005) used a social network perspective to understand the success of and the growth behind the high-tech cluster surrounding Cambridge University. They found a high level of social capital in the cluster that arose from individual entrepreneurs who have been working together in other companies within the cluster over time. They identified a high level of structural capital from interlocking directorships involving venture capitalists, angel investors and members of the business and academic community. The cluster was a rich source of information of opportunities for strategic alliances, industry trends, government initiative and grants, laboratory space and new business opportunities. The study emphasised the importance of creating a rich and strong network to support the formation and growth of high-tech companies in general. Scholars have also found a positive relationship between venture capital available in the region and the rate of start-ups and commercial orientation of the university (Lockett & Wright, 2005). Access to venture capital affects the likelihood of survival for new start-ups based on university inventions (S. Shane & Stuart, 2002).

Nicolaou and Birley (2003a) showed the difference between support from a strong and weak network to support academic entrepreneurs (faculty staff starting a new venture based on university technology or know-how). If the network is strong, then the academic entrepreneur is more likely to

leave his or her university position to concentrate on developing the business. If the network is weak, then the academic entrepreneur is more likely to retain his or her position at the university and work part-time for the company. This could delay growth of the start-up as academic duties could take attention away from developing the business. This also implies that a strong network support can reduce the entrepreneurs perceived risk/return outcomes (Mustar, et al., 2006).

Universities that aim at becoming more entrepreneurial also need to support the development of the surrounding network, which may consist of experienced entrepreneurs, business mentors, technical experts, government agencies, angel investors and venture capitalists (Debackere & Veugelers, 2005). Especially universities can commit to establishing incubators and science parks to strengthen the physical infrastructure supporting such networks (Etzkowitz & Leydesdorff, 1995; Etzkowitz, et al., 2000; Monck, Porter, Quintas, Storey, & Wynarczyk, 1988; Phillip H. Phan, et al., 2005).

3.4 Chapter summary

The purpose of this chapter was to examine how the transformation of universities has affected the opportunities for small firms to engage in relationships with universities. The examination was conducted through a critical review of the literature on university and research commercialisation. The main findings from this review are summarised below followed by a discussion on how this chapter is intended to contribute to the overall purpose of this study.

Trends in research commercialisation at universities

The review concentrated on four main areas: (1) the ongoing transformation of universities; (2) incentive structures; (3) organisational capabilities and technology transfer offices; and (4) network and surrounding environment. These four areas and their main elements are illustrated in Figure 3-1.

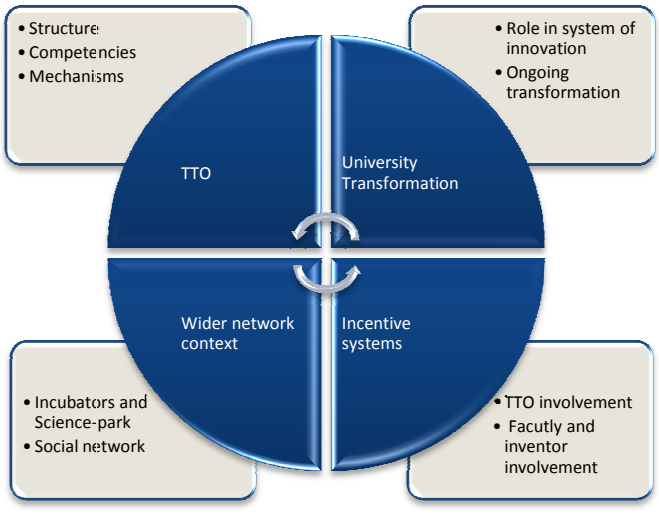

Figure 3-1: University and research commercialisation

Most national governments have increasingly stressed the importance of research commercialisation from universities to enhance national and regional economic growth including generating viable innovation and technologies to stimulate national competitiveness and drive social development (Godin & Gingras, 2000; Rosenberg & Nelson, 1994). Universities have undergone a transformation from being isolated in knowledge production towards becoming an integrated part of the system of innovation (Etzkowitz, 1998). This transformation is assumed to be ongoing as described in the newer perspective on knowledge production and distribution (Mode-2 knowledge production and the Triple Helix framework). This transformation is context dependent and is also influenced by factors external to the universities, i.e. government interventions and industrial initiatives. Universities can take up different roles in knowledge production and distribution depending on needs. Some universities might be orientated more towards research commercialisation than others. Some universities, or units within universities, might still be more orientated towards basic research over applied research and entrepreneurial activities.

The degree of orientation towards research commercialisation at universities is usually reflected in their organisational structure. Universities focusing more on research commercialisation often have established dedicated technology transfer offices, implemented incentive structures to promote research commercialisation among faculties and staff and established supporting structures in form of incubators, science-parks and social networks. It has been emphasised in this chapter that these organisational structures are relatively new to most universities. Universities themselves are undergoing an evolution requiring new capabilities and learning experiences to adapt to their new role in the innovation system.

The contribution of this chapter to the overall purpose of this study

This chapter contributes to the overall purpose of this study in two ways. Firstly, the opportunities for small firms to collaborate with universities are assumed to be affected by the orientation at universities towards research commercialisation. Universities that are more commercially orientated tend to have developed supporting organisational structures for industry interactions in the form of technology transfer capabilities, incentivised staff and infrastructure. Small firms that collaborate with non-commercially orientated universities might find resistance among university staff to engage in research commercialisation or lack of skills to support the transfer of knowledge and technologies to industrial firms in general. Under these circumstances the costs are assumed to be more likely to outweigh the benefit from collaborating with universities. Hence it is assumed in this study that the

degree of orientation towards research commercialisation at universities might help explain why some small firms are (or are not) collaborating with universities in the first place.

Secondly, competence development and learning becomes even more important for small firms as universities are constantly evolving. In this review of universities and research commercialisation it has been stated that universities also try to optimise their own outcome from engaging in research commercialisation. Research commercialisation is increasingly seen as a method for universities to increase revenue streams. Universities are increasingly experimenting and developing new practices to increase these revenue streams. This is different from when universities more or less were concentrating on producing knowledge as public goods. Small firms need to understand this ongoing transformation at universities and adjust their competences accordingly, e.g. within negotiating contracts and license agreements, securing intellectual property rights and finding alternative and cheaper ways to transfer knowledge and technologies from universities.

4 Small firms and innovation

The purpose of this chapter is to critically review literature on small firms and innovation to determine what small firms are and what makes them unique. The review shows that (1) small firms are fundamentally different from large firms and also take up a special role in the system of innovation; and (2) the variations among small firms are vast but can be sub-grouped according to their industry belongingness, resources endowments or growth stage. The contribution from this chapter to the overall purpose of this study is the identification of a number of dimensions that can be used to explain why some small firms pursue different strategies towards university relationships than others.

4.1 Introduction

Since the beginning of the 1980s the role of small firms for economic growth, job creation and competitive advantages in society has continued to grow (R. Rothwell, 1989). Today most economies are largely composed of small firms (Erkko Autio & Yli-Renko, 1998). As the importance of small firms and their contribution to innovation and the economy has continued to grow, there has been an increasing interest in these firms among research scholars and policy makers ever since (de Jong & Marsili, 2006; Hoffman, Pajero, Bessant, & Perren, 1998; Shaw, 1999). This chapter focuses on small firms and their innovation practices. Research shows that small firms are fundamentally different from large firms. At first, these fundamentally differences were treated as small firms being constrained as it was argued that small firms had limited resources compared to large firms' more abundant resource positions (Hoffman, et al., 1998; Schumpeter, 1934). More recent research, however, has argued that small firms are not directly comparable to large firms and do not necessarily strive to become large firms either (Erkko Autio & Yli-Renko, 1998). Small firms have different organisational features than large firms, which are reflected in how they operate and pursue innovation (Acs & Audretsch, 1988; Nooteboom, 1994). Hence it has been established that small firms need special attention and are not to be considered generically alongside large firms in research (R. Rothwell, 1989).

At the same time the diversity among small firms is in fact very high and often much higher than what is seen among large firms (de Jong & Marsili, 2006). This constitutes a challenge for researchers as it can be difficult to categorise all small firms under one single definition (Yehuda, 1997). Research shows that small firms and their innovation practices may vary across technological regimes (S. Winter, 1984) and industry sectors (Pavitt, 1984), resource and competence endowments (P. Almeida, Dokko, & Rosenkopf, 2003; Starbuck, 1992) and lifecycle and growth stages (Hite & Hesterly, 2001; Robert K. Kazanjian & Drazin, 1990). These various theoretical approaches classify small firms that share common traits into sub-groups.

The overall aim of this chapter is twofold: (1) describe the nature of small firms and (2) substantiate variations among small firms. The first part outlines the role of small firms in today's society and draws a comparison between small and large firms. The second part consists of three different approaches to categorise and label small firms. The first approach is based on Winter's (1984) technical regimes and Pavitt's (1984) sectoral patterns. The second approach is based on the resource-based view (Barney 1991) and dynamic capabilities (Teece, Pisano, & Shuen, 1997) from which it is argued that patterns in resource and capability constellations can form a basis for categorising small firms. The third approach is based on firm stage models (Churchill & Lewis, 1983; R. K. Kazanjian, 1988). These models divide a firm's life cycle into stages and advocate that small firms are facing different internal and external challenges throughout each stage. The chapter concludes with a summary.

4.2 The nature of small firms

Small firms and systems of innovation

The contribution of small firms to economic growth and technological changes has been a subject of debate amongst research scholars and policy makers for almost a century (Pavitt, 1984; R. Rothwell, 1989; Schumpeter, 1934). In his 'Mark I' hypothesis, Schumpeter (1934) argued that small firms, in particular entrepreneurial firms, operate as agents of creative destruction by introducing innovations to the market that made existing firms redundant. Although Schumpeter later on revised this view on the fate of existing firms in his 'Mark II' hypothesis (Schumpeter, 1942), the former view of entrepreneurial firms as agents of innovation has persisted (E. Autio, 1997; Etzkowitz, 1998; R. Rothwell, 1989).

Rothwell (1989) described how the attitude of the US government towards small firms changed during the 1950s with the passing of the Small Business Act of 1953. The Act declared the commitment of the US Government to aid, counsel, assist and protect as far as possible the interests of small firms to preserve free and competitive markets. This shift towards supporting small firms was based on a belief that small firms were more efficient innovators, employment creators and source of economic renewal than large firms (Acs & Audretsch, 1990). During the 1970s and 1980s more substantial statistical evidence started to materialise supporting small firms' contribution to the economy. Based on data from 5.6 million US firms, Birch (1979) discovered that most new jobs were created by small firms and large firms were no longer the major provider of new jobs in US. Brock and Evans (1989) found that between 1976 and 1986 the rate of new firm creations grew 87 percent and that these new firms' contribution to the gross domestic product continued to grow. Acs

and Audretsch (1987; 1988) reported that US small manufacturing firms accounted for about one-fifth of total sales in 1976 within the sector, but by 1986 this share had risen to over one-quarter. Later on evidence on the contribution of small firms also started to accumulate in Europe. Robson and Townsend (1984) found that the share of innovations from small firms in Britain increased from 22.6 per cent between 1965-69, to 38.3 per cent between 1980-1983. Based on data from different European countries, Schwalbach (1994) noted that the growth in small firms varied across countries but in general the share of small firms in numbers and sales had increased during the period of 1979-1986 in all countries.

Acs and Audretsch (1990) and Rothwell (1992) argued that the contribution of small firms to the economy has been even greater within the high technology sector than within the manufacturing. It was found that small firms played an important role in the emergence of new technological product groups such as semiconductors and computers (Dosi, 1984). While Tether (1998) found that it took 100 innovations from small firms to create the same value as seven innovations from large firms, he argued that small firms play a huge role in creating diversity in society. Small firms also play a huge role in regional economic development as exemplified by the creation of local industrial agglomerations like Silicon Valley and Route 128 (Saxenian, 1996). Motohashi (2005) showed that small firms in Japan serve as important agents in transforming the Japanese system of innovation, which to date had been dominated by large firms and closed innovation. Small firms were more likely to collaborate with universities around continuous innovation and technological advancements. Because small firms lack extensive R&D resources, they have strong incentives to tap into external resources. In contrast, large firms tended to conduct R&D internally with their adequate in-house resources. There are also several empirical examples on how small firms have sped up the transition towards Triple Helix. Hung and Chu (2006) showed that small firms in Taiwan, especially new ones, played an important role in transforming emerging industries into new industries while the government provided funding, incentives and regulations to support innovation and cooperative R&D between public and private organisations.

Small versus large firms

The unique characteristics of resource constellations and capabilities of small firms have often been identified by a direct comparison of those of large firms (Almor & Hashai, 2004; Bommer & Jalajas, 2004; Pavitt, 1984). In industries characterised by rapid technological progress and high competition, small firms are usually described as outperforming large firms when it comes to the degree of specialisation (E. Autio, 1997), innovation speed (Heirman & Clarysse, 2007), ability to identify and exploit new entrepreneurial opportunities (Schumpeter, 1934) and ability to react and adapt quickly

to fast changing market conditions and internal needs (R. Rothwell & Dogson, 1991). The advantages of small firms have been described as coming down to a number of factors:

- **Organisational flexibility** – The notion of organisational flexibility has received particular attention among research scholars on small firms. Small firms often have less organisational bureaucracy and more informal communication, which has been found to shorten decision making and reaction time (Bougrain & Haudeville, 2002). Bougrain and Haudeville (2002) described the innovation activities in small and medium sized enterprises (SMEs) as not as formal and organised as large firms, which also led to faster reaction time towards external changes. Nooteboom (1994) noted that the most important characteristic of small firms is its diversity, which is created due to a lesser compulsion from outside to conform with existing norms and practises and a variety of internal motives and goals of the founder.

- **Informal communication** has been found to promote and facilitate innovation by speeding up decision making in small firms (Hadjimanolis, 2000). Bommer and Jalajas (2004) found that many creative ideas surface as the result of informal communication between staff, suppliers and customers. Informal communication is more common in small firms because it requires openness and trust rather than contractual arrangements and bureaucratic decision making. It has also been noted that informal communication lowers control and coordination problems, hence, lowers cost of innovation (Hadjimanolis, 2000).

- **Risk taking** – Several scholars have also noted that small firms tend to be more risk averse than large firms (Mitchell & Singh, 1993). However, some scholars have modified this perspective by arguing that small firms are not risk averse per se, but accepting risk as part of being a new venture operating with highly uncertain technologies and markets (Nooteboom, 1994). To be able to compete against established firms, taking risk is a pre-condition (Hadjimanolis, 2000). It has also been found that when small firms fail, they do so efficiently without too much delay because they only have a restricted scope and limited assets to dispose of (Nooteboom, 1994).

- **Niche marked orientation** – Small firms are also often described as concentrating on niche markets that are less attractive to larger firms (Hicks & Hegde, 2005). This creates opportunities for small firms to introduce new products and services in unexplored fields, which may in turn provide them with a first-mover advantage and less competition from existing firms (Hadjimanolis, 2000). As part of a niche-market strategy, small firms often work closely with customers to customise products and services, which gives small firms an edge over scale and

scope-based large firm (Allocca & Kessler, 2006). This is even more important today as it has been argued that the demand structure of society has moved away from mass produced products and services towards high quality individualised products (Pine, 1993).

Small firms were also more likely to be involved in product and service innovation rather than process innovation (de Jong & Marsili, 2006). Hicks and Hedge (2005) argued that small firms spend relatively more of their innovation capacity developing products new to the market compared to large innovative firms. Large innovative firms dedicate a higher share of their R&D capacity to develop specific technologies to use in internal processes.

Disadvantage of being small and inferior capabilities

In contrast to the above mentioned advantages, small firms are often described to be disadvantaged compared to large firms when it comes to personal and financial resources for R&D and inability to attain economies of scale (P. Almeida, et al., 2003; Bommer & Jalajas, 2004). Almor and Hashai (2004) refer to these disadvantages as inferior capabilities. A firm might have superior capabilities while others might be comparatively inferior. Inferior capabilities might neutralise the value of superior capabilities; for example a firm might have superior R&D capabilities but inferior marketing capabilities. Especially this problem has been pointed out in research on new ventures established by academics that have superior research skills but lack business development skills (Clarysse, Wright, Lockett, Mustar, & Knockhaert, 2007; Colombo & Piva, 2008).

Research shows that small firms can compensate inferior capabilities though externalisation, but only when those inferior capabilities are non-core to the firm (Almor & Hashai, 2004). If the inferior capabilities are core to the firm, the firm needs to find methods on how these capabilities can be internalised either through capability building or external acquisition (Pursey & Heugens, 2003). But none of these two methods are perfect as capabilities evolve over time and can be difficult if not impossible to transfer from one context to the other (Cavusgil, Calantone, & Zhao, 2003; Helfat & Peteraf, 2003). Almor and Hashai (2004) found that small firms often had inferior marketing capabilities which limited their opportunities to engage with customers and generate revenue. They found that small firms tended to solve this problem by internalising marketing activities by only focusing on small niche markets or organisational customers (in contrast to mass consumer markets), thereby avoiding having to build extensive distribution networks, brands and service infrastructure. Small firms also had inferior production capabilities, but these often appeared non-core to the firm and therefore were often outsourced. This study indicates that small firms often develop and implement strategies that circumvent disadvantages of being small rather than necessarily trying to

replicate those of large firms. In fact small firms are usually portrayed in the literature as a distinct group of firms that do not necessarily strive to become large, but continue to succeed because they specialise in becoming leaders within a narrow technological field by using their organisational flexibility to adapt quickly to changing market needs (Acs & Audretsch, 1990; E. Autio, 1997; R. Rothwell, 1989). Research also shows that small and large firms often play complementary roles along the life cycles of products or technical regimes (Nooteboom, 1994). Large firms are relatively strong in more fundamental innovations and efficient production and distributions, which exploit scale and scope. Small firms are more focused towards application of basic technologies and tend to implement and introduce new products and services to niche markets (Nooteboom, 1994).

In summary, studies contrasting innovation practises in small and large firms have been elementary in defining the unique nature of small firms. Small firms usually rely more on flexible organisational structures, which allow them to take advantage of new technological opportunities faster and react quicker to changing market needs than large firms. Small firms often serve niche markets or few organisational customers and outsource production activities. These strategic choices are made by small firms to circumvent inferior capabilities.

4.3 Diversity among small firms

This section examines three theoretical approaches that explain factors influencing the formulation and implementation of strategies in small firms. It is argued that small firms vary substantially across the industry they belong to, in terms of their resource positions and stages of development. Understanding variation across small firms is important in research on small firms as it is expected that the opportunities and constraints for collaboration with universities can be explained partly by the unique characteristics surrounding each individual small firm (A. C. Cooper, 1981). At least researchers on this topic need to take individual firm characteristics into consideration when analysing and concluding on why some small firms behave differently from others.

4.3.1 *A sectoral taxonomy of small firms*

Nelson and Winter (R. R. Nelson & Winter, 1977) argued that the innovation patterns of a firm is shaped and constrained by technological regimes, which is defined by the common properties that dominate innovative processes and activities within a distinctive technological field. Technological regimes are understood to evolve over time determining the directions and natural trajectories of technological opportunities and the conditions for appropriating the economic rents from innovation (Dosi, 1984). Therefore it was argued that firms within the same technological regime would most

likely exhibit similar patterns of innovation behaviour (Dosi, 1984; R. R. Nelson & Winter, 1977; Pavitt, 1984).

Pavitt's taxonomy

The idea of a technological regime was inspirational to Pavitt's taxonomy of innovative firms (Pavitt, 1984). Based on data from about 2,000 significant innovations in Britain since 1945, Pavitt (1984) identified four distinctive categories of innovative firms: (1) scale intensive, (2) supplier-dominated, (3) specialised suppliers and (4) science-based firms. These categories were based on differences in sources, nature, appropriability and intensity and direction of technological change across industry sectors.

Table 4-1: Pavitt's (1984) taxonomy of innovative firms

	Sources of innovation	Nature of innovation	Means of appropriation	Intensity and directions of technological change	Typical industry sector
Supplier-dominated	Suppliers	Process	Aesthetic design Trademarks Marketing	Low vertical	Agriculture Textiles Printing and publishing
	Supplier-dominated firms exist in more traditional industry sectors, i.e. agriculture and textile. Technological change is often initiated through suppliers of machinery and equipment as internal R&D and competences often are very weak. Technological changes in supplier-dominated firms are most likely being directed towards processes in production. However, technological changes only play secondary roles in supplier-dominated firms with a higher proportion of profit being generated from trademarks and design and marketing related activities.				
Scale-intensive	Engineers	Process	Process technology Know-how Patents	High vertical	Bulk materials Assembly
	Scale-intensive firms use innovation to achieve higher productivity and economies of scale. The most important source of innovation is internal engineers, whose main task is to build and operate large-scale assembly systems in order to produce a final product at the lowest cost. Large firms devote more of their R&D effort to process innovation to cut cost in production because such strategy is more economically rewarding. Technological leads are maintained through technical know-how, patents protections and through inevitable lags in imitation.				
Specialised suppliers	Users	Product	Design know-how Knowledge of users Patents	Low concentric	Machinery Instruments
	Specialised-suppliers are often smaller technology and machinery firms that work closely with end users or customers around technological changes. The focus of specialised-suppliers is often to design and construct specialised machinery or technology to be integrated into the customer's production processes. The strength of specialised-suppliers lies within specialised knowledge and experience gained from designing and building technical solutions for a variety of users often spread across a number of industries (low concentric).				
Science-based	Internal R&D Universities	Mixed	R&D know-how Patents Dynamic learning	Low vertical or High concentric	Electronics Electrical Chemicals
	Science-based firms are often found in electrical, electronic and chemical sectors. The main sources of innovation for science-based firms are in-house R&D departments, universities and other public and private R&D units. They are involved in both product and process innovation that is diffused to both related and unrelated industry sectors (low vertical and high concentric). For example, the invention of semi-conductors have led to the development of its own industry but also enabled process and product innovation in unrelated industries such as automobiles, robotics and service-orientated firms. Science-based firms appropriate their innovation leads mainly through R&D know-how and patent protections but also in their ability to learn fast.				

Pavitt's study emphasised that distinctive patterns of innovation exist across sectors. Supplier-dominated firms tend to have fewer in-house capabilities and technological changes are initiated through suppliers of machineries and equipment. Scale-intensive firms mainly use innovation to improve productivity and economies of scale with their main source of innovation deriving from engineers. Specialised suppliers design and construct machinery and technologies closely with the end-user. They rely on specialised knowledge and experience gained from the process of tailor-making solutions to a variety of customers. Science-based firms are concentrated on more fundamental innovations. They rely on in-house R&D skills and the ability to learn fast. These taxonomies have been inspirational to a number of studies. Hauknes and Knell (2009) found that specialised-suppliers and scale-intensive firms were essential for the production, diffusion and use of technology. Science-based firms appear to function as a kind of mediator between industry groups. They found strong evidence that technology flows from high-tech sectors into low-tech sectors. In contrast only little evidence suggested that low-tech sectors had any impact on knowledge production in high-tech sectors. This suggests a hierarchical order in knowledge production.

Pavitt's taxonomy also provided strong evidence for the importance of vertical linkages for innovation, i.e. the different set of relationships innovative firms have with organisations from other sectors of the economy. Castellacci (2008) stressed the importance of inter-sectoral knowledge exchanges between interrelated sectors in society using Pavitts taxonomy. He found that knowledge-intensive sectors are in fact those that drive innovation in society and generate knowledge spill-over effects to less knowledge-intensive sectors. This also corresponds with the systematic nature of innovation in which attention is on interactions and exchanges involving producers, suppliers and users of new knowledge (Kline & Rosenberg, 1986; B-Å. Lundvall, 1992). These vertical linkages represent one major factor of competitive advantage of nations (Porter, 1990) and firms (Gulati, Nohria, & Zaheer, 2000).

Despite the strong impact of Pavitt's work in other innovation studies, scholars have often questioned the validity of his taxonomy because of the sectoral composition of the firm categories (Archibugi, 2001; Evangelista, 2000). It has been pointed out that that new sectors have emerged that do not fit into any of the four existing categories or that existing categories have changed over time and have followed their own distinctive patterns of technological change (I. Miles, 1993). For example, Evangelista (2000) and Bogliacino and Pianta (2010) found that service-based firms did not fit into supplier-dominated firms nor specialised suppliers, but should be categorised as a distinctive firth category. Others argued that service-based firms cannot easily be differentiated from those already existing categories and therefore it might be more appropriate to bundle manufacturing and

services into one category (Archibugi, 2001). Especially de Jong and Marsili's (2006) study of small firms showed that manufacturing and services shared similar characteristics in the process of innovation such as interaction with suppliers and innovation intensity, hence need to be considered as one category.

Small firms and industry taxonomy

A second point of criticism of the Pavit's taxonomy relates to his unit of analysis being the firm but the empirical data being collected is on industry level (Archibugi, 2001). It is argued that industry data cannot explain intra-industry diversity of innovation across firms. De Jong and Marsili (2006) even went further arguing that firm size has stronger explanatory effect on innovation practices in firms than specific industry characteristics. In the same paper, the authors also point out that small firms are underrepresented in Pavitt's study with a majority of firms being large firms with more than 10,000 employees and small firms being defined as having less than 1,000 employees. De Jong and Marsili (2006) replicated Pavitt's study on 1,234 small firms (less than 100 employees) in the Netherlands. Based on the same taxonomies as Pavitt, they found that out of 1,234 small firms, 26% were categorised as science-based and were found across more varied industries than in Pavitt' study. The lowest number of small firms was found in construction (11%) and the highest in communication and medical instruments (38%), economic services (41%) and engineering and architecture (41%). Baruch (1997) also found in a study of high-tech firms that these firms increasingly appeared in other sectors other than those normally referred to such as electronics, computers and IT – an indication that innovation is and is becoming more widespread among small firms than first argued by Pavitt. Based on data from Denmark and Finland, Leiponen and Drejer (2007) found that homogenous sectors were challenged as most firms within sectors were pursuing niche strategies that required a unique set of capabilities and relationships to pursue.

On the other hand, some studies have found that certain patterns of innovation are very unique to certain industry sectors. For example, several scholars have found that commercialisation among biotech firms is very distinct. Rothaermel and Deeds (2004) described biotech firms as intermediaries taking on a dual role of knowledge transformation and commercialisation. Firstly biotech firms transform basic research from universities into new products and services. Secondly biotech firms then commercialise these products conjointly with established pharmaceutical firms. McMillan et al. (2000) found that biotech firms are dependent more than any other industry group on basic research from universities based on citations from academic journal papers in their patents. Several scholars also noted that the biotech industry takes a longer time on average to commercialise a product compared to other high-tech sectors (Al-Laham & Souitaris, 2008; Joel A. C. Baum, et al., 2000).

In the software industry, Lakhani and von Hippel (2003) and West and Gallagher (2006) found an increasing number of firms practising open source innovation. Open source is seen as unique feature within parts of the software industry where firms lose their control of source code to inspire user-innovation (Joel West & Gallagher, 2006). As a consequence of open source, several scholars have observed unique innovation practices within the software industry where geographically scattered programmers and individuals collaborate to develop software using mainly virtual channels to communicate (Grand, von Krogh, Leonard, & Swap, 2004).

In summary, taxonomies can appropriately be extended to map differences in innovation practices across sectors. Pavitts taxonomy has been inspirational to numerous studies that have extended the general understanding on how sectors are operating, inter-relating and contributing to the economy in general. However, more recent studies also showed that innovation patterns in small firms or niche-orientated firms are more diverse than generally believed by Pavitt, but still the idea of industry aggregation is not completely rejected (e.g. de Jong & Marsili, 2006; Evangelista, 2000; Leiponen & Drejer, 2007). Industries become segmented but do not disappear and therefore still need to be accounted for in research on small firms and innovation (de Jong & Marsili, 2006).

4.3.2 *Resource and capabilities of small firms*

Unique resources and competitive advantage

In the previous section it was established that differences in innovation practices across small firms can be observed across industry sectors. In this section another approach on how to categorise small firms will be presented. Prior research has documented the appropriability of the resource-based view (RBV) to understand patterns of innovation across small firms (Branzei & Vertinsky, 2006; Crossan & Berdrow, 2003; Frank T. Rothaermel & Deeds, 2005). According to the resource-based view, a firm's competitive advantage may be best explained by the heterogeneity of firm specific resources and capabilities and their application rather than by optimisation of production functions (Barney 1991; Peteraf, 1993). A firm consists of inter-connected tangible and intangible resources that create organisational capabilities. Miller and Shamsie (1996) differentiate between property-based and knowledge-based resources. The latter one is of greater utility in uncertain and unpredictable environment as they allow the organisation to respond and adapt quickly to new challenges internally or externally through capability building. An organisational capability refers to the ability of a firm to undertake a value creating activity or process (Teece, et al., 1997). Unique organisational capabilities enable a firm to gain higher rents than competing firms (Peteraf, 1993). Capabilities change over time through a learning process and become tacit and specific to the firm (Eisenhardt & Martin, 2000). Therefore, firm's endowment of capabilities are not similar; and once

they are built they provide the firm with a competitive advantage (S. G. Winter, 2003). Variance in capabilities stems from firms' accumulated experiences as prior choices support the development of distinct paths from which new capabilities are expected to progress (Macpherson, Jones, Zhang, & Wilson, 2003; Teece, et al., 1997; Zander & Kogut, 1995).

Critical resources and competences of small firms

Capabilities of small firms are many and diverse, e.g. adaptability (Nooteboom, 1994), entrepreneurial orientation (Walter, Auer, & Ritter, 2006), human resource management (K. Laursen & Foss, 2003), new product development (Branzei & Vertinsky, 2006) and risk management (Mitchell & Singh, 1993), just to mention a few. However, for small firms involved with innovation it has been pointed out that the essential part of their competitive strategy comes down to how well they acquire new knowledge to stay ahead of competitors (Joel A. C. Baum, et al., 2000; R. M. Grant, 1996; Inkpen, 2000).

Proprietary knowledge constitutes a distinctive resource on which the firm's profit earning potential is developed (R. M. Grant, 1996; Robert M. Grant & Baden-Fuller, 2004). Firms with proprietary knowledge will normally enjoy first-mover and monopolistic advantages leading to higher entry barriers (Wernerfelt, 1984). For a firm that wishes to establish and maintain competitive advantages based on knowledge must create and acquire new knowledge continuously (W. M. Cohen & Levinthal, 1990). Firms may obtain knowledge through a variety of sources both within (e.g. training, education, experiments, imitation) and outside of the firm (e.g. external partners, internet, journals) (Bommer & Jalajas, 2004). But in today's innovation landscape, firms are increasingly finding internal knowledge production insufficient, which require most firms to look for new knowledge outside of the boundaries of the firm to ensure continued competitiveness and survival (H. Chesbrough, 2003; W. M. Cohen & Levinthal, 1990; R. M. Grant, 1996; Norman, 2004; Simonin, 1999). This is even more so for resource restricted small firms that do not posses sufficient in-house R&D capacity to generate enough knowledge to stay competitive (Hyder & Abraha, 2004).

Nonaka and Konno (1998) described knowledge management as a continuous process through which the boundaries between self and others transcend. Knowledge management is in principle related to generation of new knowledge but essentially new knowledge is created mainly through stages of learning, knowledge acquisition and sharing (Huber, 1991; Kline & Rosenberg, 1986; Norman, 2004). Cohen and Levinthal (1990) pointed out that a firm's ability to learn, acquire and share knowledge depends on its absorptive capacity.

Absorptive capacity

Absorptive capacity is defined as a limit to the rate or quantity of knowledge a firm can absorb (W. M. Cohen & Levinthal, 1990). The process of absorbing new knowledge goes through three stages: (1) recognition of knowledge through exploratory learning, (2) assimilation of knowledge through transformative learning and (3) deployment of assimilated knowledge through exploitative learning (W. M. Cohen & Levinthal, 1990; P. J. Lane, Koka, & Pathak, 2006). Cohen and Levinthal (1990) stressed that firms cannot benefit from new knowledge merely through exposure. Instead, firms must develop the ability to recognise the value of new knowledge. Assimilation capabilities are required to use new knowledge to improve the firms' existing routines, skills and know-how (Rosenkopf & Nerkar, 2001). Lastly, deployment of assimilated knowledge through exploitative learning reflects the firms' ability to effectively apply improved routines, skills and know-how to innovation activities (P. J. Lane, et al., 2006).

Several scholars have argued that learning capabilities are not equally distributed across firms. Especially small firms may be at a disadvantage over large firms because the resources required to recognise, assimilate and deploy external knowledge can be extensive (Peter J. Lane, Salk, & Lyles, 2001). Also across small firms, variation in absorptive capacity has been reported to exist based on a number of factors:

- **Competitive strategy** – The process of deploying assimilated knowledge is said to depend on the firm's competitive strategy. Knowledge that is relevant to solve immediate problems faced by the firm in a given context is more likely to be deployed compared to knowledge that is not supporting the existing strategy of the firm (Peter J. Lane & Lubatkin, 1998).

- **Flexibility** allows for new knowledge to be integrated into the firm even though it may cause existing routines and structure to be eliminated. It was also found that assimilations of external knowledge was stronger in those firms that had established explicit goals and plans for what knowledge was to be transferred from the external source (Lyles & Salk, 1996).

- **Receptiveness** – The firm needs to be receptive to learning from external sources. Receptiveness requires the firm to be open, as opposed to hostile, to new knowledge as a requirement for developing new capabilities (Inkpen, 2000; Nonaka, 1994). Openness is found to be more likely to exists in firms that in general have flexibility in organisational structures (Lyles & Salk, 1996).

- **Founder** – Studies have found that the success of small firms often comes down to skills of the founder**.** Boungrain and Haudeville (2002) noted that the education level of the founder influences the scope of the external network. Higher educated founders tended to rely more on relationships with external research organisations. Several studies have found that founders of small firms often have extensive technical skills earned through formal training and education at universities (Klofsten, 2005). Studies of entrepreneurial firms often points out that founder team are of significant importance for the time of introducing the first product to the market (Heirman & Clarysse, 2007). A founder team who previously worked together leads to better coordination processes and development of team-based competences. Another study also found that, employing people who previously have been working together has positive effect on innovation speed rather than employing experienced but unrelated individuals to the firm (Heirman & Clarysse, 2007). Yet, research also shows that firms that only employ new staff with similar background and knowledge base cause knowledge inbreeding, which inhibits learning new skills and competences (Hansen, et al., 2001).

- **Prior experiences** – Cumulative or related experience in a given knowledge field pre-determines the level of familiarity and thus eases transferability of knowledge from external sources (Tsai, 2000; Zander & Kogut, 1995). Prior experiences have also been referred to as causing variation among small firms to learn through external partners (Inkpen, 2000; Zollo, Reuer, & Singh, 2002). The accumulation of prior experiences is often described as a learning-by-doing process that takes time and can result in mistakes (Dierickx & Cool, 1989). It can be very costly for small firms to invest in learning-by-doing. Huber (1991) showed that learning-by-doing does not always lead to improved performance as firms can learn incorrectly. It has been argued that mistakes from learning-by-doing are disproportionately more expensive to small firms than to large innovative firms (Lu & Beamish, 2001). Small firms should reduce the risk of learning incorrectly by observing best practices in other firms, e.g. through collaboration.

- **Start-up size** – Even among small firms, Almeida et al. (2003) found that start-up size determined the firm's ability to learn through external partners. Almeida et al. (2003) found that learning through external partners was dependent on establishing intra-organisational mechanisms, processes and systems to allow for more interaction between those who had access to external knowledge and those within the organisation that could benefit from this knowledge. Larger start-ups were more likely to possess these characteristics (in their study defined as firms with more than 133 employees).

- **Scale and scope of external linkages** – Greater efforts to search, identify and select relevant knowledge from external sources, widen the scale and scope in external connections and higher frequency and speed of learning increases the likelihood of recognising new external knowledge (Zander & Kogut, 1995).

Relationship capabilities

Several scholars see the relationship capabilities of small firms to be a corner stone of their competitive strategy (Clarke & Turner, 2004; Dowling & Helm, 2006). Having access to a large resource-full network has showed to reduce financial constraints in the form of cost sharing (Williamson, 1991), higher rate of new product development (Frank T. Rothaermel & Deeds, 2005), faster innovation speed (Heirman & Clarysse, 2007), increased venture capitalists investment (J. A. C. Baum & Silverman, 2004) and increased learning and absorptive capacity (Peter J. Lane, et al., 2001). Together, these studies suggest that the ability of small firms to build, maintain and use a network is critical (Anand & Khanna, 2000; Lorenzoni & Lipparini, 1999). Yet, managing relationships is not without costs. These costs relate to resources (time, effort, financially etc.) that the firm needs to allocate to establish and develop relationships with external partners (Williamson, 1991). A firm needs to make decisions about how scarce resources are allocated between establishing new relationships and developing existing relationships (Ritter & Gemunden, 2003). Difficulties also occur due to the complexities and uncertainties inherent in managing innovative projects across firm boundaries (Boateng & Glaister, 2002; T. K. Das & Teng, 2000a). Therefore, the management of relationships and networks are a critical task in order to achieve competitive advantage for a firm (Ritter & Gemunden, 2003).

Relationship and network tasks refer to activities related to establishing and developing single or multiple relationships (Frank T. Rothaermel & Deeds, 2005). Inter-organisational relationships do not start on their own, but are the result of specific investments into organising and coordinating these constellations (Ritter & Gemunden, 2003). Kale et al. (2002) identified five components of relationship capabilities: (1) planning, (2) selection, (3) negotiation, (4) management and (5) termination. These components were developed through studies of best practices in 78 well established firms in industries normally high on inter-firm collaboration.

Table 4-2: Relationship capabilities; adapted from Kale et al. (2002) p. 763

Planning	Selection	Negotiation	Management	Termination
• Value chain analysis • Needs analysis	• Partner screening • Cultural fit evaluation	• Assessment of needs and wants • Contracting	• Trust building • Communication	• Evaluation • Yearly status reporting • Termination

Kale et al. (2002) and Ritter and Gemunden (2003) argued that relationship capabilities are required from each stage of the relationship life cycle from early planning to termination. The approach to establish and develop relationships is somewhat very similar to the approaches of Das and Teng (2000b) and Parkhe (1993), who also divided relationship capabilities into different categories depending on the stage of the relationship.

As with any other capability, relationship capabilities are developed over time through accumulation of experiences through repeated engagements in relationships and networks (Frank T. Rothaermel & Deeds, 2005; Teece, et al., 1997). Reuer et al. (2002) and Zollo et al. (2002) divide experiences into prior partner and prior relationships experiences. The partner with prior relationships might have developed routines and standard operating procedures specific to the existing relationships, which might further enhance the quality of the relationships and lower coordination and set-up costs (Pangarkar, 2003; Zollo, et al., 2002). Nielsen (2002) found that positive prior partner experience led to willingness to invest further in developing the relationship.

Even if partners have not had any prior experiences collaborating together, they might have learned from managing other relationships. Prior relationship experience allowed firms to design and establish new relationships more effectively (Reuer, et al., 2002). Anand and Khanna (2000) also found a positive correlation between prior relationship experience and the ability to create value through relationships. Yet, Pangarkar (2003) and Khanna et al. (1998) argued that if only one partner is experienced it might lead to a risk of opportunist behaviour or early termination. An experienced firm may be able to learn 'faster' than the inexperienced firms and discontinue the relationships when there is no further need for it.

A firm's relationship capabilities are path dependent and as such are constrained by the firm's prior partner and relationship experience. This puts pressure on firms to assimilate and deploy knowledge from prior experiences to future relationship activities in similar ways as described under learning capabilities. Kale et al. (2002) recommended that firms create a dedicated relationship function that coordinates all relationship and network related activities. This allows for more systematic processes to teach, share and leverage prior experiences throughout the firm (Dyer, Kale, & Singh, 2001). Yet, as pointed out by Rothaermel and Deeds (2005) it is not likely that small firms can afford such luxury to have a dedicated relationship unit due to their resource constraint. In the next section, this problem will be discussed further.

As small firms usually do not have extensive experience with working with external partners, the literature suggests that it is even more important for these firms to formulate strategies for how to gain their first experiences (P. Almeida, et al., 2003; Lu & Beamish, 2001). Several scholars argue that the learning curve from collaborating with external partners is curvilinear but flattens as more experiences are gained (Draulans, deMan, & Volberda, 2003).

It is obvious that mapping all influential resources and capabilities of small firms is an enormous and almost impossible task. Yet, the method of mapping patterns in resource and capability constellations among small firms has been applied frequently in the literature to label groups of small firms; for example Bougrain and Haudeville (2002) found that internal research capacities could differentiate between successful and less successful innovative firms. Baruch (1997) differentiates high-tech firms from conventional firms by (a) existence of internal research and development as a significant share of operations; (b) proportion of academic and professional staff; and (c) the novelty of the technology. The author argues that high-tech firms are not determined by industry codes, but should be defined through pre-determined criteria.

What is important when labelling and categorising small firms according to the Resource-based view (RBV) and dynamic capability perspective is that their unique constellations of resources and capabilities can explain firm specific strategies and behaviour. Thus it is necessary to at least make an effort to understand if variations in resource and capability constellations can explain variations among small firms when it comes to collaborating with universities. For this purpose the RBV and dynamic capability perspective provides an alternative approach compared to industry taxonomy to categorise small firms and understand variations in strategies and behaviours among these firms.

4.3.3 *Firm stage models*

Growth related strategic and managerial challenges of small firms have been a popular topic in the literature for decades (Doutriaux, 1987; R. K. Kazanjian, 1988; McAdam & McAdam, 2008; Quinn & Cameron, 1983; Zhai, Shi, & Gregory, 2007). The main motivation behind these studies is that a better understanding of growth patterns of small firms will improve the power of management theories and ultimately advance the performance of these firms. In this study it is also argued that growth patterns of small firms may affect the course whereby they seek to collaborate with universities. Especially it is argued in here that small firms face different challenges as they grow organisationally or as their technologies mature. The aim of this section is to identify firm factors related to growth that may affect the course of small firms' strategy of collaborating with universities.

Life cycle models

Traditionally, the growth of new ventures has been described in various life cycle models (Churchill & Lewis, 1983; Quinn & Cameron, 1983). Life cycle models suggest that environmental, information needs and organisational structure are critical for the development of the firm (Robert K. Kazanjian & Drazin, 1990; Koberg, Uhlenbruck, & Sarason, 1996). It is suggested that a consistent pattern of development seems to occur in new ventures over time. Yet, the problem in the existing literature is that different scholars have emphasised somewhat unique sets of characteristics and life cycle models of small firms.

Traditional life cycle models pictured the growth of small firms as a curvilinear pattern that eventually flattens or declines over time, but not before the firms have been through the cycle of early development, late development, growth, maturity and saturation. Within this view, growth is measured in revenue or organisational size (Doutriaux, 1987). Yet, it has been found that the life cycle models describes only in very few situations how firms actually do grow (R. K. Kazanjian, 1988). For example it is well known today that a large proportion of new innovative firms do not survive their first year or many small firms do not strive to become large innovative firms (Doutriaux, 1987; R. K. Kazanjian, 1988; Robert K. Kazanjian & Drazin, 1990). Empirical evidence suggests that most small high-tech firms become profitable based on high specialisation rather than organisational growth (E. Autio, 1997; Erkko Autio & Yli-Renko, 1998). They often serve smaller niche markets or are subject to acquisition before they have even completed their first sale. Therefore, small firms do not necessarily aspire to become large over time (Hicks & Hegde, 2005).

Other scholars also found that new firms are not facing the same starting point. For example, Heirman and Clarysse (2007) analysed the innovation process in new small firms and found that they had different starting point for new product development. 43 percent started up from scratch with only a vague product idea, 25 percent of firms were founded on proof of concept, 12 percent had a beta prototype at founding and 20 percent of the firms had an almost market ready product. These differences had a great impact on innovation speed and the time to first product launch. Yet, firms founded with beta prototype or almost market ready products did not always manage to launch their first product faster than the other groups of firms. The reason is that a prototype that did not meet customer demands caused serious delays in redesigning and building up market intelligence.

Despite the criticism of the life cycle theory to picture firm growth, it is still acknowledged that firms do progress over time but perhaps not in pre-determined successive phases (Koberg, et al., 1996). Rather life cycle models have been replaced by stage growth models that do not necessarily assume

that firms need to go through all stages to succeed, but that each stage is characterised by distinct internal and external challenges (Robert K. Kazanjian & Drazin, 1990).

Stage growth models

While the traditional life cycle model has clear limitations in terms of describing the growth of all small firms, the view is still useful in framing different stages that a small firm may face (Hite & Hesterly, 2001). Yet, the key point addressed in more recognised growth models is that each stage represents a proxy for strategic challenges that need to be solved before the firm can move on to the next stage (R. K. Kazanjian, 1988; Koberg, et al., 1996). There are several examples of stage models in the literature. Katz and Kahn (1978) describe three stages beginning with a stage where an emerging problem is identified and primitive production structures are identified. At stage two the organisation starts to form and becomes the basis for managerial tasks. At stage three the organisation evolves and structures become more obvious. Koberg et al. (1996) defined growth in new technology-driven firms to go through two distinct stages of early and late development. Based on a review of nine stage models from various authors, Quinn and Cameron developed a stage model consisting of four distinct stages as illustrated in Figure 4-1.

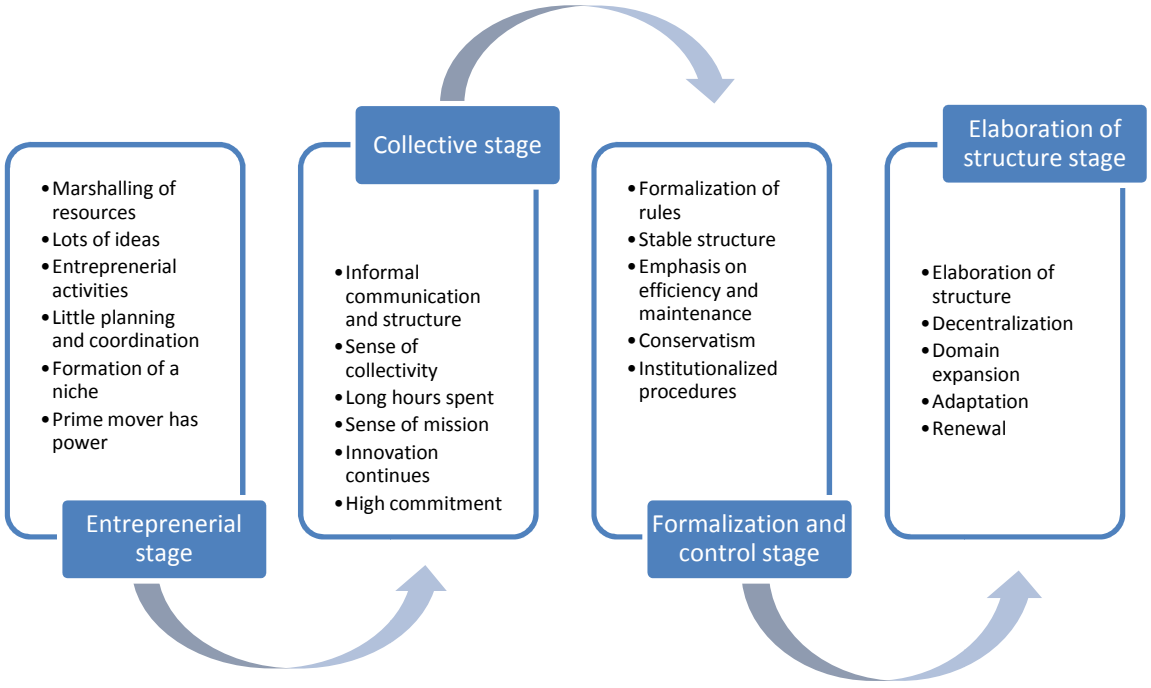

Figure 4-1: Stage model; adapted from Quinn and Cameron (1983, p. 35)

The logic in stage models is that organisational structure and challenges in one stage are not the same as the structure and challenges occurring in another stage. In Quinn and Cameron's model the

entrepreneurial stage is dominated by innovation, creativity and marshalling of resources to actually be able to get the firm off the ground. The organisational structure is emerging but remains highly flexible and readiness to act on new internal or external stimulus is prioritised. A major challenge is turning an idea into a real business (R. K. Kazanjian & Drazin, 1989).

During the collective stage, a more coherent strategy for the firm is formulated. The firm focuses on assembling a new product development team in which informal communication and work routines start to appear (R. K. Kazanjian & Drazin, 1989). Innovation focus is on turning initial ideas into prototypes (Koberg, et al., 1996). Relationships with external partners are more or less formulated through the owner/partner's personal network where work is contracted out or people are appointed to sit on advisory boards (Hite & Hesterly, 2001; R. K. Kazanjian & Drazin, 1989). Major challenges relate to developing prototypes and identifying and attracting competences to the firm.

In the formalisation and control stage, the firm begins to build more stable structures and routines to improve productivity and efficiency. An organisational hierarchy starts to emerge with focus on more professional and trained personnel. Innovation becomes more focused on refinements and preparations for production (R. K. Kazanjian & Drazin, 1989). Relationships with external partners become more institutionalised and incorporated in the competitive strategy of the firm (Hite & Hesterly, 2001). Major challenges relate to formalising internal organisational structure and external relationships and improve productivity and efficiency.

Finally, in the elaboration of structure stage, the firm has become more established in the market and may even be a technological leader within a smaller niche marked (E. Autio, 1997). They work on continuing expanding within that field or try in other ways to apply their technology to new domains. This involves both exploring new technological and market opportunities as well as continuing improving existing technologies and serve existing markets (Koberg, et al., 1996). The organisational structure is stable and executive managers and board of directors have replaced the owner as decision makers (R. K. Kazanjian & Drazin, 1989). Major challenges are related to developing a second generation of technology while maintaining growth momentum and market position.

Even today, stage models are frequently used to analyse evolutionary aspects of new ventures and high-tech firms in particular. Zhai et al. (2007) used a stage models to illustrate a relationship between firm growth and capability development in electronic manufacturing service firms. They identified four different patterns of capability development during firm growth: penetration, accumulation, evolution and adaptation. Another recent paper studied how the use of incubator's

resources changed throughout different stages of high-tech start-ups (McAdam & McAdam, 2008). The authors found that new high-tech firms' valued the credibility given to the firm based on being invited into the incubator. But as the firms matured, the creditability became a problem as being associated with an incubator was tied into newness, inexperience and vulnerability.

In summary, there has been a change in how the growth of small firms is pictured from life cycle to stage models. Different from the life cycle model, stage models assume that not all small firms follow the same path to success. In fact most new innovative firms do not even survive their first year of existence. The stage model presented above by Quinn and Cameron (1983) represents only one way of dividing growth into stages. Yet, the logic is the same across most known stage models as it is assumed that the firms face different strategic challenges at each stage that need to be solved before progressing to the next stage (Hite & Hesterly, 2001; R. K. Kazanjian & Drazin, 1989). Some firms might be advantageous over other firms because they are born with a more mature technology or certain strategic resources (e.g. network contacts or financial resources). Yet, the stage model accommodates that by allowing a firm to progress faster to the next stage. Also some firms might be subject to acquisition by larger firms even before they have undertaken production or sales and therefore do not go through all stages but still can be considered a success. For the purposes of this study, the growth of small firms is an important parameter to consider when studying relationships with universities. A very crucial conclusion from the discussion above is that organisational structures, innovation focuses and external relationships do evolve according to what stage the firm belongs to.

4.4 Chapter summary

Small firms and innovation

The purpose of this chapter was to (1) describe the nature of small firms and (2) substantiate variations among small firms. The first part was approached through a review of the literature on how small firms contribute to the economy, their role in the innovation system and how they differ compared to large firms. The main findings are summarised below.

- **The contribution of small firms to the economy is increasing** in terms of economic renewal, job creation and creation of competitive advantages (D. Audretsch, 1999; R. Rothwell, 1989). Small firms are especially becoming more important when it comes to innovation and introducing new technological products to the market (B.S Tether, 1998). This section justifies that research on

small firms is important as it increases our understanding on how these firms can continue playing an important role in the system of innovation as agents of renewal and transformation.

- **Small firms are distinctive compared to large firm** – since small firms are organisationally more flexible, niche market orientated, risk takers and more informal which all help to speed up decision making and adaptation (Bougrain & Haudeville, 2002; Nooteboom, 1994). These unique characteristics of small firms create an environment for strategic and innovation management in which the behaviours and objectives are different from those in large firms. Hence, research on small firms needs its own space in the management literature.

The chapter proceeded with the development of a conceptual framework of small firms and innovation. The framework consists of three theoretical approaches to categorise and label small firms and innovation. None of these approaches are argued to be dominant but rather they are seen as complementary.

- **Sectoral taxonomy** – Winter's (1984) technological regimes and Pavitt's (1984) sectoral taxonomy have been fundamental contributions to the idea of diversity in innovation patterns across industries. While sectoral taxonomy on small firms showed less discrepancy (de Jong & Marsili, 2006), it has been found that certain sectors such as the biotech and software industry have developed their own unique patterns of innovation (McMillan, et al., 2000; Joel West & Gallagher, 2006). Hence, industry belongingness may explain variations in how small firms pursue innovation.

- **Resources and capabilities** – Based on the resource-based view (Barney 1991) and dynamic capability perspective (Teece, et al., 1997), it is argued that firms build up unique resource positions over time. A unique resource position allows a firm to pursue a value creating strategy and develop sustainable competitive advantages (Almor & Hashai, 2004; Barney 1991). At the same time, building a unique resource position is path-dependent, which eventually may also restrict the firm from pursuing alternative strategies. In this section it has been argued that strategies of small firms can be explained by their unique resource position and the path they have travelled.

- **Growth patterns** – A final approach is based on firm life-cycle and stage theory (Katz & Kahn, 1978; Quinn & Cameron, 1983). In this approach it is argued that firms pass through distinct

stages throughout their life time. Each of these stages presents the firm with distinct internal and external challenges (Hite & Hesterly, 2001). The argument here is that it can be misleading to compare the performance of two firms if they are at two completely different stages in their evolution.

Based on this framework it is suggested than an analysis is undertaken focusing on strategies and behaviours for small firms to collaborate with universities from the perspective of their industrial belongingness, resources, capabilities and stage of development.

The contribution of this chapter to the overall purpose of this study

This chapter contributes to the overall purpose of this study in three ways. Firstly, it is stated in this chapter that small firms are an integrated part of the system of innovation. It is important in this study to understand the inter-connectivity between the internal and external environment of the firm. While it is important for small firms to develop competitive advantages, they also contribute to the economy by creating new jobs and economic growth and renewal. This chapter has more specifically described the role of small firms in the system of innovation, which relates directly to chapter 2 of this study where *the innovation landscape* is described.

Secondly, small firms are fundamentally different from large firms. In the introduction to this study it was argued that the literature on university-industry relationships has been dominated by studies on large firms. This chapter has described a number of unique characteristics of small firms that explain why they pursue strategies differently from large firms, e.g. organisational flexibility and niche market orientation. These unique characteristics of small firms are important in this study to extend the understanding on why small firms pursue relationships with universities in their own distinct way.

Thirdly, diversity among small firms is substantial and it needs to be accounted for. The diversity can be controlled by applying different theoretical approaches (industry taxonomy, resource-based view and firm stage models). Research, that considers small firms as a homogenous group without controlling for variation, risks ending up with highly ambiguous results (Yehuda, 1997).

5 A review of University-small firm relationships

This chapter reviews prior research on university-small firm relationships using a systematic approach. The chapter consists of three parts: (1) methodology applied to the systematic review; (2) the presentation of the evidence; and (3) a summary of the evidence and identification of research gaps. Through a systematic screening process 74 articles were identified and included in this review. These articles were further divided into three main themes: (1) relationships logic; (2) formation of relationships; and (3) managing relationships. Based on the review it is concluded that research on university-small firm relationships is still an emergent research field. The field has so far been dominated by descriptive studies of the nature of the relationship and identification of causal relationships between firm antecedents and relationship performance. More research is required to understand how small firms actually establish and develop successful relationships with universities.

5.1 Introduction

Factors such as changing innovation systems (B-Å. Lundvall, 1992), growing number of government initiatives to promote innovation (Etzkowitz & Leydesdorff, 2000), increasing pressure on universities to engage in research commercialisation (Rosenberg & Nelson, 1994) and the rising number of small firms dependent on science for innovation (de Jong & Marsili, 2006) have contributed to a growing interest for university-small firm relationships among research scholars (Debackere & Veugelers, 2005; Keld Laursen & Salter, 2004).

The focus of this chapter is to review the growing body of literature on how small firms manage relationships with universities to establish what is already known about such relationships, i.e. why they are formed; in what shape do they appear; and what internal and external factors underpin these relationships. The overall objective of this review is to determine *what is already known about how small firms establish and develop relationships with universities.*

This review is carried out by following a systematic approach (see Petticrew & Roberts, 2006). A systematic approach reduces the risk of biased and unreliable handling of the evidence by applying scientific principles to the review the process. In this study the systematic approach consists of a scientific methods used to select, analyse and discuss the articles included in the review (H. Cooper, 1998; Hart, 1998; Petticrew & Roberts, 2006). The review in this study covers relevant articles published in recognised peer-reviewed academic journals from 1999-2009[4]. The time period is chosen, because research on relationships between small firms and universities is a relatively new

[4] Articles from 2010 are included in the review ad-hoc.

topic that has only become more established in the literature within the past decade (Perkmann & Walsh, 2007).

This review consists of three parts: In the first part, the methodology behind the chosen systematic approach for this review is introduced. This includes an outline of the applied keyword search for articles in electronic databases. This was a major challenge as research on university-small firm relationships comes from a range of disciplines and was not easily identified through well defined and unambiguous keywords and dedicated academic journals. The first part also explains how selected articles with similar themes were grouped together and named: *relationships logic, formation of relationships* and *relationship management.* The second part provides a thematic review of each theme based on the selected articles. In the third part the review will be concluded by summarising the evidence and outlining the research.

5.2 Methodology: a systematic approach to a literature review

A systematic review is a scientific investigation in itself as it is based on systematic methods for reviewing studies subject to the phenomenon being researched. In this section the method behind this systematic review will be described.

5.2.1 *Introduction*

Any study needs to start from a base of what other research has already established (Hart, 1998). This also applies to this study as research on university-small firm relationships has a history, which comprises what is already known about the topic (Perkmann & Walsh, 2007). As important research decisions are made from a literature review, it is argued that it is not sufficient just to rely on a collection of preferred evidence: "*if a review purports to be an authoritative summary of what the evidence says, then the reader is entitled to demand that this is a comprehensive, objective, and reliable overview, and not a partial review of a convenience sample of the author's favourite studies" (Petticrew & Roberts, 2006, p. 6).* As undertaking a literature review implies making sense of a large body of evidence, research scholars suggest that it is essential to apply systematic principles to the process of selecting and reviewing the evidence to minimise authorial bias and random errors (H. Cooper, 1998; Hart, 1998). Petticrew and Roberts (2006) argue that a literature review should be subject to the same rigorous scientific principles as one would apply to primary research.

Although a systematic approach is applied to the literature review in this study, there is no such thing as a perfect review. All reviews are written from a particular perspective that often originates from an ideological view on ontology and epistemology (Hart, 1998). Petticrew and Roberts (2006) argue

that in case subjective decisions have to be made by the author, at least the reader is entitled to know when they have been made and what the implications are.

5.2.2 *A six-steps systematic approach*

A systematic approach to literature reviews essentially consists of a set of scientific methods applied to identify, appraise and synthesise studies relevant to a particular research phenomenon (Pittaway, et al., 2004; Tranfield, Denyer, & Smart, 2003). Cooper (1998) proposes that a literature review should begin with a clear description of the purpose of the review. A systematic approach to a literature review is particularly useful to provide an authoritative overview of current evidence, evaluate effectiveness (e.g. strategies and policies), assess relationships between variables and outcomes, answer questions about concepts and meanings, examine the performance of particular research methods and suggest directions for future research (H. Cooper, 1998; Petticrew & Roberts, 2006; 1988; Pittaway, et al., 2004; Tranfield, et al., 2003). A systematic review can help overcome issues of confusion or lead to a qualified assessment of the confusion. In contrast to a systematic review, single studies taken in isolation can be misleading and cannot provide a sufficient foundation to make such qualified judgements (Petticrew & Roberts, 2006; Pittaway, et al., 2004). Hart (1998) proposes that a systematic literature review should continue with a definition of the methodological approach including the methodological assumptions applied. These assumptions refer to how evidence is collected, interpreted or excluded. For example, since most evidence is available in electronic databases today, Pittaway et al. (2004) describe a process of using keywords to search these databases for evidence. As initial searches for evidence may generate huge amounts of material, most systematic reviews would require strategies to screen what evidence to include and exclude. The methodology applied to a systematic review needs to justify how keywords have been selected and applied and how evidence has been screened and appraised (Pittaway, et al., 2004; Tranfield, et al., 2003). Petticrew and Roberts (2006) described six steps in a systematic approach to a literature review before presenting the evidence:

1. Define the purpose.
2. Determine the process for identifying evidence.
3. Locate the evidence.
4. Screen the evidence.
5. Appraise the evidence.
6. Synthesise the evidence.

In the following sections, these six steps will be described in more details in relation to this particular review for this study.

Step 1 – Define the purpose

It is argued in this study that research on university-small firm relationships is a relatively new research field and has only recently started to grow in popularity as a research topic within academic circles (Perkmann & Walsh, 2007). Perhaps because it is only within the past 5-10 years that evidence on university-small firm relationships have started to occur regularly in academic journals, only few attempts have been made to synchronise evidence systematically into a comprehensive review. Those attempts that have either been on university-industry relationships in general (see Perkmann & Walsh, 2007) or university-small firm relationships as a vehicle for commercialisation of academic research (see P. H. Phan & Siegel, 2006). No review to date has been focusing on the managerial and strategic implications of establishing and developing university relationships related to small firms. The lack of a comprehensive review on university-small firm relationships causes difficulties for researchers to form an overview of what has already been investigated and what needs further attention (Petticrew & Roberts, 2006).

The intention of this review is to contribute to the research on university-small firm relationships by conducting a comprehensive review of current research following a systematic review approach. Repeated from the introduction, this review intends to determine *what is already known about why and how small firms establish and develop relationships with universities.* More specifically, this review intends to address the following issues: (1) outline research topics related to university-small firm relationships within the past decade; (2) describe how these topics contribute to the understanding of how small firms collaborate with universities; and (3) identify gaps in the literature that are of particular interests to explore in future studies. Also for the purpose of this study, the review forms part of the foundation used to develop the research model and research questions related to this particular research. The research model and research questions are to be presented and discussed in chapter 6.

Step 2 - Determine the types of studies required to satisfy the purpose

A literature review can in principle be conducted based on any form of available evidence but cost and time often put certain limitations to the task (H. Cooper, 1998; Hart, 1998). Also certain types of evidence is not easily retrieved which may compromise systematic screening processes for the review (Petticrew & Roberts, 2006). For example, books, government reports or various types of government might not be publicly available or are not accessible online. Pittaway et al. (2006) argue

that research in social science is usually driven by published peer-reviewed research. On the other hand, limiting search to peer-reviewed articles also has certain shortcomings. Petticrew and Roberts (2006) note that conference proceedings and unpublished working papers might include more novel ideas and concepts. The dilemma with conference proceedings and unpublished work is the lack of thorough and independent examination of the evidence, which may challenge the creditability of the review. Unpublished work can also be difficult to locate, which make researchers rely on snowball sampling rather than systematic sampling (Perkmann & Walsh, 2007). For the purposes of this review, it was decided by the author to only include articles published in research based peer-reviewed journals. Pittaway et al. (2006) and Petticrew and Roberts (2006) argue that the strength of using peer-reviewed articles for a review only is that the evidence is of recognised quality and the accessibility of evidence is consistent. It is decided in this study that the strength of unbiased material and the credibility from peer-reviewed work outweigh the benefits from including non-peer reviewed work and unpublished work that only can be located through random searches.

Step 3 - Carry out a comprehensive literature search

Electronic databases

In this review, tracking relevant journals were undertaken using five different electronic reference databases: (1) ABI/INFORM, (2) Business Source Premier, (3) Science Direct, (4) Emerald and (5) JSTOR/Wiley. These particular databases are well recognised in social science studies and have also been included in other systematic reviews within innovation and inter-organisational collaboration (see Perkmann & Walsh, 2007; Pittaway, et al., 2004; F. T. Rothaermel, et al., 2007).[5] Using multiple electronic databases reduces reference bias (F. T. Rothaermel, et al., 2007).

Keyword and search strings

The next challenge was to find the relevant articles to be included in this review. The method applied in this review is based on searching each electronic database through a set of pre-determined keywords. A keyword search strategy allows for consistency in identifying articles for the review, but also may exclude relevant studies if the researched topic is inherently ambiguous (Petticrew & Roberts, 2006). Another limitation of using keywords is that there is no authorised or perfect set of keywords, which leaves it to the discretion of the author to generate the relevant search keywords. Pittaway et al. (2004) used a brainstorming session with colleagues as a technique to generate the list of keywords. Perkmann and Walsh (2007) started out with a brainstorming session but iteratively improved the list by running test searches and taking into account new results.

[5] Google Scholars have become increasingly useful to search for academic journals, but to date many search results do not provide full-text options and do not differentiate between peer-reviewed journals and books.

In this study the pre-determined keywords were identified through the following process. (1) Four different journals that often publish research on university-industry collaboration were selected. These were: *Research Policy, Technovation, The Journal of Technology Transfer*[6] and *International Journal of Technology Transfer and Commercialisation.* (2) The first article published each year between 1999 and 2008 and related to university-small firm relationships were selected from each journal. A total of 40 articles were selected. (3) Keywords used in these 40 articles were marked down in a list. (4) Additional keywords were added through a brainstorming session with colleagues. (5) The final step was to modify the list of keywords into search strings applicable for searching the electronic databases.

In the literature search, the main key word categories (relation, small firm, university and innovation) all had to be present in the search. In the electronic search this is complied with by using 'AND' between each key word category in the search string. But within each key word category just one of the synonyms had to be present. This is complied with by using 'OR' in the search string (e.g. relation* OR interface* OR network*...). The '*' is used to allow for keywords in single or plural form (e.g. relation* in the search string will include 'relation', 'relation**s**', 'relation**ship**' and 'relation**ships**') or English or American spelling (e.g. commer* will include commer**cialisation** and commer**cialization**). An overview of the keyword strings applied for this review is displayed in the Table 5-1.

Table 5-1: Keyword Strings

Relation		**small firm**		**University**		**Innovation**
Relation* Interface* Network* Collabo* Triple Link* Interact* (OR)	AND	Spin* Entrepre* Firm* Indust* Private* Business* SME*[a] Venture*[a] (OR)	AND	Acade* Institut* Public* Scien* TTO Univer* (OR)	AND	Research* Commer* Innov* Proper* Invent* Knowledge Learn* Trans* Licen* Techno* Patent* Scien* R&D (OR)

[a] Additional keywords added through a brainstorm session with colleagues

[6] Keywords only available from 2005 and onwards. In this case, two articles per year were chosen.

Search strategies

The review in this study only includes peer-reviewed articles published post-1999. The time period is chosen, because research on university-small firm relationships is a relatively new topic that only recently has become more established in the literature (Perkmann & Walsh, 2007). Some test searches of articles published before 1999 was conducted revealed very little or insignificant evidence (e.g. generic studies on university-industry relationships).

The search was limited to citations and abstracts only. Initial full-text searches led to an overwhelming mass of material, which could not be proceeded within the timeframe of this study. The problem was mainly that some of the keywords applied to the search were too generic and often used indiscriminatingly. One example out of many: an article might start with '*This **research**...',* with research being a synonym for innovation in this study without the article being related to innovation. This problem was reduced but not eliminated by limiting search to citations and abstracts only. Still from the citations and abstracts search the number of excluded articles was relatively high but this also was an assurance that the decision to limit search to citations and abstracts only most likely had very little or no negative consequence for relevant articles not being included. A total of 1,928 articles were identified using the keyword strings for citation and abstract searches within the selected electronic databases.

Step 4 - Screen the results

Further screenings of the initial 1,928 articles was conducted by importing all citations and abstracts to the database software program Endnote that was used in this study. Using a database software program made it easy to find duplicates and sort all initial articles according to author, publication year and journal name. The initial search result was reduced through the following steps:

1. Delete duplications (278 deleted) – 1,650 remaining. This was easily conducted in Endnote through the function 'find duplicates'.
2. Delete journals from unrelated fields of study and with titles of articles are unrelated to research topic (1,299 deleted) – 351 remaining. Examples of journals deleted from the sample: *'Advances in Accounting', 'Health Education'* and *'Library Management'*. In case it was difficult to establish the focus of the journal from its title, a visit to the journal's homepage led to clarification.
3. Abstract screening (186 deleted) – 165 remaining. Unrelated articles were often included in the first place. For example: 'University' appeared in Author's signature; 'research' appeared as a generic term describing 'this research...'; 'industry' or synonyms were often used terms

in any business subject; and 'network' often related to computer networks or other types of inter-connected objects or entities. The purpose of the abstract screening was purely to identify those articles that did not under any circumstances relate to university-small firm relationships.

4. Full text screening (90 deleted) – 74 remaining. Full text screening involved reading the full article. Excluded articles were usually referring to (1) university-industry relationships as mechanisms to commercialise academic research without providing any relevance to management issues for small firms; (2) university-industry relationships that only were applicable to large firms; and (3) public-private contracting or outsourcing that did not relate to innovation.

The actual screening process was a major challenge during this review. It was evident already from the beginning that the selected keywords showed weaknesses in discriminating relevant articles from irrelevant ones. Since the keywords were generated from already published work within university-small firm relationship, the problem with the keywords seemed to be that they also were frequently used in other research areas unrelated to business studies. While that is said, the initial screening of 1,928 articles is still only a small fraction of all articles (related and unrelated) accessible from the electronic databases used for this review.

Step 5 – Appraise the evidence

The process of assessing the quality of the evidence is often referred to as critical appraisal. Petticrew and Roberts (2006) argued that systematic appraisal is needed to assess the creditability of the individual studies included in the review. A study can be produced by a wide range of methods and approaches that do not necessarily comply with the standard and quality associated with scientific research. For example, it can be difficult to interpret data in a meaningful way if information on context, background, methods and analysis is not introduced by the author. Petticrew and Robert (2006) noted that critical appraisal is of particular importance if the evidence is collected from a variety of different sources each with their own quality standards (e.g. websites, newspapers, journal articles and books). Pittaway et al. (2004) also argued that critical appraisal can be useful when the author decides not to present all articles in the review. They described a process of appraising each article according to their theory robustness, implication for practice, quality of data, generalisability and contribution. Only those articles that scored *high* in the appraisal process were included in the review. In this study, all the evidence is peer-reviewed articles that already have been quality assessed by reviewers before being published and none of the included articles were excluded from the synthesis of evidence that follows this section (step 6).

However, a subjective appraisal of the individual studies is difficult to avoid when reviewing the actual evidence in the review. One study may be described more in detail in the review than another despite that their contribution is more or less of the same quality. To avoid author's bias in this review, key information regarding publication year, journal, method and key findings for each article is presented in the review (see Table 5-4 to Table 5-10).

Step 6 - Synthesise the evidence

The synthesis of the studies was conducted with the purpose of identifying patterns across the evidence. First evidence was synthesised according to year of publication, articles per journal and articles per geographic location (geography of empirical study). A thematic synthesis of the evidence was conducted following a meta-analysis (Petticrew & Roberts, 2006; Pittaway, et al., 2004).

Year of publication

This review only covers articles published post 1999. Yet, the exponential trend line in Figure 5-1 clearly indicates that research on relationships between small firms and universities is growing. It is only in recent years, that researchers have started to recognise that small firms behave differently from large firms and therefore may also require different conditions for establishing and managing relationships with universities.

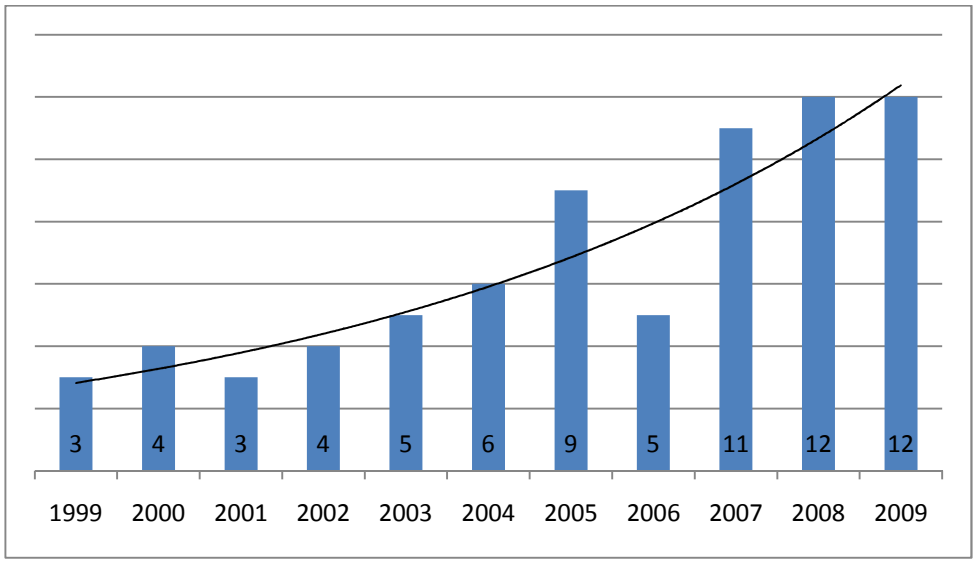

Figure 5-1: Articles published per year

Articles per journal – a multidisciplinary approach

The selected articles used in this review were published in a variety of journals. Approximately one-third were published in Research Policy, which is known to be a multi-disciplinary journal devoted to the policy and management problems concerned with innovation and related topics within the areas

of knowledge diffusion and inter-organisational learning. Its papers examine these topics at a variety of levels including system of innovations, government, university, firm and individuals. More than 10% of the reviewed articles were published in Technovation, which concentrates on topics such as innovation and technology management, new venture creation, new product development and organisational structures mainly from the perspective of small and medium-sized enterprises (SMEs). In total the 74 reviewed articles were published in 27 different journals, which include a number of fields such as economics, regional geography, public sector management, marketing, technology transfer and organisational behaviour.

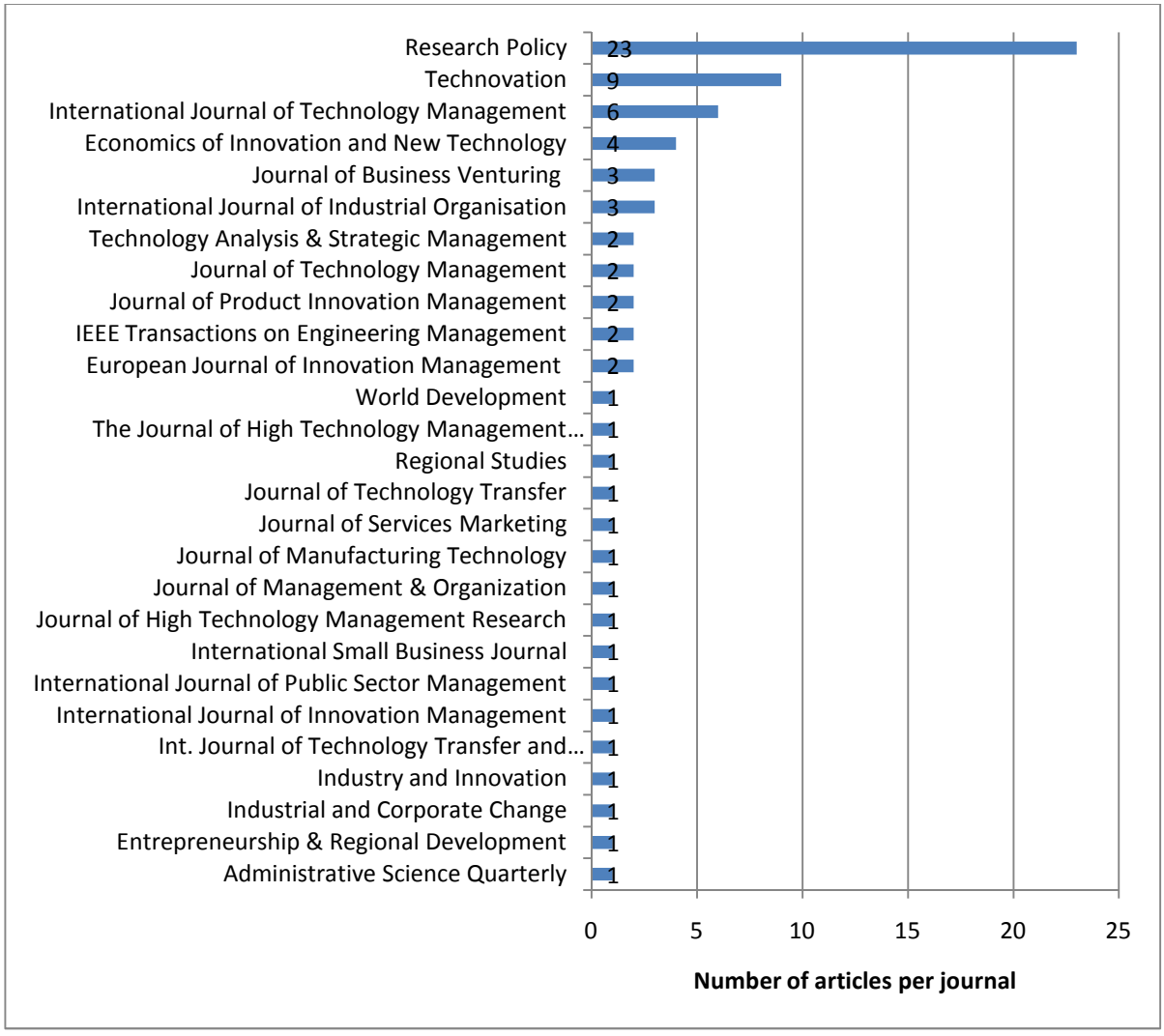

Figure 5-2 Number of articles per journal

Geographic location of empirical studies

Among the articles selected for this review, it is interesting to note that all populated continents are represented (Africa, Asia, Australia, Europe, North America and South America), which indicates that challenges with managing relationships between small firms and universities are in fact a worldwide

phenomenon. 16 articles have empirical data based on the US, seven on Germany, Spain and UK. A total of 61% of the empirical data used are from European countries.

Possible explanations to the overweight of studies based on European data could be that the European Union has systematically collected data to monitor the performance of science and university-industry collaboration for years, which makes data for research more accessible (see for instance European Commission, 1995, 2003, 2005). In early 1990's it was also pointed out that European countries had a problem creating value of academic output, which has been named the 'European Paradox' (Debackere & Veugelers, 2005; European Commission, 1995). Compared with the US universities, European universities produced more or less the same output, but it was less likely to be realised into economic growth or innovative new products and services. Stronger linkages between universities and industrial firms in Europe were identified as an important method to stimulate more research commercialisation and improve competitiveness of European firms against US firms. Hence, this might explain the overweight of articles based on European data.

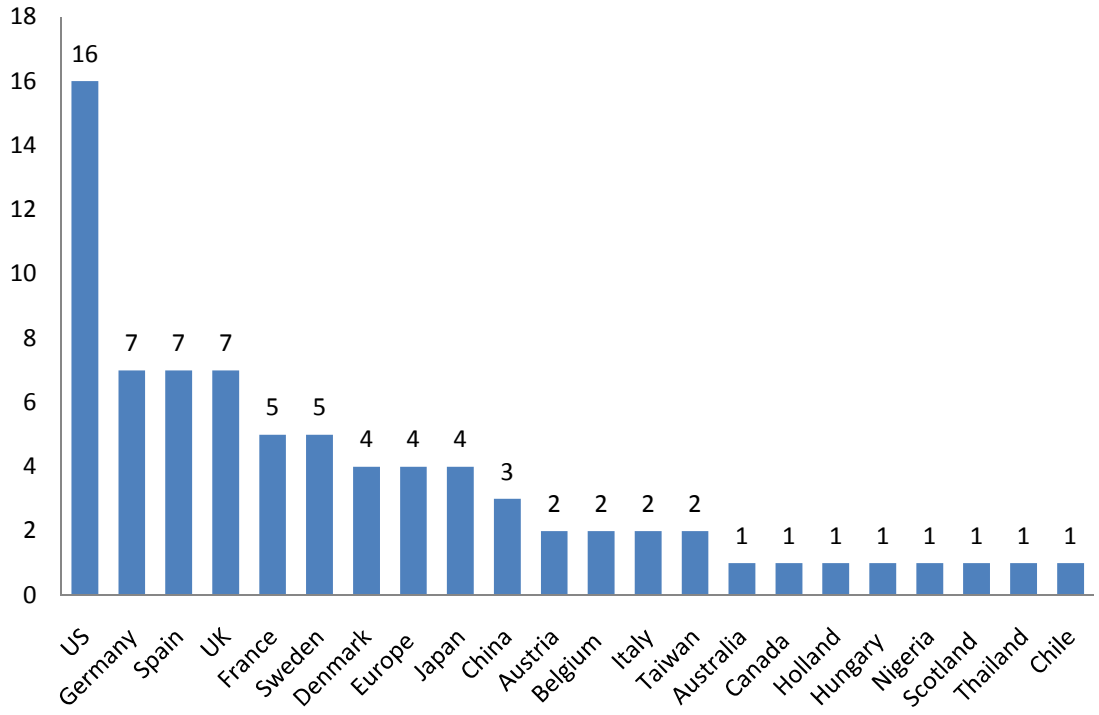

Figure 5-3: Articles per country

Note: 4 studies include more than one location. 3 studies did not mention location or were only conceptual papers. 4 studies are based on data from European Union (recorded as Europe).

Thematic analysis

The synthesis of the articles follows a meta-analytical method as described by Petticrew and Roberts (2006) and Pittaway et al. (2004). According to a meta-analysis method, articles are grouped together by themes. The purpose of this exercise is to reach a 'critical mass' of studies within each theme that

allows for a more nuanced discussion of what is known and what is not known about small firms establishing and managing relationships with universities (Petticrew & Roberts, 2006). It was an iterative process to identify the theme of each study, but the following main steps were carried out. First, a short description of the content of each article was produced. Second, patterns across the short descriptions were identified. Articles were grouped together according to commonalities in these patterns. Third, a more generic subject theme that represented all articles within the group was developed by the author. The thematic distribution of articles included in this review came out as follows:

Table 5-2: Articles per theme

Group	Theme	Description	No. of papers	% of theme
1	**Relationship logic**		**34**	**46%**
1.1	Motives	Studies that deal with motives for small firms to collaborate with universities. For example: cost-sharing, risk-sharing and access to strategic resources.	14	
1.2	Who collaborates?	Studies that explain what types of firm who are more likely to collaborate with universities. It is given that benefits from collaborating with universities are not equally distributed across firms. For example: firm size, location, internal R&D skills, industry sector and external support.	14	
1.3	Obstacles to collaboration	Studies that examine how different factors impede small firms from collaborating with universities. For example: how lack of absorptive capacity impedes small firms from absorbing and integrating academic research into their innovation processes.	6	
2	**Formation of relationships**		**18**	**24%**
2.2	Search, screen and selection strategies	Studies that focus on how relationships with universities are formed and what factors inhibit or assist their formation. For example: search and selection strategies	4	
2.1	Formation behaviour	Studies that focus on how relationships with universities are formed and what factors inhibit or assist their formation. For example: prior partner experience, partner familiarity and external funding	14	
3	**Relationship management**		**22**	**30%**
3.1	Governance mode	Studies that link factors with certain pattern of interaction. For example: how internal R&D strategy, firm size and organisational culture affect formal or informal interaction.	10	
3.2.	Governance management	Studies that examine how different factors affect different performance parameters. For example: how trust or certain capabilities affect knowledge spill-over effects.	12	
Total			**74**	**100%**

Table 5-2 highlights the themes studied and the number of articles relevant to each theme. A large proportion of the articles reviewed related to relationship logics, which mainly looked into 'why' and 'who' collaborate with universities (46%). A smaller proportion of the articles examined formation of relationships (25%), with four articles addressing search, screen and selection strategies and 13 articles looking into formation behaviours. 29% of the reviewed articles focused at relationship management, which include three subthemes: governance mode, governance management and developing the relationship.

A number of key points can be made with regard to the overall evidence used in this review. Firstly, research on small firms and universities has been growing in popularity over the past 10 years. Secondly, research on small firms and universities is inherently multi-disciplinary as they are seen as vehicles for economic growth, knowledge diffusion and competitive advantage at the same time. Also it has been argued earlier in chapter 2 that university-industry relationships are seen as an important component of the system of innovation. Thirdly, based on location of empirical studies, challenges for small firms collaborating with universities is a world-wide problem, including developing economies. Finally, the existing research is fragmented and can be spread across a variety of themes related to establishing and developing relationships between small firms and universities. The challenge for the remaining part of this review is to analyse and discuss contributions from the included articles in detail with the aim of identifying what is already known about relationships between small firms and universities and what needs further attention.

5.3 Presenting the evidence of the review

In the following section the evidence included in this review is presented in order to create a detailed overview of what is already known about this topic and what needs further investigation. The evidence will be presented according to the three themes that emerged from the meta-analysis: (1) relationship logic; (2) formation of relationships; and (3) managing relationships.

The evidence related to each theme is presented in tables with the following headlines: (1) author; (2) year; (3) Journal; (4) methodology, data, location of study, unit of analysis; and (4) key findings. The table ensures that all evidence related to each topic is presented objectively (Petticrew & Roberts, 2006). Each table and theme is described in text supported by headlines indicating subthemes within the themes. A more critical synopsis of each theme is placed at the end of this chapter in the conclusion section. The conclusion section includes: (1) an overview of key trends in research on university-small firm relationships; (2) a summary of the evidence within each theme; and (3) a discussion of research gaps and future research opportunities.

5.3.1 *Relationship logic*

The research stream on relationship logic concentrates on answering fundamental questions regarding 'why' and 'who' collaborate with universities. Consequently, most research within this stream attempts to reveal the motives for small firms to establish relationships with universities in the first place. In addition to motives, other studies argue that not all firms are likely to benefit from collaborating with universities. These studies have revolved around identifying internal and external factors inhibiting or enhancing relationships between universities and small firms. In this section, studies related to relationship logic will be presented according to their relation to one of the following three sub-themes:

- Motives for small firms to collaborate with universities;
- Who collaborates with universities;
- Obstacles for small firms to collaborate with universities.

Motives for small firms to collaborate with universities

The question of why collaborate with universities has been addressed by several scholars. One group of scholars are describing why industrial firms in general are collaborating with universities (Fritsch & Lukas, 2001; Heirman & Clarysse, 2007; Montoro-Sanchez, et al., 2006). A second group of scholars focuses more on motives of small firms (Hu & Mathews, 2009; Santoro & Chakrabarti, 2002) or motives of distinctive groups of small firms (van Geenhuizen & Soetanto, 2009). Finally, a third group of scholars compare the motives to collaborate with universities in contrast to other types of external sources (Abramovskya, Kremp, López, Schmidt, & Simpson, 2009; Bierly III & Daly, 2007; Lhuillery & Pfister, 2009).

General motives for industrial firms to collaborate with universities

Montoro-Sanchez et al. (2006) identified five distinctive groups of motives for industrial firms to collaborate with universities: financial, technological, strategic, educational and political motives. Strategic motives relate to maintaining and developing the firm's competitive advantage, risk reduction, launching new businesses, access to new markets and improving image or reputation. Technical motives include gaining access to resources, knowledge, technologies and scientific advancements. Training of employees and recruitment of graduates constitute the educational motives. Relationship with universities may also be formed to gain access to additional financial sources and state grants or for purposes of tax or cost reduction. Finally, adaptation to governmental initiatives can be seen as political motive for engaging in relationships with universities.

Table 5-3: Motives for industrial firms to engage in university-industry relationships, adapted from Montoro-Sanchez et al. (2006) p. 168-169.

Strategic	**Technological**
Maintenance and improvement of competitive advantage Risk reduction Launching new businesses and access to new markets Improving image and reputation	Access to resources, knowledge, technologies and scientific advance Innovations on products and processes
Financial	**Educational**
Additional financial sources State grants Cost reducing Tax advantages	Training of employees Recruitment
Political	
Adaptation to governmental initiatives	

Montoro-Sanchez et al. (2006) ranked these motives (in Table 5-3) for industrial firms to collaborate with universities based on data from 800 different university-industry R&D projects. The ranking gave the following results: Improve competitive position and advantage (scored 5.87 on a 1-7 Likert Scale), launch new products/services (scored 5.72), access to partner's technologies and knowledge (scored 5.43), access to new markets (scored 5.43) and improvements of firm image and reputation (scored 4.96). In general strategic and technological motives were ranked highest. Among 1,800 German manufacturers, Fritsch and Lukas (2001) found that joint R&D was the most common reason for collaborating with universities followed by thesis collaboration, use of equipment and laboratories and contract research.

While risk reduction is usually considered to be one of the main motives for cooperative R&D between industrial firms (Joel A. C. Baum, et al., 2000; Belderbos, Carree, & Lokshin, 2004), several scholars have found that it is of lesser importance in university-industry relationships (Abramovskya, et al., 2009; Montoro-Sanchez, et al., 2006). Veugelers and Cassiman (2005) explained that collaborating with universities might help in reducing technical but not market related risk. Another explanation, although not presented by the authors, could be that industrial firms prefer to collaborate with universities around early stage technologies that inherently are related to high technical and market risk (Heirman & Clarysse, 2007). For example, Jensen and Thursby (2001) found that 71% of technologies from universities transferred to industry are no more than proof of concepts, which indicates that commercialising high-risk technologies is more of strategic importance to the firm rather than necessarily avoiding risk.

Specific small firms' motives to collaborate with universities

Several scholars have also looked further into motives to collaborate with universities among small firms in particular. Hu and Andrews (2009) and Barbolla and Corredera (2009) found that SMEs were more likely to request technical assistance from universities in relation to more mature technologies

and incremental innovation. Only rarely were SMEs engaged in more radical innovations that required access to basic research from universities. Similar findings were reported by Santoro and Chakrabarti (2002) who discovered that small firms were more likely to collaborate with universities to solve critical issues affecting central business areas and core technologies rather than developing new business areas in non-core technologies. Considering the small firms are often resource restricted, it is of no surprise that they do not engage in long-term research projects with high uncertainty to outcome, for example basic research. Rather they try to commercialise existing technologies and knowledge that often has been discovered or invented at universities (Perez-Perez & Sanchez, 2003).

Van Geenhuizen and Soetanto (2009) learned that academic entrepreneurs continued working with the host university because of easier access to equipment and favourable employment terms (e.g. stay or return in academic position), which helped reduce perceived risk of starting up new business. Based on data from ten university spin-offs, Perez-Perez and Sanchez (2003) found that these firms gradually became less dependent on the host university. In the beginning they were highly dependent on accessing technical knowledge and competences, but as their technology matured they became more commercially orientated and distant to universities.

Universities compared to other types of external sources

Several studies have also contrasted motives to collaborate with universities against other types of external sources. Bierly III and Daly (2007) found that SMEs mainly collaborate with universities to get access to technical competences and basic research. Collaboration with customers helped towards understanding customer preferences and led to higher speed of innovation. Suppliers provided new technologies to help improve operation efficiency. This study showed that universities often bring different things to the table than customers and suppliers. Other scholars have also found that small firms prefer collaborating with universities over competitors. Risk of partner behaving opportunistically is perceived to be lower in relationship with universities over competitors (Abramovskya, et al., 2009). Also if a cooperation with competitor fails then there is a risk the competitor may have absorbed a significant proportion of the partner's knowledge base that can be used to increase its competitiveness over the rival (Lhuillery & Pfister, 2009). While George et al. (2002) did not compare universities with other types of external sources, they did find that firms collaborating with universities experienced lower R&D cost than those firms that did not. Studies contrasting universities to other types of external sources of innovation are important as they tell us that universities are an unique partner for collaboration that provide collaborating firms with access

to resources and knowledge that cannot easily be substituted or imitated through internal or external access.

Table 5-4: Motives to collaborate

Author	Year	Journal	(1) Methodology; (2) data; (3) location; and (4) unit of analysis	Key findings
Abramovsky et al.	2009	Economics of Innovation and New Technology	(1) Quantitative (2) 8,665 firms – mixed size (3) France, Germany, Spain and UK (4) Firm	The paper focused on the roles of knowledge flows, cost- and risk-sharing and public financial support in influencing firms' decisions to enter into co-operative innovation agreements. Access to Knowledge flows depends on the firm's openness. Cost- and risk-sharing often perceived to be less when collaborating with universities over competitors. But the difference is less if the firm has strategic appropriability methods in place.
Barbolla et al.	2009	Technology Analysis & Strategic Management	(1) Qualitative (interview) (2) 30 university researchers (3) Spain (4) Project	The authors characterised the criteria for success in university-industry projects against less successful projects. Through explorative studies, they found that four dimension where particular relevant to successful compared with less successful research project: (1) technology, (2) corporate usefulness, (3) corporate capacity and (4) corporate confidence. Projects around more mature technologies, high level of corporate applicability and capacity to leverage university knowledge and competences and confidence in university teams increased the chances of successful innovation outcomes.
Bierly III and Daly	2007	International Journal of Technology Management	(1) Quantitative (2) 98 firms (294 respondents) (3) US (4) Firm	The paper identified sources of learning among SMEs and the relationship between learning sources and dynamic capabilities. SMEs mainly collaborate with universities to get access to technical competences and basic research. This is important for new product development. Relationships with customer provide better understanding of preferences, hence, speed up the innovation speed. Relationships with suppliers are associated with process technologies and help towards operation efficiency.
Fritch and Lukas	2001	Research Policy	(1) Quantitative (2) 1,800 firms (3) Germany (4) Firm	The paper provides evidence to explain who and why firms collaborate with universities. 33.8% of the firms collaborated with universities. Out of those, 22.2% for joint R&D projects, 18.8% for thesis collaboration, 16.5% for use of equipment or laboratories and 14.9% for research contracts.
George et al.	2002	Journal of Business Venturing	(1) Quantitative (2) 147 firms (3) US (4) Firm	Firms with university relationships have lower R&D cost than firms without university relationships. Mainly because university relationships allow for access to university equipment, pooling of knowledge stock and easy access to scientific talents. Yet, relationships with universities did not lead to higher financial performance than those without relationships. Firms in university relationships also appeared to have more relationships with other external partners. The authors speculate that this might be because relationships with universities signal strong technical association and therefore attract other technical partners. The number of relationships with universities was marginally associated with products under development but not with products on the market.
Heirman and Clarysse	2007	Journal of Product Innovation Management	(1) Qualitative (2) 99 firms (3) Belgium (4) Firm	The authors examine the relationship between innovation speed and collaborating with universities for start-ups. The findings show that start-ups that do collaborate with universities appear to have slower innovation speed compared to start-ups that collaborate with other types of suppliers and customers. Yet, the authors explain that this might be the case because start-ups that do collaborate with universities are more likely to work with new technologies that require substantial further R&D before being ready to be introduced to the market. Collaboration with universities mostly serves to stay at the leading edge of new technologies.

Motives to collaborate (cont.)

Hu and Mathews	2009	Journal of Management & Organization	(1) Qualitative (2) 43 university executive (3) Taiwan (4) Firm	The authors found that SMEs were more likely to form relationship with private and technical universities, simply because these universities tended to focus more on matured technologies (applied). Yet, public universities tended to enjoy more abundant resources and higher reputations, which also attracted some SMEs but mainly to gain marketing advantage. Public universities were also more likely to focus on basic research, which led to more radical product innovations. Only few SMEs were engaged with radical product innovation. The authors recommend more SMEs to see public university as a source of knowledge for more radical innovations.
Lhuillery and Pfister	2009	Research Policy	(1) Quantitative (2) 2,354 firms (3) France (4) Firm	The paper showed that firms experienced cost of relationship failure to be less when collaborating with universities compared to competitors. If cooperation fails with competitor then they risk the competitor may have absorbed a significant proportion of the partner's knowledge that can be used to increase its competitiveness relatively to its rival. It was also found that cooperation with foreign universities were more likely to fail than with domestic universities because it is more complex to manage cross-border relationships. It was also found in general that prior collaboration experience with universities lowered the risk of relationship with university to fail.
López-Fernández et al.	2007	Journal of Manufacturing Technology	(1) Quantitative (2) 3,964 firms (3) Spain (4) Industry/Firm	When operating costs represent an important obstacle to innovation, firms are more responsive to cooperate with universities (cost sharing). Risk sharing did was not confirmed to be a determining factor. Propensity to collaborate with universities increases with firms size and intensity of in-house R&D. For manufacturing firms (but not service firms) higher complexity in protecting IP made them prefer collaborating with universities compared to other types of external partners. Mainly because universities were considered more trustworthy.
Montoro-Sanchez et al.	2006	International Journal of Technology Management	(1) Quantitative (2) 800 projects from 574 firms and 155 research organisations (3) Spain (4) Project	Divide benefits into 5 categories: strategic, financial, technological, learning and political. The authors found that firm are most likely to collaborate with universities to strengthen their competitive position, launch new products or services, gain access to partner's technologies and to enter new markets. The firms were less likely to collaborate with universities to reduce risk.
Nerkar and Shane	2003	International Journal of Industrial Organisation	(1) Quantitative (2) 128 firms (3) US (4) Firm	The focus of this paper is to investigate the relationship between survival of new ventures and what type of university patent they try to commercialise. It is found that new ventures that commercialise university patents for radical innovation are more likely to survive. Yet, in more concentrated markets, wide patent scope and radical innovation decreases the likelihood for the new venture to survive.
Santoro and Chakrabarti	2002	Research Policy	(1) Quantitative (2) 189 firms (3) US (4) Firm	Larger firms have higher intensity knowledge transfer and research support relationship in order to strengthen skills and knowledge and gain access to university facilities for advancing non-core technologies. In contrast, small firms are not primarily interested in long-term competence building in non-core technologies. Rather they collaborate with universities to solve critical issues affecting central business areas and core technologies.
van Geenhuizen and Soetanto	2009	Technovation	(1) Qualitative (case) (2) 58 firms (spin-offs) (3) Holland (4) Firm	While the focus of this paper is mainly on growth of spin-offs, it is also revealed how spin-offs can use relationships with universities to strengthen commitment to research commercialisation and improve credibility. Commitment, spin-offs formed by former academics tend to have an advantage as they can negotiate with faculty boards to keep their position part time or even return after a few years out. This reduced perceived risk of staring up a new venture. Credibility, former academics could also negotiate contracts with faculty to allow access to equipment and labs leading to cost sharing.

Who collaborates with universities?

It is important to recognise that benefits from collaborating with universities are not equally distributed among firms. Prior research is rich on explanations on what cause variation in terms of who benefits from universities. The existing literature has identified a number of firm-related factors to explain 'who collaborates with universities' such as firm demographics (e.g. as firm size or age), firm specific capabilities or resources (e.g. absorptive capacity) and internal innovation strategy.

Firm size

Firm size has been scrutinised thoroughly among factors explaining 'who collaborate with universities' in the existing literature. Several scholars have noted that large firms are more likely to collaborate with universities compared to small firm (Keld Laursen & Salter, 2004; Schartinger, et al., 2001; Tödtling, et al., 2008; Veugelers & Cassiman, 2005). Motohashi (2005) found that only 23.1% of small firms (1-100 employees) in Japan collaborated with universities. In comparison, 89.5% of large innovative firms (more than 1,000 employees) reported to collaborate with universities. Common explanations to why large firms are more likely to collaborate with universities than small firms are due to large firms' enhanced market power, economies of scale, financial independence and more abundant resources for new product development (López-Fernández, Serrano-Bedia, & García-Piqueres, 2008; Motohashi, 2005; Tödtling, et al., 2008). Among small firms, Motohashi (2005) and Schartinger et al. (2001) argued that younger firms tended to rely more on knowledge from universities than older firms. A higher percentage of younger firms are involved with developing products or services new to the markets. Older firms are more likely to be involved with refining existing products and services, which require less input from universities. This result contradict findings by Laursen and Salter (2004) who did not find that start-ups relied more on knowledge from universities compared to more established firms. Yet, Laursen and Salter explained the insignificant value of firm age with the fact that their sample included start-ups from both high and low research intensive industry.

Capabilities and resources

Several scholars have also looked into specific capabilities and resources of the firm to explain 'who collaborates with universities'. Laursen and Salter (2004) applied the concept of openness which refers to the probability of firms drawing on knowledge from external sources. Small firms that are more open (in terms of drawing knowledge from various sources) are more likely to consider knowledge from universities as important for their innovation activities. It has also been well documented that firms with high level of absorptive capacity within scientific and technical research are more likely to learn from universities, hence collaborate with universities (Bruce S. Tether &

Tajar, 2008; Tödtling, et al., 2008). Different measures for absorptive capacity have been applied in the literature: for example larger proportion of scientific staff (Bigliardi & Dormio, 2009; Bruce S. Tether & Tajar, 2008) size of internal R&D department (Schartinger, et al., 2001; Tödtling, et al., 2008) and R&D intensity (Busom & Fernández-Ribas, 2008; Bruce S. Tether & Tajar, 2008) all increased the probability of small firms collaborating with universities. In comparison, Inzelt (2004) found that low research intensity among industrial firms in Hungary explained the deficit of university-industry relationships in the country.

Geographic location

Several scholars also claimed that geographic location is important to determine 'who collaborates with universities' (Löfsten & Lindelöf, 2002; Quintana-García & Benavides-Velasco, 2006). Especially for smaller firms, close geographic proximity to a university partner is found to be crucial as it reduces travel time and cost (Scott Shane, 2002) and also improves knowledge spill-overs (D. B. Audretsch, et al., 2004). Löfsten and Lindelöf (2002) and Quintana-García and Benavides-Velasco (2006) also found that small firms located within science-parks or biotech clusters were more likely to collaborate with universities, one reason being that science parks and biotech clusters usually are located nearby local universities. The importance of location in science-parks was also confirmed by Yang et al. (2009), who discovered that new technology-based firms located on-park experienced higher externalities (access to equipment and laboratories, knowledge diffusion and network opportunities) from local universities, which had a positive effect on R&D productivity. Yet, Tödtling et al. (2008) did not find any relationship between the location of Austrian firms and the probability of collaborating with universities. Firms interested in and capable of collaborating with universities seem to do so regardless of whether located in close proximity to universities or not.

Yet other studies showed that close geographic proximity was not necessarily related to higher knowledge spill-overs from universities. Monjon and Waelboeck (2003) found that highly innovative firms were more likely to experience positive knowledge spill-overs when collaborating with international universities than local universities. Similar findings were reported by Gallie and Legros (2007), who found that European universities compared to domestic French universities had the strongest knowledge spill-over impact on innovativeness among French firms.

Internal innovation strategy

Other studies have investigated the relationship between firm's internal innovation strategy and the likelihood of collaborating with universities. Bigliardi and Dormio (2009) found a positive association between manufacturing firms collaborating with universities and product innovation measured in

total turnover. In contrast, the same study showed a negative relationship between collaborating with universities and process innovation. Tether and Tajar (2008) and Tödtling et al. (2008) found that firms undertaking advanced innovations were more likely to draw on scientific inputs from universities compared to firms engaged in less advanced innovations. This also corresponds with finding from Bercovitz ad Feldman (2007) who discovered that innovative firms focusing on exploration were more likely to collaborate with universities. Nerkar and Shane (2003) also found that new ventures that commercialised university patents for radical innovation were more likely to survive.

Industry sectors

Several scholars have also proclaimed that some industry sectors are more likely to benefit from knowledge spill-overs from universities. Gallie and Legros (2007) and McMillian et al. (2000) found that biotech firms were more dependent on knowledge from universities than any other industry sector. Tether and Tajar (2008) found that high technology manufacturing firms and those in technical services were most likely to engage with specialist knowledge providers (e.g. universities). Firms from the transport and storage services were reported to be less likely to collaborate with universities. Yet, Tödtling et al. (2008) did not find any variation in likelihood of collaborating with universities across firms from the high-tech, manufacturing and service sector as long as the firm was involved with innovation. This also corresponds with findings from de Jong and Marsili (2006), who found that small firms collaborating with universities increasingly came from a variety of industry sectors including those that commonly are not referred to as highly innovative sectors.

Exogenous factors

Last, it has also been found that public funding determine who collaborates with universities. Busom and Fernández-Ribas (2008) found that the probability of a firm to collaborate with universities doubled when it received public support. The effect was significantly higher compared to collaboration with supplier and customers. The argument for this difference is the higher complexity, cost and risk of research projects with universities compared to suppliers and customers in general. Similar finding were reported by Montoro-Sanchez et al. (2006). Inzelt (2004) also showed that government initiatives to stimulate more R&D in industrial firms in Hungary lead to more interaction with local universities.

Table 5-5: Who collaborate with universities?

Author	Year	Journal	(1) Methodology; (2) data; (3) location; and (4) unit of analysis	Key findings
Audretsch et al.	2004	Industry and Innovation	(1) Quantitative (2) 281 firms (3) Germany (4) Firm	The paper explored the relationship between firm location and likelihood of collaborating with universities. It was found that the more generic the nature of the academic field less important is it to the firm to be located nearby the university. Yet, the firms tend to locate in close proximity to the university if they are highly dependent on transfer of human capital. The paper also found that young high-tech firms are more likely to locate nearby universities to utilise knowledge spill-overs compared to older firms
Bigliardi and Dormio	2009	European Journal of Innovation Management	(1) Quantitative (2) 98 firms (Food manufacturing equipment – mostly SMEs) (3) Italy (4) Firm	The authors found a positive relationship between collaborating with universities and product innovation measured in total turnover. In contrast, the results showed a negative relationship between collaborating with universities and process innovation measured in total turnover. Firms that introduced more new products were more likely to collaborate with universities. Those firms that collaborated with universities were often characterised by sufficient qualified personnel, sufficient knowledge and a flexible organisation structure.
Busom and Fernández-Ribas	2008	Research Policy	(1) Quantitative (2) 716 firms (manufacturing) (3) Spain (4) Firm	The paper examines the relationship between firm's research intensity and likelihood of collaborating with universities. It was found that research intensity is the most important driver for university-industry relationships. The authors interpret the result as a proof of the importance of absorptive capacity when collaborating with universities. The authors also investigated the relation between public support and formation of university-industry relationships. It was found that public support significantly increases the chances that a firm will collaborate with universities. Yet, the authors warned not to believe that public support is the only method to promote more university-industry relationships.
Gallie and Legros	2007	Economics of Innovation and New Technology	(1) Quantitative (2) Patent data (biotech) (3) France (4) Industry/firm	The paper challenged the importance of geographic proximity for knowledge spill-over in relationships between universities and biotech firms. The authors found that non-local spill-overs often were higher valued by biotech firms because they were more diverse than local spill-overs. This result underlined that organisational proximity may be more important than geographic proximity. Yet, biotech firms are often in need of more breakthrough knowledge to support their innovation than other industries.
Laursen and Salter	2004	Research Policy	(1) Quantitative (2) 2,655 firms (3) UK (4) Firm	The authors examined who collaborate with universities. They found that 73.1% of innovative firms do not collaborate with universities. Firms with existing capabilities in R&D or who have adopted an open approach to innovation were more likely to collaborate. Firm size did also increase the probability of utilising university as source of innovation.

Who collaborate with universities? (cont.)

Löfsten and Lindelöf	2002	Research Policy	(1) Quantitative (2) 134 on park and 139 off park (3) Sweden (4) Firm	The authors investigate patterns of interaction with universities differ between new ventures located on and off science-parks. On-park firms were more likely to have links to universities. There is also evidence that on-park location increases formal relationships with universities, but they still remain in numbers very low compared to informal relationships. But the more relationships to universities among on-park firms did not cause any significant difference in profitability or R&D output compared to off-parks firms.
McMillan et al.	2000	Research Policy	(1) Quantitative (2) 119 firms (3) US (4) Industry	The results indicated that biotech firms depend more on knowledge from universities than any other industry sector. In addition, biotech firms are mainly dependent on basic research from universities to support innovation.
Motohashi	2005	Research Policy	(1) Quantitative (2) 7,442 firms (3) Japan (4) Firm	89.5% of large technology-based firms (1,001 employees or more) collaborate with universities while only 23.1% of small technology-based firms (100 employees or less) reported to do so. Yet, small technology-based firms achieved higher productivity through relationships with universities than large technology-based firms. The author explained this finding with small firms have more practical goals such as developing a new product and are more willing to take risk related to radical innovation.
Quintana-García and Benavides-Velasco	2006	International Journal of Technology Management	(1) Quantitative (2) 64 firms (biotech) (3) Spain (4) Firm	The study concludes that firms' geographic proximity to universities is positive related to knowledge transfer from universities. Being located within a technological cluster with universities and other external partners also had a positive effect on extent of foreign downstream collaboration agreements. Potentially because being part of a cluster provides positive reputation and lessens perception of risk.
Schartinger et al.	2001	Journal of Technology Transfer	(1) Quantitative (2) 99 firms and 421 university departments (3) Austria (4) Firm	It was found that larger firms had a higher demand for qualified R&D personnel than small firms. They explain the result by larger firm more likely to have a R&D department. Larger firms also benefited more from universities when it came to direct input into the product development process compared to small firms. Also larger firm appeared to value benefits from consulting services from academics higher than small firms. However, there was no significant difference between how small and large firm perceived the importance of basic research to their work.
Tether and Tajar	2008	Research Policy	(1) Quantitative (2) 3,996 firms (3) UK (4) Firm	The paper explores a number of factors and how they affect likelihood of collaborating with universities. The results showed a high correlation between those engaging with universities also engaged with other sources of external knowledge. Firms that engaged in broader search strategies are more likely to collaborate with universities than those following a narrow search strategy. A high proportion of graduates as well as science and engineering professionals are found to motivate more links with universities in a study of UK firms. High technology manufacturing firms and those in technical services were the most likely engage with specialist knowledge providers (universities, consultancies and private research organisations) with less intensity amongst transport and storage services. It was also found that in-house R&D department improves the capability of the firm to undertake new product development in collaborating with universities. Variation in university-industry relationships across industries might also be explained by the science conducted at universities have become more biased in favour of certain industries during the past few decades. It is very common that science in red biotech receive a lot of government funding compared to other science fields in many Western countries. The study also highlights the importance of human capital to strengthen relationships with universities. Density of graduates from universities in the firm was positively associated with building social capital, hence, successful relationship with universities.

Who collaborate with universities? (cont.)

Tödtling et al.	2008	Technovation	(1) Quantitative (2) 400 firms (3) Austria (4) Firm	The paper investigates the relationship between type of innovation the firm is undertaking and the type of knowledge they seek from universities. It was found firms involved in more advanced product innovation were more likely to collaborate with universities. In addition, it was found that firms with internal R&D capabilities were more likely to collaborate with universities. In this study, internal R&D is also a measurement for absorptive capacity. In contrast, close geographic proximity or specific sectors had no significant explanatory effect on who collaborate with universities.
Veugelers and Cassiman	2005	International Journal of Industrial Organization	(1) Quantitative (2) 439 firms (3) Belgium (4) Firm	The study investigates innovative firms and their use of universities as source of innovation. Out of 429 firms, 325 are innovating, out of those 325 firms 27% are collaborating with universities. Only 7 firms are collaborating with international universities. Larger firms more likely to collaborate with universities. Chemical and pharmacy more likely to collaborate with universities. Larger international firms more likely to collaborate with local universities. Cost sharing is a strong motivator for university-industry collaboration. Risk-sharing is not. If risk is high firms prefer to organise innovation internally
Yang et al.	2009	Research Policy	(1) Quantitative (2) 247 firms (3) Taiwan (4) Firm	New technology-based firms (NTBFs) located in science-parks showed higher R&D productivity than those located off-park. The authors proposed that this might be because externalities are higher to NTBFs located in science-parks, e.g. technology and knowledge flow from nearby universities, access to equipment and laboratories and network opportunities. They did not find any significant difference in R&D productivity between university spin-offs and independent formed NTBFs as long as they were located in a science-park.

Obstacles to collaborate with universities

In contrast to 'why' and ´who´ collaborates with universities, a major stream of research has studied obstacles to collaboration with universities. Obstacles in this study refer to contrasts between universities and small firms that prevent these relationships from being formed in the first place. Schmidt (2008) divided these obstacles into four main categories: (1) structural and contextual, (2) legislation and regulation, (3) institutional and (4) cultures, norms and practices as barriers.

Structural and contextual barriers

Structural and contextual barriers refer to but are not limited to information asymmetries, difficulties obtaining reliable information of existing university knowledge reservoirs, low private sector market transparency, uncertainty of outcome of public research and risk aversion of private sectors (Schmidt, 2008). Fransman (2008) investigated the costs of information asymmetry that apply to large, small and medium sized and university spin-off firms collaborating with universities. He found that large firms and university spin-off firms had significantly lower transaction cost in establishing relationships with universities compared to independent SMEs. Large firms utilised their existing network to identify the needed competences and resources. University spin-offs had the advantage of having been an integral part of the knowledge base of the university before being spun-off. In another study, Schartinger et al. (2001) found that the biggest inhibitors to university-industry relationships are unclear and uncertain outcomes of basic research.

Legislation and regulation barriers

Legislation and regulation barriers cover problems related to IP rights and restrictions created by the financial market (Schmidt, 2008). Jelinek and Markman (2007) proposed that one of the biggest barrier for industrial firms to collaborate with universities is related to conflicts over ownership of IP. Among sources of contentions are deliverables, cost, timing, ownership, control, exclusivity, confidentiality, patent prosecution, maintenance and royalty fees. The difficulties and risk facing industry partners converting academic output into tangible products and services are generally beyond the realm of university understanding. Small firms, which are resource restricted and lack IP management skills, may be deterred or even avoid engaging with universities if doubts about ownership of IP exist initially (Rappert, et al., 1999).

Institutional barriers

Institutional barriers refer to complications caused by bureaucracy and inflexibility among universities, lack of commercial skills of universities, lack of adequate competences to address needs of the private sector, inadequate resources allocated to knowledge and technology transfer to industry and lack of incentives for academics to engage with industry partners (Jones, 2005; Schmidt,

2008). For example, Brimble and Doner (2007) found that the biggest impediments to set up university-industry relationships relate to immature interface for industry to contact and communicate with academic scientists and lack of reward system for academics to undertake more contact with industry and bureaucracy.

Cultural barriers

Cultural barriers involve conflicting research objectives, divergent research practices, lack of interests to commercialise research and unrealistic expectations regarding the value of their own research (Schartinger, et al., 2001; Schmidt, 2008). López-Fernández et al. (2008) refer to the conflict in research objective with university scientists who desire publication and the commercial scientists who wish to defer disclosure until appropriate mechanisms (such as patents) have been employed to protect the future economic returns of the invention.

Table 5-6: Obstacles to collaborate

Author	Year	Journal	(1) Methodology; (2) data; (3) location; and (4) unit of analysis	Key findings
Brimble and Doner	2007	World Development	(1) Qualitative (case) (2) Industry case descriptions/expert interviews (3) Thailand (4) Firm	The paper investigates obstacles for university-industry collaboration in developing countries. Firms in Thailand have traditionally not exhibited strong interest in university-industry relationships. Lack of research intensive industries. Yet, universities themselves impede closer ties to industry: Difficult for industry partner to identify appropriate person, long turn-around time because academics have other obligations, suspicion towards collaborating with industry, pure research direction not influenced by industry needs are preferred, when contact is made it is made on an individual level, which reduces the benefits accruing to the university, resources being allocated to too ambitious interfaces, such as science parks that have only shown very doubtful result.
Fransman	2008	Economics of Innovation and New Technology	(1) Qualitative (2) 13 universities and business managers (3) Scotland (4) Universities	The author investigates the cost of establishing and developing relationships with universities from the perspective of university-spin-offs, SMEs and large firms. SMEs often face greater difficulties in forming relationships with universities than university spin-offs and large firms. Large firms utilise their existing network to identify the needed competences at universities. University spin-offs have the advantage of having been an integral part of the knowledge base of the university before being spun-off. Also fewer incentives for academics to engage with SMEs that have only little financial backup and reputable importance.
Jelinek and Markman	2007	IEEE Transactions on Engineering Management	(1) Qualitative/conceptual (2) Interview with University researchers, TTO staff and industry people (3) N/A (4) Relationship	The paper outlines and presents potential solutions to manage intellectual property (IP) in university-industry relationships. The authors point out that the university-industry relationships often fail to succeed because of conflicts in managing IP. Based on explorative data, the authors suggest that more transparency and flexibility in the IP management process at universities are needed. The problem being that most universities have set rules that is based on university standards rather than industry realities. Also it is not transparent how university management determine license and royalty fees. The authors argue that the current problems managing IP lead to less industrial firms to collaborate with universities.
Jones	2005	Technovation	(1) Qualitative (case) (2) 1 case (3) – (4) Relationship	Through an in-depth longitudinal case study, the author describes how conflicts between stakeholders from university and industry led to research project not being established. While mutual interests to get involved existed in the beginning it soon after turned into a conflict dominated process with people leaving the planning stage because of disagreements. Three main factors led to the project being terminated: conflicts over the profit motive, changed objectives and micro-political activities among certain stakeholders.
Schmidt	2008	International Journal of Public Sector Management	(1) Qualitative (2) 31 firms (3) Denmark (4) Firm	The paper identifies obstacles for industrial firms to collaborate with universities. In general, obstacles to university-industry collaboration derive from differences in research objectives, lack of absorptive capacity, differences in cultures values and norms and lack of incentive structures. It was found that large firms reported less problems collaborating with universities than small firms because they had more absorptive capacity and experiences collaborating with universities. Yet, the biggest obstacle for small firms to collaborate with universities was the knowledge gab between the two different organisations.

5.3.2 *Formation*

The literature provides two major explanations to how relationships between small firms and universities are formed. The first set of explanations sees formation as a strategic process based on the resource requirements of the firm (named *strategic partner selection* in this review). The second set of explanations argues that opportunities to form relationships are a product of the firm's existing or prior relationships with universities (named *formation behaviour* in this review). In the following section, research within the two streams, partner selection strategies and formation behaviour, will be presented, discussed and contrasted.

Strategic partner selection

Within research on search, screen and selection strategies, formation of relationships with universities is seen as a rational and strategic decision making process (M. Almeida, 2008; Carayol, 2003; Fontana, et al., 2006). This is aligned with research conducted on motives to collaborate, which clearly states that small firms usually collaborate with universities for strategic and technical purposes (Motohashi, 2005). This highlights that small innovate firms are most interested in forming relationships with universities where those universities have a high level of strategic and technical capabilities and resources that complement those of the firm. Accordingly, the ability of the firm to identify and attract the right partner is considered an essential part of turning relationships with universities into competitive advantage. In contrast, forming relationship with wrong university partners may lead to relationship underperforming or holding up resources that could have been utilised more efficiently in other relationships (Fontana, et al., 2006).

Search, screen and signalling strategies

Fontana et al. (2006) translated partner selection strategies into three components: (1) searching, (2) screening and (3) signalling. Searching involves looking for potential partners through different channels, e.g. fairs, conferences and databases. Screening involves identifying and selecting the best and most suitable partner from the search results, e.g. screening patents or publications to learn about potential partner's key competences. Signalling refers to activities related to convincing prospective partner to collaborate with the firm, e.g. through project proposals or voluntarily disclosing knowledge to inform about research competences of the firm. They found that searching did not affect the likelihood of engaging with universities. Screening appeared to be positive determinant for SMEs to *establish* relationships with universities. SMEs that are involved with patenting and signalling showed *higher level of collaboration* with universities. This means that screening affected the number of relationships established and signalling affected the depth of the relationships established. These results are of significant importance in explaining formation of

university-industry relationships. While most firms are involved with searching activities, it is only those that are also involved with screening and signalling that are most likely to form prosperous relationships with universities. Yet, their proxy for measuring especially screening and signalling also has some limitations in terms of generalising the results. Some industry sectors, e.g. biotech, are known for higher level of patenting compared to ICT and service firms. Rather than signalling through patents and publications, Al-Laham and Souitaris (2008) found that a firm's centrality within its network affected its likelihood of entering relationships with universities. Central positions were a strong indication of access to and control of knowledge and resources flows in science networks.

Rational decision making, opportunity cost and research synergies

Carayol (2003) also described formation of relationships as a strategic exercise based on rational decision making upon opportunity cost versus potential research synergies. If the potential research synergies were assessed to be between the firm and the university, then the expected opportunity cost would be less. She found that a firm and an academic researcher are more likely to collaborate if the firm is pursuing explorative research and the academic researcher's preferred research activities are related to basic research. If the firm is pursuing exploitative research, then the academic researcher is more likely to reject to collaborate if he/she has achieved high excellence in academic research and is primarily focusing on basic research. For the academic researcher in this scenario, the opportunity costs are simply too high. The notion of research excellence also has some wider consequences because a firm in exploitation mode might avoid contacting the 'best' researchers (measured in publication and patents) simply because their opportunity cost of collaborating with industry are too high. Yet, in another study it was found that some industrial firms may in fact benefit more from not working with 'star scientists'. Baba et al. (2009) found that firms working with advanced material experienced less impact on their innovation output when collaborating with star scientists compared to scientists with a more applied approach. Applied research scientists appeared to be more effective boundary spanners than star scientists when it came to transferring knowledge from universities to the firm in industry sectors less dependent on fundamental and basic research.

Strategic and innovative focus

A number of studies investigate the relationship between the firm's internal innovation strategy and formation of relationships with universities (J. E. L. Bercovitz & Feldman, 2007; Harryson, Kliknaite, & Zedtwitz, 2008; Veugelers & Cassiman, 2005). The logic is here that the firms formation behaviour is affected by the strategic decision as to balance exploration of new opportunities and exploitation of existing capabilities (Harryson, et al., 2007). Bercovitz and Feldman (2007) found that firms were

spending a greater share of their R&D budget on collaborating with universities over other types of external partners if their internal innovation strategy was explorative. This was further amplified if the research conducted at the particular university was also exploratory. The authors argue that their results are showing that universities are the preferred partner when there is a high component of exploration involved in the R&D. Also they argue that exploration often requires establishment of long-term relationships because of the complexity and time required to achieve useful outcomes. Yet, choice of partner comes down to the degree of exploration in the internal innovation strategy of the firm and the amount of explorative research conducted at the respective university.

Table 5-7: Search, screen and selection

Author	Year	Journal	(1) Methodology; (2) data; (3) location; and (4) unit of analysis	Key findings
Al-Laham and Soutiaris	2008	Journal of Business Venturing	(1) Quantitative (2) 853 biotech firms (3) Germany (4) Firm	The paper test if there is any association between degree of internalisation of local network and formation of relationships with international universities among biotech firms. The findings show that if the local network is highly internationalised then it is also more likely that the firm collaborate with international universities. This is important as local universities usually provide technical knowledge primarily, while international relationships are more likely to involve knowledge that is new to the firm and needed for more radical innovation. Membership of an internationalised network leads to capability building in managing international relationships and also referrals.
Baba et al.	2009	Research Policy	(1) Quantitative (2) 455 firms (advanced material) (3) Japan (4) Industry	Prior research has often argued that industrial firms are better off by collaborating with 'star-scientists'. Yet, in this paper it is argued that this might be the case in industry sectors highly dependent on basic and fundamental research such as biotech. They sought to explore if that was any different in industries relying on more applied research. Among Japanese firms working with advanced material they found that firms working with star-scientists experienced little impact on their innovation output. Scientists with a more applied research approach showed to be the most effective partner for collaboration among the sample firms. Applied research scientists appeared to be a more competent boundary spanner than star-scientists, when it came to transferring knowledge form universities to the firm.
Carayol	2003	Research Policy	(1) Qualitative (2) 46 Relationships (3) US/Europe (4) Relationship	Define typologies for partnership between university and industry partners. They describe the process of establishing the relationships as a rational decision process consisting of research agenda. An academic would refuse to collaborate if his research agenda does not allow for any synergies to be exploited based on opportunity costs. The firm choose to collaborate with partners following an adverse selection process relying on reputation of scholar and institution to reduce information asymmetry.
Fontana et al.	2006	Research Policy	(1) Quantitative/qualitative (2) 558 firms (3) Europe (4) Firm	The paper investigated partner selection strategies for industrial firms seeking universities as partner for collaboration. It was found that screening of publications affects the probability of signing an agreement with a university. It was also found that firms that signal competencies through patenting or publishing showed higher level of collaboration.

Formation behaviour

In contrast to formation of relationships based on strategic consideration, several studies showed that formation of relationships between small firms and universities is a social process that is facilitated through the firm´s social relationships (Al-Laham & Souitaris, 2008; Motohashi, 2005). The logic is that information asymmetry challenges rational behaviour and decision making and leave firms to depend more on their social network to obtain reliable information about potential partners (Murray, 2004).

Prior partner and collaboration experience

Stressing the importance of social networks in formation of university-industry relationships, several scholars have pointed out that two firms' or organisations' direct or indirect experiences facilitate the formation of future relationships (Al-Laham & Souitaris, 2008). As a natural consequence of social interaction, a firm will tend to collect information from the partner with whom it regularly interacts. When seeking a new university to partner up with, a natural solution to the firm is to first consider partners with whom it has had prior experiences of collaboration. This is even more so, if the firm is resource restricted and high uncertainty exists about the benefits that may be derived from engaging with a specific partner (Sternberg, 1999). Al-Laham and Souitaris (2008) examined the association between degree of internationalisation of the firm's local network and likelihood of this firm to form relationships with foreign universities. They found that if there was a high representation of international universities in their local network, then there was a higher chance that the firm would also form relationships with international universities outside their local network. The presence of international universities locally, generated opportunities for the firm to learn about potential international university partners, hence, reducing search cost and information asymmetry. It also gave the firm valuable experiences managing relationships with international universities that could be transferred to manage relationships non-locally. As discussed earlier in this chapter, forming relationships between universities and small firms are not without obstacles as it can be difficult to predict future cost and benefits because of the uncertain nature of R&D, risk of inappropriate or opportunistic behaviour and the lack of clear research objectives and practices (i.e. López-Fernández, et al., 2008; Schmidt, 2008). Thus, when a firm has positive prior experiences working with a specific partner, it can be difficult to justify searching for new partners (Santoro, 2000). On the contrary, Fransman (2008) and Motohashi (2005) proved lack of experiences working with universities was a direct reason why industrial firms did not collaborate with universities.

Based on evidence from 2,354 French firms, Lhuillery and Pfister (2009) noted that industrial firms usually found it more difficult to manage relationships with universities than relationships with

suppliers. Firms that had prior experiences collaborating with universities reduced the risk of relationships failure significantly. Among more than 2,500 firms in Germany, Sternberg (1999) discovered that most relationships formed between industrial firms and universities were intra-regional and based on personal relationships between former colleagues.

Formation of relationships based on prior social relationships may even be more exaggerated among certain types of small firms. Fransman (2008) found that especially university spin-offs had an advantage over independent SMEs as they use to be an integrated part of the knowledge base of the university before being established. In this case, it is often the founder who used to be part of the academic community before creating the firms.

Murray (2004) explored the mechanisms through which academic inventors contributed social capital to entrepreneurial firms. Based on qualitative data from university spin-off firms within biotechnology she found that inventor's social capital does shape the firm's social capital by being translated into a network for the firm to leverage for on-going scientific work and long term collaboration. The magnitude of the contribution of academic inventor's social capital to the firm depends on how committed the inventor is to the firm. Furthermore, the social capital that the academic inventor was bringing to the firm was divided between the inventor's laboratory (local academic laboratory including colleagues and graduate students) and cosmopolitan network (broader co-authorship relationships, fellow researchers met during conferences etc.). Besides appointing the inventor, a firm could access inventor's laboratory social capital by employing a technician on partial or full-time basis, sponsor on-going research or position a firm technician in the inventor's laboratory. Firms gained access to the inventor's cosmopolitan network mainly through personal referrals. The result was often new research collaboration and membership to scientific advisory board, which for the firm would not be accessible without translating the social capital of the inventor into the firm's social capital. This also corresponds with other studies that discovered the importance of staff mobility and hiring students as means for building relationships with universities (Bruce S. Tether & Tajar, 2008). Ojewale et al. (2001) found that entrepreneurs/founders with higher level of education showed more awareness about capacities at universities and willingness to collaborate. These studies indicate that small firms can access prior partner experience through mobilisation of academic staff from universities to the firm.

Yet, a few studies have also touched on the implications of only relying on prior social relationships when forming new relationships. For example, Rothaermel and Thursby (2005a) argued that

ventures that had strong relationships with universities and employed academic staff to senior management positions took longer time to graduate from the incubator compared to those ventures that were managed by a non-academic senior management team. On the other hand, those ventures that did not build relationships with universities to access technical knowledge and know-how were more likely to fail. This suggest that small firms must try to avoid over- or under-socialising with universities to the extent it impedes growth.

Prior technical experience

Other scholars also found that if the firm had technical experience working with a specific technology from a specific university, then it was more likely to continue collaborating with that university (Daghfous, 2004; Guan, et al., 2005). Santoro and Bierly (2006) referred to technical relatedness, which may not necessarily mean that the original technology was developed at the host university, but that there is an overlap in knowledge stock and technical capabilities across the firm and university. Thus, technical relatedness may also determine the formation of relationships between small firms and universities. Yet, Daugfous (2004) tried to contrast the effect of prior partner experience against prior technical experience on operational benefits in university-industry relationships. He found that prior technical experience had high effects on operational benefits while prior partner experience had only moderate effects. This finding suggests that information asymmetry in university-industry relationships is often caused by divergence in technical knowledge bases across organisations rather than by organisational structures and processes. This may also relate to some of the studies that found that the risk of a partner behaving opportunistically seem to be less relevant to relationships between universities and industrial firms than between industrial firms alone (López-Fernández, et al., 2008). Yet, Daugfous' study used projects as the unit of analysis and did not take firm size into consideration. For example, a project is often more specific in regards to input and output than an ongoing relationship. Also, larger firms are more likely to have abundant resources available to use legal contracts, which reduce the risk of partner behaving opportunistically. Yet, Sherwood and Covin (2008) did not find that technological familiarity had any significant effect on knowledge acquisition success. The explanation is that highly innovative firms are at the frontier of the technological development domestically, therefore they only marginally benefit from aggregate spill-overs from local actors. These two studies proposed that especially for highly innovative firms, there is a hazard of becoming too socially embedded in local networks as it may impede learning through partners.

Partner familiarity

Sherwood and Covin (2008) found that partner familiarity had a positive effect on knowledge acquisition from universities. Partner familiarity referred to how well the firm were familiar with the organisational structures, work practices and culture of the respective university partner. Santoro (2000) found that higher levels of success generated in the past served to stimulate higher levels of collaboration with the same universities in the future.

Success breeds collaboration

Izushi (2003) sought out to investigate how the length of the relationships affect the use of public research institutions as a source of knowledge from SMEs in Japan. He found that SMEs start using the research institutions with those services that involve a lower degree of information gap to begin with. Such services include product testing and evaluation and accessing equipment and laboratories. As the firm begins to improve communication with the institutions and accumulate partner experience, they begin to use a wider range of services including those involving a higher degree of information gap including technical advice, training, workshops and joint research. In a similar way, Gonard (1999) argued that efficiency in university-industry relationship require a balance in focus between short-term industrial requirements and basic research. Yet, to set up such balance is a lengthy process where mutual demands and understandings gradually evolve. Bjerregaard (2010) also found that similar institutional logics (e.g. organisational culture, research practices and objectives) to R&D across the firm and university shaped the relationship. Overlapping or complementary institutional logics helped facilitating richer interaction between the partners. In general the author found that SMEs and universities had increasingly converging institutional logics as more SMEs where involved in publishing and patenting and more university researchers understood the challenges faced by the firm. These findings demonstrate that long-term relationships are a key factor for firms to utilise the full potential of collaborating with public research institutions. It also implicitly touches on how the firm can develop long-term relationships as a strategy towards reducing information asymmetry and building absorptive capacity over time to assimilate and exploit knowledge from external sources. While still recognising the importance of social aspects in forming relationships, Carayannis et al. (2000) argued that relationships are often formed to operate over a finite period. Montoro-Sanchez et al. (2006) found that a research project between an industrial firm and a university partner lasted 22.6 months on average.

National culture

One study also learned that national culture plays a part in formation of relationships between universities and industrial firms. In a comparison of relationship between universities and wine

producers in Italy and Chile, Giuliani and Arza (2009) found that universities in Chile were somewhat more selective (pick the winner), while universities in Italy were more pervasive. They explained the difference in behaviour with the fact that collaboration with firms was seen more as the norm in Italy, while Chilean universities would only do so if it could strengthen their research output directly. In another study, Harryson et al. (2008) explored how six firms in Europe and China formed relationships with local universities. They described the process of forming relationships between universities and industrial firms as top-down in China and bottom-up in Europe. Chinese firms put more value on university ranking when choosing a partner for collaboration, while European firms valued reputation of individual scientists higher. In these two situations, national culture and infrastructure have showed to moderate the value of prior experiences in forming relationships between small firms and universities.

Table 5-8: Formation behaviour

Author	Year	Journal	(1) Methodology; (2) data; (3) location; and (4) unit of analysis	Key findings
Bjerregaard	2010	Technovation	(1) Qualitative (2) 19 firms and 9 universities (3) Denmark (4) Project	The author sets out to explore how institutional logics of R&D practices shaped the relationship between researchers from SMEs and universities. Institutional logic refers to ways in which the differentiated contents of institutions affect both individuals and organisations. He found that overlapping or complementary institutional logic helped towards facilitating more rich interaction. Often this logic was tacit rather than written down agreements. While organisational logics often have been used to describe obstacle in university-industry relationships, it was found that SMEs and universities to a larger extent have converging logics. More SMEs are involved in publications and patenting and more university researchers understand the challenges by the firm.
Carayannis et al	2000	Technovation	(1) Qualitative (case) (2) 3 case studies of consortium. Multiple partner perspective (3) US, Germany and France (4) Consortium	The paper explores the theoretical foundation for studying formation of relationships between government-university-industry (GUI). The authors made the following observations: (1) GUI relationships are often formed to operate over a finite period. There is a need for life cycle models to identify the stages of GUI Relationships. (2) Knowledge sharing is a social embedded process, which is tied to the ability of the involved partners to engage in inter-organisational learning. There is a need for application of inter-organisational learning theory to understand the success factors in GUI. (3) GUI relationships often facilitate knowledge diffusion. There is a need for application of innovation and knowledge management theories to deal with the design and measurement of processes for knowledge diffusion.
Daghfous	2004	Technovation	(1) Quantitative (2) 120 projects (3) US (4) Project	The paper examines the relationships between the roles of prior knowledge and learning activities in technology transfer between universities and industry partners. It is found that prior technical knowledge and training and cross-functional teams are highly correlated with operational benefits to the firm. Prior organisational knowledge is only moderately correlated with operational benefits. The author suggests the following: High emphasis on experimentation and training and cross-functional teams when technical uncertainty is high. High emphasis on systematic learning when technical uncertainty is low. Establish training and cross-functional teams when organisational uncertainty is high. Acquire new skills and knowledge when organisational uncertainty is low.
Gonard	1999	International Journal of Technology Management	(1) Quantitative/qualitative (2) 32 firms (3) France (4) Firm	The paper investigates how to improve R&D efficiency in university-industry relationships. The author argues that efficiency requires a balance in focus between short-term industrial requirements and basis research. Yet, to set up this balance is a lengthy process where mutual demands and understandings gradually evolve over time. It is necessary for both firm and university to invest simultaneously in both research and commercial activities. One effective method to bringing together the two organisations are through staff mobility.

Formation behaviour (cont.)

Giuliani and Arza	2009	Research Policy	(1) Quantitative (2) 73 firms (wine producing firms (3) Italy and Chile (4) Country/firm	Through a comparison between wine companies in Chile and Italy, the authors found that the probability of forming relationships with universities where higher when the strength of firm's knowledge base and quality of university research were high (research quality measured in citation and publication in wine related publications). In Italy the situation where different. As the quality of research went up, the likelihood of that university to collaborate with industry decreased. Also the firm's knowledge base (strong or weak) did not seem to differentiate between those that did collaborate with universities and those that did not. The authors explained their results with universities in Chile being somewhat more selective (pick the winner), while university-industry relationships in Italy were more pervasive.
Guan et al.	2005	Technology Analysis and Strategic Management	(1) Quantitative (2) 950 firms (3) China (4) Firm	Based on data from China, the paper examined what types of firm collaborate with universities. It was found that only 13% of state owned enterprises and 18% of high-tech considered universities as an important source of innovation. High-tech firms were more likely to hire R&D personal from universities than state owned enterprises. This was of some surprise as state owned enterprises often were significant larger in size than high-tech firms. A possible explanation put forward was that state-owned enterprises are more likely to train and educate internal R&D staff.
Harryson et al.	2008	Journal of Technology Management in China	(1) Qualitative (case) (2) 6 firms (3) Europe/China (4) Firm	The paper explored how formation behaviour of relationships between industrial firms and universities differ between Europe and China. It was found that forming relationships with university is top-down in China and bottom up in Europe. In China, it takes longer time to establish trust with university partners. Firms also use ranking of universities in China compared to reputation of individual academic scientists in Europe. It was also found that it took longer time in China to create a win-win relationship. In the beginning the firm often had to contribute more to the relationships. Chinese professors also were less inclined to pass on top students to industrial firms.
Izushi	2003	Research Policy	(1) Quantitative (2) 264 firms (3) Japan (4) Firm	The paper investigates how SMEs can develop long-term relationships with universities. SMEs start using universities with 'low information gap' services and gradually move on to 'high information gap' services that often require more absorptive capacity. It is argued that small firms over time develop absorptive capacity and accumulate first hand information about the host university. Therefore length of relationships is a key driver to the usage of 'high information gaps'.
Monjon and Waelbroeck	2003	International Journal of Industrial Organization	(1) Quantitative (2) 1,644 firms (3) France (4) Firm	The paper explored knowledge spill-over from universities. It was found that firms engaging in formal relationships with universities experienced higher knowledge spill-over effects. Knowledge spill-over effects were also highest among firms that were involved in exploiting university inventions or technologies. Yet, the studied also found that highly innovative firms often were more likely to experience knowledge spill-over effects when collaborating with international universities than local universities. Simply, because highly innovative firms often were local champions within their technological field.
Murray	2004	Research Policy	(1) Quantitative/qualitative (2) 25 interviews with founder/inventors, patent and publication data, archival data (3) US (4) Firm/founder	The paper explores the importance of engaging academic inventors in entrepreneurial firms. It is found that firms can benefit from engaging the academic inventor in the firm, for example as an advisor or CSO. This is an effective method for transferring human capital to the firm and also eases transfer of tacit and non-codified knowledge. Simultaneously, the academic inventor also brings with him/her social capital to the firm. Through the academic inventor, the firm may get access to the inventors laboratory staff as well as wider academic network.

Formation behaviour (cont.)

Ojewale et al.	2001	Technovation	(1) Quantitative/qualitative (2) 21 firms (3) Nigeria (4) Individual (entrepreneur)	Factors promotion interaction with universities: entrepreneurs aged 30-49 more aware of idle capacities at universities compared to younger or older age groups. Higher education of entrepreneur created higher awareness and willingness to utilise capacities at universities.
Rothaermel and Thursby	2005	Research Policy	(1) Quantitative (2) 79 firms (3) US (4) Firm	The study focused at new ventures located in university incubator. In the incubator, new ventures founded to commercialise a license from universities were less likely to fail than those firms without such license. A license provided the new ventures with a strong technical foundation to start with, which also was more attractive to venture capitalists. Yet, new ventures that had very strong relationships with the university (e.g. through founder or through having academic staff in senior management) were less likely to graduate from the incubator (leave the incubator) compared to these new ventures that were led by professional management. This caused a dilemma, as having strong linkages could potentially lead to both lower probability of outright failure but also delay graduation from the incubator.
Santoro	2000	The Journal of High Technology Management Research	(1) Qualitative/Quantitative (2) 31 firms and 21 research centres and interviews (3) US (4) Firm	The author explores the association between intensity of the relationship and relationship performance. Higher levels of industry/university relationship intensity tend to produce higher levels of tangible outcomes while higher levels of tangible outcomes generated in the past serve to stimulate higher levels of industry/university relationship intensity in the future. This suggests that a spiralling interaction exists.
Sternberg	1999	Regional Studies	(1) Quantitative (2) Approx. 2,500 firms and 1,078 research institutions (3) Germany (4) Dyad/firm	The author investigates the relationship between spatial proximity and formation of relationships between SMEs and universities. He found that relationships tend to be intra-regional and often based on personal relationships between former colleagues.

5.3.3 *Managing relationships*

Relationships between small firms and universities are seen as voluntary cooperative relationship in which the participating partners are exposed to risk of opportunism. Governance is a way of creating incentives in the relationship to forbear and discourages inappropriate behaviours and conflicts and help steering the relationship in a desired direction. Yet, the efficiency and effectiveness of these knowledge activities are significantly shaped by modes of governance and governance management (Rappert, et al., 1999).

Governance mode

Within the existing literature, governance modes is described as various structures and channels through which knowledge, technologies and other resources are exchanged between small firms and universities. Tödtling et al. (2008) divided governance modes into four categories: market relations, knowledge transactions, cooperation and milieu. Kleyn et al. (2007) described six forms of governance modes relevant to university-industry relationships: Arm's length licensing, consultancy services, contract research, collaborative research, joint ventures and in-sourcing. Inzelt (2004) identified 18 different types of governance modes, but divided these into individual and institutional levels. For example, guest lectures and informal discussions were seen as individual governance modes, while access to equipment or joint research was considered as institutional governance modes. Different types of governance modes also appear in university spin-offs where universities may take equity share in return of patents or licenses transferred to the firm (Scott Shane, 2002). Other types of governance modes are also applied to transfer knowledge and specific technologies from universities to the firm, e.g. license agreements (Frank T. Rothaermel & Thursby, 2005a), mobility of staff and students from the university to the firm (Murray, 2004), accessing or creating knowledge through patents and journal publications (D. B. Audretsch, et al., 2004; Bierly III & Daly, 2007; Monjon & Waelbroeck, 2003; Okubo & Sjöberg, 2000), supervision of students (Inzelt, 2004), use of equipment and laboratory at universities (Fritsch & Lukas, 2001) and training and education (Inzelt, 2004). A firm that only collaborates with universities to access knowledge through hiring students can barely be regarded as participating in a mutual inter-organisational relationship. But at the same time, Murray (2004) showed that mobility of staff from university to firms can be classified as a mechanism to achieve relational structures as some relationships with previous colleagues, departments or even universities are maintained or developed further after the move. Such mobility may be permanent such as graduate students or academic staff taking up full-time positions in the firm or even starting up a firm, or temporary, such as industrial PhD students, academic staff taking up positions in advisory board or as external consultants or in other ways helping out the firm in shorter time periods.

The existing research has also allocated considerable attention to describing what types of governance structures are most common in university-industry relationships. Based on data from 1,800 firms of all sizes, Fritch and Lukas (2001) learned that collaborative research (22.2%) was the most common type of formalised governance structure in university-industry relationships followed by supervision (18.8%), use of equipment and laboratories at universities (16.5%) and contract research (14.9%). Among 274 Chinese state-owned large and medium sized firms and 676 privately owned Chinese high-tech firms Guan et al. (2005) discovered that the preferred governance mode was cooperative research. Schartinger et al. (2001) found that the main mode among Austrian firms to access knowledge from universities was through hiring graduate students and academic staff. Also joint supervision of PhD or master students were seen as an important method to access new knowledge and find new talents for the firm. Cassiman et al. (2008) explored the association between patents of university-industry relationships and quality based on number of forward citations. The logic applied is that patent citing science is more likely to have a stronger technological impact and therefore more likely to be cited by other patents. The results showed that patents with references to scientific publications were not likely to receive higher numbers of forward citations. But firms that were involved in publishing scientific publication (alone or with universities) in general produced patents with more forward citations. The authors concluded that firms that collaborate closer to the scientific frontier and were active in publishing in academic journals also were more likely to have the highest quality of patents.

Small firms and governance mode

More specific to small firms, Motohashi (2005) found that the most common governance structures were consultancy, collaborative research and contract research. Rappert et al. (1999) argued that small firms tend to rely more on informal relationships to receive general and specific expertise from universities. Pérez-Pérez and Sánchez (2003) discovered that university spin-off in their early beginning preferred governance structures to facilitate consultancy and cooperative research with universities, but not after the initial technology had been fully transferred to the firm. Löfsten and Lindelöf (2005) found that new ventures that were located in science parks were more likely to have formalised relationships with universities compared to off-park firms. Yet, the numbers of formalised relationships among on-park firms were still outnumbered significantly by informal relationships. Bierly III and Daly (2007) discovered that the smaller the firms were, the less likely they engaged in knowledge creation with universities, hence less likely they would engage in joint research and joint ventures with universities. Smaller firms were more likely to engage in less cost intensive governance structures to facilitate ‘free’ learning and knowledge transfer. Fukugawa (2005) came to

similar findings as he found that SMEs were more likely to engage with university scientists in less interactive spill-over channels such as technical consultations. Larger firms were more likely to engage with university scientists in highly interactive spill-over channels such as joint research. Yet, most relationships between industrial firms and universities are based on a multitude of governance modes and where some are formal while others are informal, which makes relationships between universities and industrial firms difficult to specify and quantify. For example, it is rarely that a relationship between a university and an industrial firm is based on arm's length transactions only without being supported by other types of governance modes (Agrawal, 2006).

Strategic and innovative focus dictates governance mode

Other scholars found that the innovation strategy of the firm dictated the governance structure. Bercovitz and Feldman (2007) found that firms allocating a higher share of their R&D budget to exploration type of innovation were more likely to collaborate with universities in deeper multifaceted relationships. This is also confirmed by Santoro and Chakrabarti (2002) who found that firms collaborating with universities to advance non-core technologies were more likely to choose a governance mode that allowed for intensified knowledge sharing and research support (e.g. collaborative research or joint ventures). In contrast firms that collaborate with universities around core technologies were more likely to engage in governance structures allowing for knowledge and technical know-how and information to be transferred (e.g. consultancy). It was found that large innovative firms were more likely to be involved in advancing non-core technologies and small firms in advanced core-technologies. Yet, Kock and Strotmann (2008) found that being involved in developing more radical innovation with input from universities did not make any difference to the probability of being involved in formal or informal relationships. Wang and Lu (2007) also found that choice of governance structure depended on knowledge stickiness and knowledge gap. Knowledge stickiness is based on the difficulties associated with transferring knowledge from the university to the firm. Knowledge gap refers to the differences in institutional proximity and mutual understanding that exists across organisational boundaries. When the knowledge gap is high and the knowledge stickiness is low, the firm can easily access knowledge from universities through license agreement or acquiring patents. When the knowledge gap is high and the knowledge stickiness is high, then the knowledge transfer becomes more difficult. In this situation, the knowledge provider needs to get involved actively in the transfer, e.g. through the creation of a new venture. When the knowledge gap is low and the knowledge stickiness is low knowledge transfer becomes more routine dominated and can be facilitated through consultancy or contract research. When the knowledge gap is low but the knowledge stickiness is high, the firm seeks access to specific competences at universities through contract or joint research.

Table 5-9: Governance mode

Author	Year	Journal	(1) Methodology; (2) data; (3) location; and (4) unit of analysis	Key findings
Bercovitz and Feldman	2007	Research Policy	(1) Quantitative (2) 45 firms (3) Canada (4) Firm	The paper explores how innovation strategy influences firms' level of involvement in university-based research. It is found that firms that allocated a greater share of their R&D budgets on exploration are more likely to collaborate with universities in deeper multifaceted relationships. It is also suggested that if research involve high risk to IP protection, then the firm prefer to collaborate with universities over other types of external partners.
Cassiman et al.	2008	Industrial and Corporate Change	(1) Quantitative (2) Patent data (3) Europe (4) Firm	The authors explored the association between patents of university-industry relationships and quality based on number of forward citations. The logic applied is that patent citing science is more likely to have a stronger technological impact and therefore more likely to be cited by other patents. The results showed that patents with references to scientific publications were not likely to receive higher numbers of forward citations. But firms that were involved in publishing scientific publication (alone or with universities) in general produced patents with more forward citations. The authors concluded that firms that collaborate closer to the scientific frontier and active in publishing in academic journals also were more likely to have the highest quality of patents.
Fukugawa	2005	International Small Business Journal	(1) Quantitative (2) 239 academics (3) Japan (4) Relationship	This paper looks into the pattern of interaction between university scientists and SMEs and the various university- and region-specific factors that promote interactions. University scientists with high research potential are more likely to be interacting with large firms through highly interactive spill-over channels such as joint research. University scientists with low research potential are more likely to be linked to SMEs through less interactive spill-over channels such as technical consultations. Large firms are more likely to interact with universities to enhance their long-term innovation capacity. SMEs with heavy resource constraints are more likely to exploit university knowledge to solve immediate problems in production or in the development stage. Because SMEs tend to rely on less interactive channels with university scientists, they are also less likely to retain sufficient absorptive capacity.
Inzelt	2004	Research Policy	(1) Quantitative/qualitative (2) Statistics and pilot survey and some case studies (3) Hungary (4) Society/firm	The author investigated the intensity of university-industry relationships in Hungary. She divided intensity into 18 different types of governance modes that begins with ad hoc consultations and ends with spin-off formations. She also divided the 18 types of governance modes into what level they span from between individuals, individual to institution and between institutions. Based on data from an economy in transition, Hungary, the author found that the lack of intensive collaborating between industrial firms and universities can be explained by the low level of R&D carried out by Hungarian firms. The lack is not related to the research quality or output from national universities. The author found that government initiatives to stimulate more R&D among Hungarian firms lead to more interaction with universities.
Kock and Strotmann	2008	Economics of Innovation and New Technology	(1) Quantitative (2) 142 firms (3) Germany (4) Firm	In this paper, the association between types of innovation and type of governance structure was examined. It was found that relationships with universities were of major importance for firms involved with radical innovation. Yet, the results showed that it made no difference to the probability of being involved in radical innovation if they had formal or informal relationships with universities.

Governance mode (cont.)

Löfsten and Lindelöf	2005	Technovation	(1) Quantitative (2) 74 university and 60 corporate spin-offs (3) Sweden (4) Firm	The paper investigates the patterns of interaction among different types of technology bases ventures collaborating with universities. 70 of university spin-offs collaborate with universities and 59% of corporate spin-offs collaborate with universities. University spin-offs place a greater emphasis on cooperation with universities and formal contacts with academics in the university. University spin-offs also appear to place greater emphasis upon access to R&D departments, consultants, and basic research and to R&D equipment. Maybe because these things are not available to those outside the university complex. However, these immediate benefits to university spin-offs over corporate spin-offs were not reflected in better performance.
Okubo and Sjöberg	2000	Research Policy	(1) Quantitative (2) Publication data (3) Sweden (4) Industry/firm	Industry contributed with 8% of scientific output measured on publications. SMEs, especially from engineering and biotechnology, took increasingly part in the scientific publication activities. Also the pattern in publications showed an increase in collaboration with international universities and Swedish firms. The authors argued that this trend is a consequence of the increased pressure on industrial firms to specialise and it is therefore not sufficient any longer only to collaborate locally.
Pérez and Sánchez	2003	Technovation	(1) Qualitative (2) 10 firms (spin-offs) (3) Spain (4) Firm	The paper explores how relationships between university spin-offs and universities evolve over time. Technology transfer from and network with universities decreased among the spin-offs over time. Most common activities with universities were consultancy, product development and training. Based on other research findings, in contrast to corporate spin-offs, university spin-offs reduced their relationships with the parent organisation over time.
Wang and Lu	2007	Journal of Technology Management	(1) Qualitative (2) Interviews with university stakeholders (3) China (4) Relationship	The paper explores the relationships between pattern of interaction and knowledge stickiness and knowledge gap. It is suggested that if knowledge stickiness and gap is high, then the firm should prioritise human interaction and transfer of tacit knowledge. If knowledge stickiness remains high but knowledge gap is low, then the firm should prioritise should share information and experiences in for example joint research. If knowledge stickiness is low but knowledge gap is high, then the firm is more likely to benefit from patent or license agreements. If both knowledge stickiness and gap is low, then the relationship becomes more equal and mutual dependent. The relationship will then build on trust and continuation.

Governance management

Governance management is considered crucial to maximising the advantage of collaborating with universities in inter-organisational relationships. Yet, the ability to apply and develop governance mechanisms is not equally distributed across firms. The logic is that the right balance of formal (contractual arrangements) and informal mechanisms (e.g. trust, social capital and familiarity) can help prosper a partner to behave in a desired way, which leads to more effective and efficient diffusion of knowledge and technologies in the relationship. For example, contractual mechanisms offer a mean of resolving tensions of ownership of IP as well as providing a mechanism for capturing and allocating economic benefits deriving from the IP in the relationship (Abramovskya, et al., 2009; Drejer & Jorgensen, 2005; Jelinek & Markham, 2007). Owing to the importance of knowledge sharing and learning in university-industry relationships, Santoro and Bierly III (2006) found a positive association between mutual trust and learning outcome for firms engaging with universities. Sherwood and Covin (2008) showed that trust and partner familiarity were significant factors for successful technical knowledge acquisitions. Plewa and Quester (2007) identified trust to be the strongest predictor of satisfaction with and commitment to the relationship and a strong predictor of relationship renewal. On the contrary, the wrong applications of governance mechanisms can have the opposite effect or lead to cost of managing the relationship outweigh potential benefits. Hence, managing governance mechanisms is considered crucial for small firms to develop successful relationship with universities (Rappert, et al., 1999).

Formal and informal governance mechanisms

One of the main areas of debate in the governance management literature is the increased focus at universities to commercialise own research. Where once knowledge from universities was seen as a public good, those in industry now find universities increasingly seeking value-creating relationships (see chapter 2). While most industrial firms have welcomed the increased focus on research commercialisation at universities, this has put more pressure on industrial firms to apply formal governance mechanism while at the same time continue developing informal mechanisms to facilitate the actual knowledge transfer in relationships with universities (Rappert, et al., 1999). Especially the development and implementation of formal contracts appear to be more of a challenge to small firms compared to their larger counterparts as the resources required for negotiating, monitoring and enforcing such contracts can be very cost intensive. Rappert et al. (1999) noted that small firms were in fact deterred from collaborating with universities because of the formalised procedures required. Shane (2002) also found that entrepreneurial firms were less likely to apply contractual mechanisms when collaborating with universities than other firms because they did not possess the competences required to negotiate and monitor such contracts. In

some situations, informal mechanisms may substitute formal mechanisms. Rappert et al. (1999) also found that mutual trust could act as a mechanism to govern IP. Mutual trust reduces the complexity inherent with IP by enabling the partners to set up mutual expectations about their future behaviour (Rappert, et al., 1999).

Organisational structures and capabilities

The increasing complexity for firms to manage relationships with universities has received further attention in some recent studies. Based on qualitative interviews with bio-pharmaceutical firms in UK, Kleyn et al. (2007) identified a few critical success factors in university-industry relationships. Firms that have established the appropriate organisational structures were more likely to benefit from collaborating with universities. Such structures included specialist teams to coordinate and support new R&D partnerships, dedicate funding for establishing the commercial potential of early stage technologies and the creation of more formal structures (e.g. consortia and clusters) for knowledge exchange and sharing. Firms that have implemented operational management practices were more likely to overcome problems related to IP, contractual issues, identify new opportunities and new partners. Relationships that had strong leadership were more likely to succeed. Leadership was characterised by identifying a project champion with the ability to manage and complete projects combined with a demonstration of passion, commitment and communication skills. Firms that actively developed organisational capabilities were more likely to improve the outcome of the relationship. These capabilities include absorptive capacity within the scientific field and relationship management skills. Both absorptive capacity and relationship management skills are accumulated over time though, which implies that learning from past experiences becomes a critical activity within the firm. Yet, Kleyn et al. (2007) also argued that many firms often found it difficult to use traditional contracts to enforce the relationship. Therefore the authors recommended the development of contracts that took into consideration indicators of progress in form of deliverables and milestones rather than output measures. Such contracts will establish a better foundation for dialogue and to jointly identify solutions to address problems as the relationships evolve. In a similar type of study, Drejer and Jørgensen (2005) put forward a number of recommendations to small firms on how to manage relationships with universities. Firstly, a relationship should provide room for flexibility and adaptation in research projects. Often the innovation process is characterised by a degree of muddling through where new problems or solutions occur irregularly. Secondly, creation of knowledge is a two-way process where input into the process can be difficult to determine ex-ante. Thirdly, the relationships will most likely involve parties with different expectations and objectives. It is important to specify these differences from the beginning and try to govern these differences through an agreed contract. Alternatively, the parties should rely on informal

mechanisms such as team-building, project management, trust and openness. Based on a single case study of a corporate spin-off, Harryson et al. (2007) and Kliknaité (2009) studied the tension for innovating firms to manage external exploration and internal exploitation in relationship with universities. The authors described how external exploration is managed in relationship with universities through autonomy and freedom to research candidates. As candidates come up with new break-through results relevant to the firm, these results are gradually internalised through a number of mechanisms such as on-site demonstration, seminars and face-to-face meetings. Acworth (2008) also identified a number of critical success factors required to manage knowledge communities that involved multiple stakeholders from industrial firms and universities. These factors included setting up multiple funding to ensure a fair distribution of commitment and communicate timeline, project plans and objectives among and across stakeholders.

Network management

Finally, some studies also discovered that the value of a firm's relationships with universities depends on the wider network in which the firm is embedded. Albors-Garrigos et al. (2009) learned that project in university-industry relationships were more likely to succeed if the firm kept a balance between strong relationships with customers and universities at the same time. Whittington et al. (2009) found that proximity to universities and centrality in networks in general led to positive returns on innovation, but this effect was lesser if the network was very dense and local. If the firm had a global centrality then it improved local knowledge spill-overs.

Table 5-10: Governance management

Author	Year	Journal	(1) Methodology; (2) data; (3) location; and (4) unit of analysis	Key findings
Acworth	2008	Research Policy	(1) Qualitative (2) One community (3) UK (4) Community	The paper illustrates through a case study how to form successful knowledge communities involving university and industry partners. It takes time to setup a community as it involves multiple stakeholders with multiple objectives. Among the critical success factors, the authors point out: set up multiple funding to get people more committed; geographic proximity is preferred; management and admin of the collaboration has to be made explicit; communicate timeline, project plans and objectives among the stakeholders early on; make reward structures to strengthen academic involvement; managers of the relationships much be given authority to actually manage the relationship; manage the interest level of diverse people involved, e.g. academics, PhD students, industry people.
Albors-Garrigos et al.	2009	Journal of High Technology Management Research	(1) Quantitative (2) 100 innovation project (3) Spain (4) Project	Projects were more likely to succeed if the firm kept a balance between strong relationships with customers and universities at the same time. Value of relationships with universities depends on the remaining portfolio of relationships of the firm.
Drejer and Jørgensen	2005	Technovation	(1) Qualitative (case) (2) 2 firms (3) Denmark (4) Firm	The paper explores managerial challenge to overcome barriers for industrial firms to collaborate with universities based on case studies. The authors put forward a number of recommendations: Room for flexibility and adaptation in research projects, because high uncertainty to required input and expected output exist. Dynamic creation and application of knowledge, because knowledge transfer does not only go one-way. Management of diverging interests and perspectives make a call for both formal agreements and commitment from the parties involved. Drawing up formal agreements and contracts especially for IP issues. Yet, team-building, project management, trust and openness should not be ignored. Institutional transformation is a result of long-term relationships that involve multiple actors, sources of knowledge and projects that are interwoven. Public support schemes and interventions are important both in terms of the funding possibilities and organisational framework (science parks, incubators etc).
Harryson et al.	2007	International Journal of Technology Management	(1) Qualitative/case/review (2) 1 firm (3) Denmark (4) Firm	The paper is based on the tension for innovating firms to manage external exploration and internal exploitation. Through a case study of a corporate spin-off, the authors described how external exploration is managed in relationship with universities through autonomy and freedom to research candidates. As candidates come up with new break-through results relevant to the firm, these results are gradually internalised through a number of mechanisms such as on-site demonstration, seminars, face-to-face meetings etc.

Governance management (cont.)

Kleyn and Kitney	2007	International Journal of Innovation Management	(1) Qualitative (2) Interviews of 20 TTOs and 25 informants from industry, university, TTO staff (3) US/UK (4) Dyad/firm	The explorative study identified critical success factors in relationships between life pharmaceutical firms and universities. Based on interview data, the authors identified 5 areas critical to managing university-industry relationships: (1) organisational structure, (2) operational management, (3) leadership, (4) relationship capabilities and (5) creating an enabling environment. These areas include: communicate the aims and objectives to all stakeholders, develop two-way knowledge sharing and knowledge transfers, improve organisational symmetry as universities compared to industry are less experiences in working with commercial partners, develop partnership contracts and agreements and developing metrics to measure success.
Kliknaité	2009	Int. Journal of Technology Transfer and Commercialisation	(1) Qualitative (2) Interviews with multiple stakeholders in firms and universities (3) Sweden (4) Firm	The author used the exploration and exploitation terminology to argue that innovative firms need to engage in open and closed networks with universities. She argued that the balancing act from exploration to exploitation can be seen as an act of conversion from relatively opened to more closed networks and more weak and organic ties to strong and mechanistic ties. Based on empirical evidence from a Swedish university, the author presented different methods whereby industrial firms can manage exploration and exploitation in relationships with universities. Most profoundly is the establishment of an on-campus unit to help the firm observe research progress and be a stepping stone towards internal integration of staff and knowledge stocks.
Plewa and Quester	2007	Journal of Services Marketing	(1) Quantitative (2) 207 firms and universities (3) Australia (4) Firm	The paper examined factors affecting satisfaction of collaborating with universities. Trust was confirmed to be the strongest predictor of satisfaction and commitment was the only influential predictor of relationship renewal.
Rappert et al.	1999	Research Policy	(1) Qualitative (2) 59 firms (3) UK (4) Firm	The paper examined patterns of interaction between university spin-offs, independent SMEs and universities. While both types of firms had formal relationships, informal relationships were more frequent among university spin-offs. In general relationships with universities were in many cases vital for the survival of university spin-offs but not so often for SMEs.
Santoro and Bierly III	2006	IEEE Transactions on Engineering Management	(1) Quantitative (2) 173 firms (3) US (4) Firm	The paper identifies factors that are of significant importance for industrial firms to learn from universities. It is concluded that learning from universities is strongly influenced by actions of key personal from both the university and the firm and does not happen automatically through knowledge spill-overs. Learning requires proactive measures to facilitate including social connectedness, build of trust, technical relatedness and technical capabilities. This is especially the case for learning involving tacit knowledge. Yet, the paper also concludes that university transfer IP-policies can be a significant obstacle for industrial firms to learn from universities. This is especially the case for learning involving explicit knowledge.
Sherwood and Covin	2008	Journal of Product Innovation Management	(1) Quantitative (2) 104 firms (3) US (4) Firm	Technological knowledge acquisition success is higher among firms that report having introduced a product as a result of their agreement with the university. Partner trust has a positive and significant effect on tacit but not on explicit technological knowledge acquisition success. Partner familiarity is also significant.
Whittington et al.	2009	Administrative Science Quarterly	(1) Quantitative (2) 141 firms (biotech firms) (3) US (4) Firm	The authors examined the relationship between knowledge spill-over in network and network position and geographic proximity. They found that proximity to universities and centrality in networks in general led to positive returns on innovations. But this effect was less if the network was very dense and local. But if the firm had a global centrality then it improved local spill-over.

5.4 *Conclusion on the systematic review*

The purpose of this systematic review was divided into: (1) to outline research topics within university-small firm relationships within the past decade; (2) to describe how these topics contribute to the understanding of how small firms collaborate with universities; and (3) to identify gaps in the literature that is of particular interest to explore in future studies. An outline of the research topics has been described thoroughly in this chapter and is only summarised in this section. The summary is followed by a discussion of the contribution of these studies and the research gaps deriving from the systematic review. These research gaps will also be organised according to the individual research topics identified in the meta-analysis (see section 5.3 - Presenting the evidence of the review).

5.4.1 *Summary of the review*

Outlining the research topics

This review is based on 74 articles related to managing relationships with universities from the perspective of small firms. The 74 articles have been selected following a systematic review process (Petticrew & Roberts, 2006). The evidence from the review was categorised into the following three categories following a meta-analysis (Pittaway, et al., 2004): (1) Relationship logic; (2) Formation of relationships; and (3) Relationship management. FTable 5-11 below presents an overview of key evidence within each of the three themes and related subthemes used in this review.

FTable 5-11: Overview of key evidence from systematic review

Relationships logic	
Motives	• Motives for industrial firms to collaborate with universities can be divided into five generic categories: (1) strategic; (2) technical; (3) financial; (4) educational; and (5) political related (e.g. Montoro-Sanchez, et al., 2006). • Small firms are most likely to be involved with commercialising existing technologies. Hence, they collaborate with universities to solve critical issues affecting central business areas and core technologies. They are less likely to be involved in long-term research projects with high uncertainty to outcome (e.g. Santoro & Chakrabarti, 2002). • Universities are often a source of fundamental and technical knowledge that can be difficult to substitute or imitate through internal R&D or through other types of external partners (e.g. Bierly III & Daly, 2007).
Who collaborate?	• Firm size is a strong predictor of what types of firms collaborate with universities. Yet, studies that look further into what characterise those small firms collaborating with universities, it is evident that openness towards knowledge from universities, absorptive capacity, prior partner and collaboration experiences and location all had significant power to explain who collaborate

	with universities (e.g. Motohashi, 2005). • Furthermore it was evident that small firms involved in product over process innovation were more likely to collaborate with universities. Some industry sectors also appeared to be more dependent on knowledge from universities than others but in general research found that small firms from a variety of industry sectors collaborated with universities (e.g. McMillan, et al., 2000). • External funding was also found to be a highly significant factor for industrial firms to collaborate with universities. Factors, affecting variation in 'who collaborate with universities', seem to be well covered at firm, industry and system level (e.g. Fernandez-Ribas & Shapira, 2009).
Obstacles to collaborate?	• Obstacles to collaborate with universities can be divided into structural and contextual, legislation and regulation, institutional and cultures, norms and practices (e.g. Schmidt, 2008). • Obstacles for small firms and universities to collaborate can often be explained by the differences in organisational settings between corporate and academic organisations (e.g. Jones, 2005).
Formation of relationship	
Search, screen and selection strategies	• Partner selection involves searching, screening and signalling strategies. While most firms engage in searching, screening affects the number of relationships established and signalling affects the depth of the relationships (e.g. Fontana, et al., 2006). • Best suitable partners can also be identified by assessing the potential research synergies and opportunity costs that exists between the firm and the university partner (e.g. Carayol, 2003). • In the same vein, small firms need to find a match between their internal innovation focus and what the partner university has to offer (e.g. J. E. L. Bercovitz & Feldman, 2007).
Formation behaviour	• Firms with prior experiences can lower the risk and cost of finding new partners significantly. This suggests that relationships also evolve over time as experiences are accumulated over time. Alternatively, staff mobility and technology acquisitions from universities can be seen as effective methods for small firms to get access to experiences and prior social relationships (e.g. Fransman, 2008). • Technical prior experience may also determine formation of university-small firm relationships. Small firms tend to continue collaborating with the universities wherefrom their core technology originated from (e.g. Daghfous, 2004).
Relationship management	
Governance mode	• Universities and small firms can share, exchange and transfer knowledge, technologies and resources between them through various governance modes (e.g. Fritsch & Lukas, 2001). • Small firms tend to choose less cost intensive modes when collaborating with universities such as consultancy or contract research. Some scholars argue that small firms choose less cost intensive modes because they are resource restricted and cannot afford more cost intensive modes such as joint ventures (e.g. Rappert, et al., 1999). • Other scholars argue that less cost intensive firms are preferred because they fit with transfer of technical know-how and information that is required by the firm to do incremental innovation and solve immediate problems (e.g. Santoro & Chakrabarti, 2002).
Governance management	• The existing research has identified formal and informal mechanisms to be widely applied in relationships between small firms and universities (e.g. Rappert, et al., 1999). • Formal mechanisms are in form of contract, while informal mechanisms are in form of social

constructed parameters such as trust and social capital. Evidence also shows that small firms are more likely to prefer informal mechanisms. Mainly because they cannot afford to develop and implement formal contracts, but also because the inherent uncertainty in R&D makes it difficult to specify required input and expected output in a contract (e.g. Scott Shane, 2004).

- More recent research has started to explore the diversity in competences required for small firms to actually develop governance mechanisms in relationships with universities. It often comes down to the ability of the firm to communicate with university partner, set realistic goals and objectives, allocate authority and leadership and accumulate and learn from experiences (e.g. Drejer & Jorgensen, 2005).

5.4.2 *The research gaps within university-small firm relationships*

Research on university-small firm relationships has continued to receive more attention by research scholars over the past 10 years. Although prior studies have considerably enhanced our understanding on how small firms manage to establish and develop relationships with universities, they also suggest even more research opportunities. In the following section, these research opportunities will be discussed by assessing prior research before outlining the specific research gaps.

Assessing the contributions of prior research

The topic of university-small firm relationships is still a relatively nascent research field that only recently has started to receive more systematic attention among research scholars. An assessment, however, reveals that prior research has mainly been focusing on describing:

- Features of university-small firm relationships. This includes research on motives for small firms to collaborate with universities, common governance structures and mechanisms and general obstacles for small firms to collaborate with universities; or
- Causal relationships between firm antecedents and certain relationships outcomes. For example how prior collaboration experience or absorptive capacity increases the likelihood of knowledge transfer from universities to the firm.

The strength of the first group of descriptive studies (features of university-small firm relationships) is that they generally are based on large quantitative data sets which allow for generalisation across the entire or at least a large population of small firms. For example:

- Abramovsky et al. (2009) identified critical factors determining knowledge flows in university-industry relationships based on data from 8,665 firms in France, Germany, Spain and UK.
- Motohashi (2005) contrasted why small firms were less likely to collaborate with universities based on evidence from 7,442 Japanese firms.
- Sternberg (1999) investigated patterns in forming university-industry relationships among 2,500 firms and 1,078 research institutions/individuals in Germany.

These, and other studies of the same character, have been important contributions to answering fundamental questions related to the nature of university-small firm relationships, e.g. w*hy do small firms collaborate with universities? What structures do university-small firm relationships have? What types of small firms are most likely to collaborate with universities?*

The second group of descriptive studies (causal relationships between firm antecedents and certain relationships outcomes) are to understand why some small firms are more successful with establishing and developing relationships with universities than others, for example:

- Firms with prior experiences collaborating with universities face lower transaction cost in forming new relationships with universities (Fransman, 2008).
- Technical relatedness leads to higher knowledge sharing output (Santoro & Bierly III, 2006).
- Firms located in science parks are more likely to formally collaborate with universities (Löfsten & Lindelöf, 2002).

These studies are anchored in the strategic management paradigm and contribute towards understanding why some small firms are more likely to succeed in collaborating with universities.

The weakness of these descriptive studies, however, is that they create the understanding that university-small firm relationships are determined by the firms' initial conditions. A firm's initial resources and competences might determine the long-term success in inter-organisational relationships if the internal and external contexts, in which the firm and inter-organisational relationships are embedded, are stable and predictable. In contrast, in unstable and highly dynamic contexts the initial resources and competences of small firms become less likely to determine long-term success in university-small firm relationships. The fact that small firms usually are embedded in highly dynamic and unpredictable circumstances has been pointed out in chapters 2 to 5. Based on

the extensive review from these chapters, it is proposed in this study that more attention needs to be paid to how small firms manage their relationships with universities in highly versatile environments. These versatile environments have been described as follows:

- Knowledge production for innovation is described as becoming more context dependent, which means that knowledge is never perfectly understood but has different meanings to different people depending on their background and the context in which it is applied (Gibbons, et al., 1994).
- Technological advancements are not predetermined but occur more often through iterative processes or when knowledge is combined in new and creative ways across firm boundaries (Kline & Rosenberg, 1986).
- As innovation does not follow a linear path and strategies of small firms pursuing innovation also exhibit strong non-linear properties (H. Chesbrough, 2003).
- Universities are constantly transforming to accommodate more research commercialisation (Etzkowitz, et al., 2000).
- Small firms undergo rapid technological developments which often take them through different growth stages at fast pace (E. Autio, 1997). The type of innovation undertaken in university-small firm relationships usually involve high technological and market uncertainty (R. Jensen & Thursby, 2001).

Under these circumstances listed above, it is proposed in this study that success in university-small firm is less likely to be determined by the firms' initial conditions or stay unchanged over time. A more dynamic view on how small firms establish and develop relationships with universities in versatile environments has only been applied in a few studies so far, for example: Perez-Perez's and Sanchez's (2003) study of how relationships between the host university and 10 spin-offs became more distant over time as the firms became more commercially orientated; Harryson et al.'s (2008) research on how a small firm balanced exploitation and exploration when collaborating with universities; and Acworth's (2008) identification of success criteria during the establishment of a knowledge community involving universities. These studies add considerable nuance to the more descriptive research on the features of university-small firm relationships and antecedents by suggesting that these relationships are dynamic entities not fully determined by their initial conditions (Perkmann & Walsh, 2007).

The research gaps

Although some studies have applied a more dynamic perspective to research on university-small firm relationships, it is evident from the systematic review in this chapter that they are very few (i.e. Drejer & Jorgensen, 2005; Harryson, et al., 2007; Murray, 2004; Perez-Perez & Sanchez, 2003). This leaves an important gap in the existing literature on university-small firm relationships still to be filled. Given that small firms are establishing and developing relationships with universities in highly versatile environments suggest the following opportunities for inquiry:

- **Relationship logic**

  The majority of research on motives is predominantly based on large quantitative studies from a variety of sources and locations, which contribute to strengthening the validity and reliability of these findings combined. However, the findings also appear very descriptive and to some extent over-simplifying the topic by focusing at single motives at a given point in time. More effort should be directed towards explaining how motives to collaborate with universities change over time. This is of particular interest to small firms as they progress through different technical stages at fast pace (Hite & Hesterly, 2001; R. K. Kazanjian, 1988). Given that governments also seem to have an interest in stimulating more interaction between universities and small firms, it is also of importance to understand how government policies, frameworks and funding can stimulate or manipulate the motives for small firms to collaborate with universities. So far research has only established that access to governments funding is an important factor to motivate interaction between universities and small firms (Fernandez-Ribas & Shapira, 2009; Montoro-Sanchez, et al., 2006).

  'Who collaborates with universities' has been well covered within the existing research on university-small firm relationships. The topic has mainly been subject to descriptive quantitative studies of factors distinguishing between small firms that do and do not collaborate with universities. Further research can benefit from taking a more analytical approach to who collaborate with universities by either looking at how changes to the innovation system or university structure can increase the number of small firms collaborating with universities; or looking at how small firms can overcome some of their internal limitations that prevent them from collaborating with universities (Schmidt, 2008).

  Existing research on obstacles to collaborate with universities is mostly generic and descriptive. More research is required to look into how obstacles are removed, for example

through changes to the existing university infrastructure or by improving competences in small firms (Inzelt, 2004). There is also a need for research that concentrates on small firms in particular. It is reasonable to assume that small firms experience obstacles to collaboration with universities differently than large firms, or that small firms have more difficulties overcoming certain obstacles compared to large firms (Rappert, et al., 1999).

- **Formation of relationships**

  The research on formation of relationships was divided into two streams: (1) strategic partner selection and (2) formation behaviour. When comparing the two streams, it was found that research has not yet demonstrated which stream is most effective to explain formation of relationships between small firms and universities (Fontana, et al., 2006). More research is required to contrast the two different streams and also to try to understand what factors determine whether a firm rely more on prior experiences or strategic considerations when forming new relationships (Perkmann & Walsh, 2007).

- **Managing the relationship**

  An important conclusion to be made from prior research on governance modes is the multifaceted nature of relationships between universities and industrial firms. One predicament is that the existing research on governance mode is not concise as some studies refer to the channels (e.g. journal publications) through which knowledge is transferred, others focus on the mechanisms (staff mobility) and finally some others focus on the actual structures (e.g. joint venture) of the relationships. Future research can benefit from a more disciplined division of governance mode. Another area that needs further attention is to analyse how governance modes evolve over time (Harryson, et al., 2007). Do relationships between small firms and universities apply the same governance mode at all time? Are there some patterns in how governance modes evolve over time? What are the factors determining this evolution?

In this section, general research opportunities have been identified based on the evidence from the extensive systematic review. In the next chapter, the specific research questions guiding this study will be discussed in more details.

6 The research model

In this chapter the research model and the research questions guiding the empirical work of this study are presented. The research model is created by combining insights from the previous chapters (2-5). The chapter begins by justifying the purpose for a research model to guide further research on university-small firm relationship before presenting the actual model and research questions.

6.1 The purpose of a research model

A research model can serve to outline the unique characteristics of a particular research field, legitimise a research field and give guidance on how theories and concepts can be applied and presented within this field (Parkhe, 1993). A research model provides a point of reference that can be easily communicated and understood among researchers within the research field (P. S. Adler & Kwon, 2002). A shared apprehension and language is important because it can lead to consistency in terms of defining what university-small firm relationships are and what they are not (Perkmann & Walsh, 2007). A research model serves as an essential reference point from which a research field emerges and continues to grow (Colombo & Piva, 2008).

To date, research on university-small firm relationships has lacked a research model. This is of no surprise as it was pointed out in the review (chapter 5) that the research field is still nascent. Also over the past 10 years, research on the topic has been published in a variety of different journals with most of them being multidisciplinary. This indicates that the research field is not dominated by a single theoretical or conceptual perspective. While the latter may contribute to the richness and diversity of the research area, it also constitutes a problem as university-small firm relationships have become a broad umbrella under which a mix of theoretical and conceptual perspectives have been applied. For example, it is not unusual to find aspects of strategic (Lhuillery & Pfister, 2009) and innovation management (Kleyn, et al., 2007), knowledge management (Wang & Lu, 2007), learning theories (Santoro & Bierly III, 2006), social network theories (Carayannis, et al., 2000), strategic alliances (Carayol, 2003), entrepreneurship (Yang, et al., 2009) and innovation economics theories (Inzelt, 2004) being applied to inform the research field.

As research on university-small firm relationships builds on existing theories and concepts, it can be difficult at times for a researcher to distinguish university-small firm relationships from other more common types of relationships. For example, Plewa and Quester (2007) and Rappert et al. (1999) found that trust is important to share knowledge in university-industry relationships, which is similar to findings from other more developed research field such as strategic alliances or inter-

organisational learning (see for instance Peter J. Lane, et al., 2001; or Schmid & Schurig, 2003). As it can be difficult for researchers within the field of university-small firm relationships to capture the distinctive characteristics of university-small firm relationships compared to those of others, researchers from other research fields may ask why research on university-small firm relationships needs to be considered as a distinct research field if it does not go beyond what is already known from other research fields.

It is argued in this study that the problem of distinguishing research on university-small firm relationships from other research fields can be explained by the lack of a clearly defined research model. In here a research model is simply seen as a logical structure for classifying and inter-relating the theoretical and conceptual perspectives that are significant in research on university-small firm relationships. Therefore, for a research model to stand out it has to include and make explicit the dimensions that are distinctive to the particular phenomenon it is meant to support (B-Å. Lundvall, 1992). In this study, vigorous attention has been directed to identifying and describing the most important dimensions related to university-small firm relationships.

6.2 The research model

Presenting the dimensions of the research model

From the previous chapters 2 to 5, it is possible to discern four dimensions relevant to research on how small firms can establish and develop relationships with universities. For example, it has been argued that:

- The environment in which the relationships and the firms are embedded is strongly affected by national, regional and local differences; also relationships between small firms and universities are formed based on a variety of motives and evolve in often unpredictable and unexpected ways;
- University structures and individual academic scientists do not provide uniform opportunities for industry interaction;
- Small firms vary widely and the type of actions they take or do not take are equally diverse;
- The actual university-small firm relationship may comprise various motives and different formation paths and be structured and governed in multiple ways.

In this sense, it requires a multi-dimensional approach to fully understand university-small firm relationships. Each dimension can be seen as a category defining a number of variables. In the

following section each of these dimensions and the related variables are summarised based on chapters 2 to 5.

- **The innovation landscape**

Small firms, universities and their mutual relationships are argued to be embedded in a system of innovation (Freeman, 1987; B-Å. Lundvall, 1992). It is described that a system of innovation that includes organisations/individuals, activities and institutions (culture, norms, laws, etc). There are several examples in the literature on how government policies and activities influence organisations and institutions in society to behave in a certain way, for example with the introduction of the Bayh-Dole Act in 1980 (D. Mowery & Rosenberg, 1993). It is important in this sense that a system of innovation exists at different levels, national, regional and local, which all may have unique characteristics and therefore may account for some variation in how small firms and universities interact across geographic locations (Lehrer & Asakawa, 2004). It is also important to point out that changes to the system of innovation are not only enforced by authorities (B.-Å. Lundvall, et al., 2002) but are also driven by the activities initiated by individual organisations or groups of organisations (Johnson, 2008; Marques, et al., 2006). This creates a dynamic system in which no system of innovation ever reaches an optimum or stays in equilibrium for long (Etzkowitz & Leydesdorff, 2000).

- **Universities**

Universities, as the partner to the firm, also constitute an important dimension as it has been argued that universities in general differ considerably from private organisations both in terms of the role they fulfil in society but also how they operate (Rosenberg & Nelson, 1994). It has also been argued that differences exist even among universities. As explained in chapter 3, these differences usually relate to the university mission (Mansfield, 1995), incentive systems (G. D. Markman, Phan, et al., 2005; D. S. Siegel, et al., 2003), technology transfer offices (P. H. Phan & Siegel, 2006) and the surrounding network structure (Phillip H. Phan, et al., 2005).

- **Small firms and innovation**

Small firms cannot easily be categorised into a homogenous group. Small firms are argued to vary across a number of aspects including industry sectors (Pavitt, 1984), resources and capabilities (Teece, et al., 1997) and growth stages (Quinn & Cameron, 1983). It is important to recognise these variations among small firms as they are expected to affect the strategies and behaviours towards establishing and developing relationships with universities. This has been exemplified by Fransman (2008) who contrasted cost of establishing relationships with universities between university spin-offs and independent small firms. University spin-offs were

used as a proxy for easiness of locating knowledge at universities as a result of the founders' prior social relationships with academic colleagues. Löfsten and Lindelöf (2005) compared patterns of collaboration with universities across academic and non-academic founded firms. Academic founded firms were used as a proxy for excessive scientific but moderate commercial knowledge. These studies clearly state the need for identifying variations among small firms when conducting research on university-small firm relationships.

- **The relationship**

The actual relationship between small innovative firms and universities also constitutes an important dimension in itself. In this sense the relationship is seen as a voluntary collaborative agreement between two or more parties in which they all agree to work together to achieve a common purpose or undertake a specific task. Relationships are formed for various reasons, which are explained by the motives for partners to collaborate (Montoro-Sanchez, et al., 2006; Donald S. Siegel, et al., 2004). Research also shows that there are several ways in how new relationships are formed (Fontana, et al., 2006; Izushi, 2003) and how existing relationships are managed by applying various types of governance modes (Inzelt, 2004) and governance mechanisms (Rappert, et al., 1999) to the relationships. It is assumed that decisions to manage relationships between universities and small firms affect performance for all parties involved (Parkhe, 1993).

The illustration below pictures the content and mutual relationships between the four dimensions of the proposed research model. The outer circle represents the wider innovation landscape in which universities and small firms are an integrated part of. The innovation landscape is, however, not static, but evolves constantly as organisations transforms (Giesecke, 2000), new hybrid organisations emerge (Etzkowitz & Leydesdorff, 2000) and distribution and production of knowledge take new forms (Gibbons, et al., 1994). Universities and small firms are part of forming the innovation landscape and often in dialogue with governments and other public authorities (Freeman, 1987). The mutual relationships between the innovation landscape and universities and small firms are indicated by the connecting double arrows in Figure 6-1 :

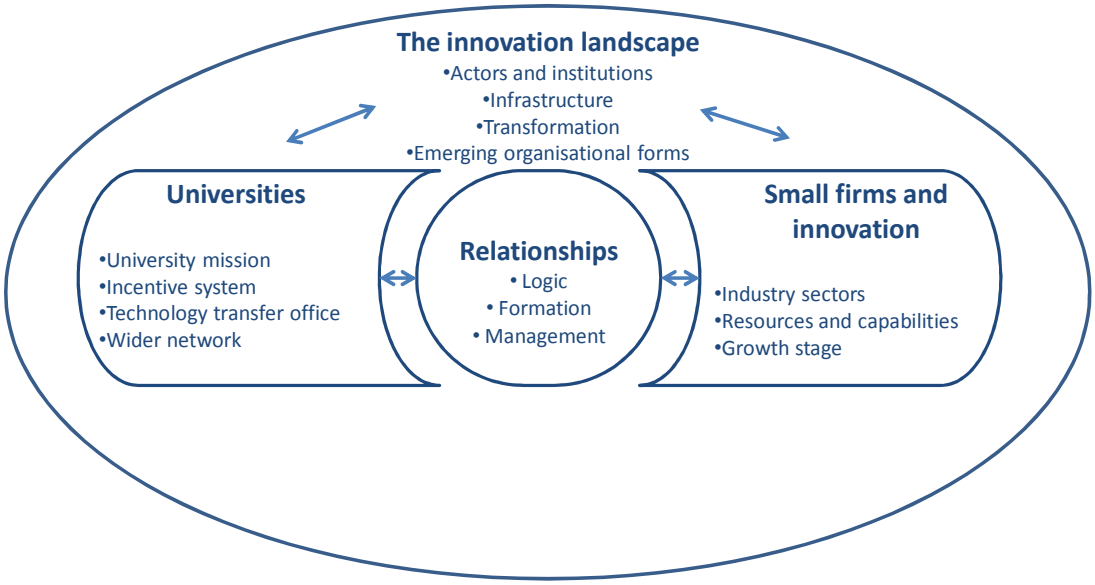

Figure 6-1: The research model

The actual relationships between universities and small firms are outcomes of reciprocal actions taken by both parties to begin interacting. The relationship is shaped directly by the strategic intent and organisational structure of both parties and indirectly by the innovation landscape. Small firms also need to respond to changes in the strategic intent or organisational structure of the partnering university. For example, many small firms are struggling with negotiating contracts with technology transfer offices (Donald S. Siegel, et al., 2003). Changes at universities may affect the nature of the actual relationships and require the firm to act based on these changes. The same situation applies to universities who also need to respond to changes in the strategic intent or organisational structure of small firms. The mutual relationship between universities and small firms in establishing and developing relationship between them is indicated by double arrows in Figure 6-1.

In summary, it is proposed in here that research on how small innovative firms can establish and develop relationships with universities should be seen through the lens of a multi-dimensional model consisting of: (1) the innovation landscape; (2) universities; (3) small firms and innovation; and (4) the actual relationships. The existence of a research model helps towards distinguishing the university-small firm relationships as a separate research field. It also provides legitimacy to the research field and gives directions and consistency for further research related to the field.

6.3 Research questions guiding the empirical work of this study

With reference to research gaps identified in chapter 5 and the research model described above, this research intends to investigate university-small firm relationships from the perspective of the firm. As small firms use relationships with universities to create, access and transfer knowledge from universities in order to enhance their own capacity to innovate (Perkmann & Walsh, 2007; Santoro & Chakrabarti, 2002), this study intends to contribute to the research field by exploring the following research question:

How can small firms succeed in establishing and developing relationships with universities?

The research question is explored in the context of small firms operating in highly dynamic and versatile environments. Knowledge production and distribution is increasingly taking place in systems of innovation (Freeman, 1987) and the undertaken processes are evolving continuously (Gibbons, et al., 1994). Organisations are required to constantly improve their abilities to develop new strategies to engage in production and distribution of knowledge (H. Chesbrough, 2003). This is not only limited to the firms' ability to develop internal R&D capabilities but also their ability to engage with and adapt to the ever-changing external environments (Etzkowitz & Leydesdorff, 2000). To make it practically possible to address the overall research question of this study, three sub-questions have been formulated. Each of these sub-questions will be addressed individually and in the chapters 8, 9 and 10 respectively. How each of these individual research questions will be approached and how they are grounded in the research model proposed above will be outlined next.

1. *How do experiences affect how small firms select which university to partner up with?*

This question addresses the conflicting explanations in the literature suggesting that partner selecting is either a strategic decision (i.e.Fontana, et al., 2006) or behaviourally determined (i.e. Frank T. Rothaermel & Thursby, 2005b). This conflict is approached in the context that small firms are born with differences in experiences collaborating with universities (falls under resources and capabilities). More specifically, this question aims to understand how different types of experiences (technical, partner and collaboration experiences) can determine strategies of partner selection.

2. *How does the increasing focus on research commercialisation at universities affect how small firms apply mechanisms to govern their relationships with universities?*

The second sub-question is focusing on how small firms and their application of governance mechanisms are affected by universities becoming increasingly commercially orientated. As universities are becoming more commercial orientated, the need for more formalised university-small firm relationships has increased. Prior research has pointed out that small firms often are disadvantages by the increasing focus on research commercialisation at universities (Donald S. Siegel, et al., 2003). Small firms often do not have the financial resources to acquire intellectual property from universities. At the same time, they often prefer to collaborate informally with universities around knowledge sharing and transfer (Rappert, et al., 1999). This paper aims at exploring how small firms adapt their governance mechanisms to these new circumstances. The question is explored in the context of universities becoming increasingly commercially orientated and how that affects the practices for how small firms govern their relationships with universities.

3. *How can small firms use their social capital to continue capturing value in the relationships with universities?*

This question is explored by applying a social capital perspective (a firm-specific resource). Prior research shows that existing social capital is a pre-condition for small firms to collaborate with universities in the first place (Fransman, 2008); or social capital leads to increased knowledge sharing and learning and better relationship performance in general (Murray, 2004). This paper builds on these studies to understand how small firms with no or only little social capital can develop such capital but also how social capital, if not managed appropriately, over time can lead to inertia or turn university-small firm relationships into social liabilities. This question is explored in the context of how social capital and growth stages affect strategies of small firms to manage their relationships with universities.

Each of these research questions will be addressed in chapters 8, 9 and 10.

7 The empirical process

In the previous chapters relevant literature was reviewed which led to the synthesis of the conceptual framework and research questions guiding this study. In this chapter the empirical process of this study is explained and justified. This includes the research design, data gathering and data analysis of the empirical work.

7.1 Introduction

In the previous chapters relevant literature was reviewed that subsequently led to the development of the research model and the research questions guiding this empirical work. In this chapter the empirical process is explained. This process includes deciding upon a research design that subsequently guides the selection of participants and the collection and analysis of the data. Each of these topics will be described more in details in the following sections.

7.2 The empirical research design

The choice of research design applied in this study to a large extent has been determined by how the study has progressed from its outset. Considering the aim of different research designs, *deduction* often aims at testing or evaluating theory through an empirical sample, while *induction* traditionally aims at developing theory through an empirical sample (E. G. Guba & Lincoln, 1998). The research design applied to this study is neither purely deductive nor inductive but more a combination of those two. The combination consists of going back and forth between theory and empirical data in iterative steps as described by Dubois and Gadde (2002) and Kirkeby (1994). The iterative steps of deduction and induction applied to this study first involved developing the research model and subsequent research questions from the existing literature on the university-small firm relationship (deduction). The next step involved refining and developing new conceptual understanding from empirical studies (induction) and finally combining the research model with the empirical studies and theory to develop new understanding (deduction and induction) (Dubois & Gadde, 2002). Therefore to understand the research design in this study, it has been deemed important to describe at what stages existing theory and empirical data have been integrated into the study.

Background to this study

This section is dedicated to describing the rationales behind choosing an explorative research design to guide this study's empirical work. At the outset of this study, I (the researcher) began investigating the research phenomenon (university-small firm relationships) by first of all reviewing

existing research but also through dialogues with practitioners working within this field.[7] For the review part, this later on turned into four review chapters and the subsequent research model and research questions guiding the empirical part of this study. The dialogues with practitioners (e.g. academics, business owners, journalists, technology transfer officers, commercial officers etc.) were mostly used to broaden the researcher's understanding of the research field in the early stage, to get a sense of what problems actually do exist 'out there' and to what extent these problems could actually be researched.

Use of existing theory and research model

As this study progressed, it was found that research on university-small firm relationships had started to substantiate in the literature. Especially over the past 10 years the number of articles published in peer-review journals on the topic has continued to increase. The researcher decided to do a thorough review of prior research within and related to university-small firm relationships. This review includes input from diverse disciplines such as innovation economics, innovation and strategic management, business networks, SME and entrepreneurship (see chapters 2-5). The objective for the literature review was to identify and argue for research gaps and to develop a research model. This part was theoretically driven (Dubois & Gadde, 2002). In the same sequence it was claimed that the research model was not finalised but only served as a reference point from which future research on university-small firm relationship evolves. As a result subsequent research questions were formulated. It is useful to restate the overall research question here: *How can small firms succeed with establishing and developing relationships with universities?*

Use of empirical data and theory

Answering the overall research question of this study is seen as an attempt to reconceptualise and extend theory on university-small firm relationships (Danermark, 2001). In other words, it is argued that the research phenomenon is well-defined but not completely understood. This is represented by the research model in this study, which only represents a snapshot in time of what is known at present about university-small firm relationship. To advance the research model more empirical and theoretical evidence is required (Dubois & Gadde, 2002; Eisenhardt, 1989). The contrast and comparison of empirical and theoretical evidence is necessary to develop further understanding. Empirical data might lead to new insights into the research phenomenon. Eventually this leads to a refinement of the research model (Crotty, 1998; E. G. Guba & Lincoln, 1998; Sturman, 1997). This

[7] None of these dialogues have been included as formal evidence in this study. These dialogues have purely taken place as a natural part of the researcher being surrounded by people having an interest in, working with or being part of university-small firm relationships.

process takes place in iterative steps, which involve going forth and back between theory and empirical data (Danermark, 2001; Dubois & Gadde, 2002). Such an approach of first developing a research model and then extending the model through empirical and theoretical studies is especially useful when reconceptualising and extending theory (Burawoy, 1991). The approach has also been described to increase the quality of using empirical data to develop new theory as it takes place in the form of iterations between the theoretical and empirical world (Dubois & Gadde, 2002; M. Miles & Huberman, 1994). The process of comparing and contrasting theory and empirical evidence also leads to improved internal validity and raises the creditability of the new theory being developed (Eisenhardt, 1989)

In this study, these iterative steps of combining and contrasting empirical and theoretical evidence to extend the understanding on university-small firm relationships take place in the individual research papers (see chapter 8). Each paper draws on different empirical and theoretical data, which is described in detail in each of these papers. While each paper produces its own conclusion, the contributions of these individual papers to the refinement of the overall research model are described in the final chapter of this study.

7.3 The empirical data

As part of a more explorative research design, several scholars argue that rich data are more likely to inform on the proposed research phenomenon and extend theory. In this section, it will be described in detail how the method for selecting participants for this study was chosen and what data was collected.

7.3.1 *Selecting the participants*

In this study a theoretical rather than random sampling approach was used to select the firms to be included as participants (Denzin & Lincoln, 1998). Theoretically sampling also allows the researchers to choose participants who are likely to expand or replicate the emerging theory (Eisenhardt, 1989). It is important to note that explorative studies based on theoretical sampling are not representative for all university-small firm relationships. Besides that each firm has to be or to have been involved in relationships with universities, some appropriate population control variables were defined to ensure some similarities across the participating firms for later analysis:

- **Firm size** – Firm size is an important parameter for choosing case studies as it is assumed that small firms are resource restricted compared to larger counterparts (Hunt, 2004). An increase in size is more likely to be accompanied by larger technological, market and

geographic scope (P. Almeida, et al., 2003). Most commonly *a small firm* is defined by the number of employees or turnover, but even these definitions vary from country to country and from study to study. In the European Union small firms are defined as having between 10-49 employees while micro firms are normally limited to a maximum of 9 employees (OECD, 2005). In US, small firms are often defined as having between 1-999 employees (Pavitt, 1984).[8] For the purpose of this study small firms are defined as having between 1-49 employees.

- **Ownership** – Ownership is related to resource access. It is argued that small firms being subsidised through a parent company might apply different patterns of interaction because they can afford it and because they have been instructed to do so (Fontana, et al., 2006). The proposed research will leave out firms owned partly or wholly by parent companies.

- **Manager available for interview –** the managers must have been involved personally in the process of establishing or maintaining the patterns of interaction with the public collaboration partners. To ensure accuracy in the gathered information a criterion is introduced that the managers interviewed are involved in day-to-day operation of the company.

The above criteria are intended to ensure a consistency among the participating firms used in this research. The participating firms were selected through personal referrals from people working in the space between university and industry (e.g. commercial directors, technology transfer officers, managers of science parks and incubators and investors) (Yin, 1994). It should be noted that it was not possible to gather any information about the total population from which the participating firms were chosen. While most but not all universities publish commercial results (e.g. spin-offs created, patents filed, license agreements signed) there seems to be no data available to suggest the actual numbers of small firms that collaborate with universities formally and informally.

A total number of 30 firms were selected for this study. An essential part of explorative research is a reliance on multiple sources of data for each firm (Yin, 1989). Sources for the participating firms may include but is not limited to interviews, documentation, observations and statistical and quantitative

[8] Financial figures have also been used to define small firms. The European Union defined small firms to have an annual turnover no more than EUR 10 million while micro firms should not exceed EUR 2 million (OECD, 2005). Yet, turnover requires the firm to have products on the market and is therefore not suitable to differentiate small innovative firms that often spend up to 10 years to develop their first product.

data (M. Miles & Huberman, 1994). Collecting data from multiple firms and multiple data sources also improves the validity and reliability of the empirical work (Yin, 1989).

7.3.2 *Collecting the data*

This study involves both primary and secondary data. This section will describe more in detail how data was collected.

Primary data

The 30 firms were interviewed face-to-face over a period of 16 months from May 2006 to August 2007. All the interviewees were founders or managers (usually chief executive officer, chief operation officer or chief scientific officer) of the participating firm. The aim was to seek information from the individual or individuals in the participating firms that were most experienced and knowledgeable to answer the questions asked in relation to the topic of this study. Managers are best able to answer questions about how and why relationships were formed with universities. Strategic choices, rationales, behaviours, considerations and knowledge about mistakes only reside with the manager and do not occur in written forms or articulated forms (E. G. Guba, 1990). Each interview lasted between 1 and 2 hours and all interviews were recorded to ensure accuracy when later transcribed and analysed (M. Miles & Huberman, 1994).

A semi-structured interview guide was developed and used during each conducted interview. The topics in the interview guide was mainly developed from the meta-analysis in the systematic review and covered:

- Motives to collaborate with universities;
- Formation and partner selection issues;
- Governance structures and governance modes;
- External environment.

The questions related to the topic were organised in a logical manner according to how relationships normally are established and developed. The interview guide also included an opening section with questions related to the nature and background of the firm. The semi-structured format of the interview guide allowed for more in-depth and open-ended questions to be asked throughout the interview without losing structure and course disorganisation of data (M. Miles & Huberman, 1994).

The use of an interview guide also improves research reliability (Yin, 1989). The complete interview guide is included as appendix 12.1.[9]

The interviews took place in two stages:

Stage 1. Preliminary interviews involving 6 small firms located in Odense (Denmark).

Stage 2. Main interviews involving 24 small firms located in Odense and Copenhagen (Denmark) and in Auckland and Dunedin (New Zealand).

The stage 1 preliminary interviews were conducted in May 2006 and involved 6 small firms. A pilot study may reveal deficiencies with the original research design that can be solved prior to the main study (Benbasat, Goldstein, & Mead, 1987; Maxwell, 2005). In this study the preliminary interviews were important as they helped towards streamlining the interview process to ensure consistency. Consistency is important in a multi-interview setting where interview data are compared and contrasted as part of the analysis (M. Miles & Huberman, 1994). The preliminary interviews were also more explorative in nature compared to the main interviews as they allow for unexpected topics to emerge that need to be incorporated systematically in the research design. Based on the preliminary interviews, however, only smaller changes were made to the interview guide and overall design. These changes were mostly related to putting more emphasis on the processes and dynamic aspects of establishing and developing university-small firm relationships through descriptive and detailed examples. In general the preliminary studies did not vary much from the later main interviews and were included as evidence base in this study on equal terms with the remaining interviews. Only in two of the preliminary interviews, follow-up interviews were conducted to ensure consistent interview procedures had been applied across all interviews.

The main interviews involved additional 24 small firms. The purpose of the main interviews was to continue collecting more evidence to add depth to the evidence base (Denzin & Lincoln, 1998). The depth was produced by interviewing a variety of small firms with different backgrounds, industry belongingness and locations. This is an important step towards sharpening the external validity in

[9] It is the policy of the University of Auckland, that all staff or student research that involves human participants must receive approval by the University of Auckland Human Participants Ethics Committee. According to this policy, the research must inform the participants of the purposes of the study and potential conflicts of interests in a 'Participant information sheet'. The research must also provide the participants with a 'Participant consent form' to be signed by the participant. Copies of the Participant information sheet and consent form are included in appendix.

explorative research (Eisenhardt, 1989). Despite including a variety of firms it was decided by the researcher of this study that collecting additional evidence after these 24 interviews would most likely only add bulk to the existing evidence base rather than generate additional insight (M. Miles & Huberman, 1994). The actual procedure applied in this study to control for saturation of evidence is discussed in section *Coding the data*.

Secondary data

Secondary data consisted of information from corporate websites of the participating firms, newspaper archives and university newsletters. Secondary data was used by the researcher as background information for each participating firm before going into the interview. Company websites usually described the purpose of the firm, key products and services and historical information (e.g. how the firm was founded). In some cases newspapers and newsletters contained information about breakthroughs, formation of strategic partnerships, fund raising or other important milestones achieved for the anticipating firms. In general, documentation also enabled factual verification of events and activities covered in the interviews (Yin, 1994).

The challenge, however, was that the amount of secondary data available varied considerably from firm to firm. Some firms had well developed websites, appeared often in public media and appeared to work actively with public relations. Others only appeared sporadically in both online and offline media. To ensure some consistency in what type of information was collected, and to make sure that what was collected could be compared across all firms, it was decided to use secondary data as factual data about each firm. These factual data was later turned into numerical scalable or discrete variables. An overview of factual data collected through secondary research is given in Table 7-1.

Table 7-1: Overview of factual data

	Description	Value
Country	Denmark or New Zealand	Discrete
Firm location	Odense, Kgs. Lyngby, Copenhagen, Auckland or Dunedin	Discrete
Located in science park/incubator	Yes or no	Discrete
Employees	1-9 or 10-49	Numeric
Year of establishment	'year'	Numeric
Founder	Inventor, entrepreneur or investor	Discrete
Type of firm	Direct spin-off, indirect spin-off or independent	Discrete
Stage of product development	Research, development or product on market	Discrete
Origin of initial technology	Internal or external	Discrete
Product on market	Yes or no	Discrete
Industry	Bio-tech or high-tech	Discrete

For almost every firm this information was publicly available before the interviews. Missing factual data from secondary data were collected through primary data.

7.4 Data analysis

In the following section it will be described more in details how the choice of a thematic method affects the analysis procedure of this study. The procedure is divided into four sections: (1) Method for data analysis; (2) preparing raw data; and (3) coding the data.

7.4.1 *Thematic analysis*

In this section it will be argued for the relevance of applying a thematic method to analyse the empirical data. Thematic analysis is a method often used to analyse qualitative data where it is mainly of textual character (Boyatzis, 1998; Joffe & Yardley, 2004). Thematic analysis can be applied inductively, deductively or as a hybrid of the two (Boyatzis, 1998; Fereday & Muir-Cochrane, 2006). Thematic analysis focuses on the search for themes that emerge as relevant to the phenomenon being researched (Joffe & Yardley, 2004; M. Miles & Huberman, 1994). A theme can be described as a pattern in the data where the pattern tells something about the theme or the pattern makes up the theme (Boyatzis, 1998; M. Miles & Huberman, 1994).

In this study, a hybrid thematic method has been chosen that incorporates both theoretical and data driven themes (Boyatzis, 1998; Joffe & Yardley, 2004). The deductive part of the thematic analysis originates from the meta-analysis in the systematic review in chapter 5 and the specific research question in chapter 6. The deductive part of the thematic analysis also integrates the research model and research question into the analysis (Eisenhardt, 1989). The inductive part of the thematic analysis consists of allowing new themes to emerge directly from the empirical data (Boyatzis, 1998). While deductive data analysis helps towards keeping the researcher focused on the specific research topic being researched, the obvious downside of deductive thematic analysis is of course that the researcher is less likely to observe unexpected themes (M. Miles & Huberman, 1994). There is no obvious solution to this trade-off besides being aware of advantages and disadvantages of both deductive and inductive thematic analysis and try to balance them. In this study, the use of computer software program, NVivo, has assisted with keeping such a balance. NVivo operates with different types of categories of themes, which makes it easy to keep control of what are expected and what are emerging themes.

7.4.2 *Preparing the raw data*

The data in this study came from interviews and documentations. The interview data was recorded on a digital recorder and transcribed into text (Microsoft Word format). All interviews were of reasonable quality which did not cause any passages being inaudible. Pauses and natural fillers during the interviews were eradicated from the text version of the interview. Data from secondary sources were copied/pasted from its original format into a single text document for each case. Data from websites followed the same procedure and was also copied/pasted into a single text document. It was of particular importance to store the information from websites around the same time as conducting the interviews as it is common practice to update a website regularly. The average length of each interview transcript was approximately 10,000 words and 30 pages long. Secondary data normally reached approximately 3,000 words and 9 pages long. In total approximately 400,000 words and 1,250 pages of raw data were generated. Finally all raw data was imported into NVivo. In NVivo raw data is treated as *sources.* In this study each firm therefore had three *sources* and their hierarchical structure is displayed in Figure 7-1:

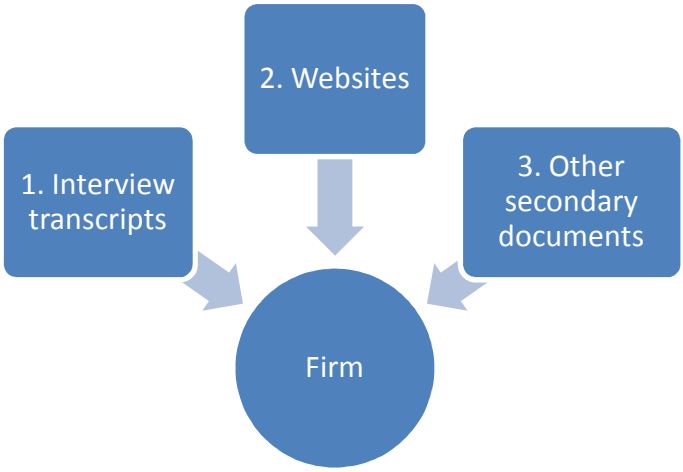

Figure 7-1: Hierarchical structure of data sources in NVIVO

The advantage of this hierarchical structure is that all evidence can be traced back to its original source easily.

7.4.3 *Coding the data*

The next step in the analysis process involves coding the raw data. Coding refers to the process of dividing facets of the available data into themes which are labelled (coded) (Bryman & Brugess, 1994; M. Miles & Huberman, 1994). The coding process is not the analysis itself but a preparation to make the analysis process more manageable (Bryman & Brugess, 1994).

Use of computer software program (NVivo) to support qualitative data analysis

The use of computer software programs to support qualitative data analysis has become increasingly common in qualitative research today (Bringer, Johnston, & Brackenridge, 2004). Software provides a particular advantage when a research project involves a substantial amount of evidence that needs to be organised and analysed. Especially if the alternative is to manage data manually by photocopying, cutting, highlighting and coding by hand. In this study, the data analysis process is assisted with NVivo developed by QSR International. NVivo is the successor to NUD*IST (Non-Numerical Unstructured Data Indexing Searching and Theorising), which also has been used widely in qualitative research prior to the release of the more sophisticated NVivo version (M. Miles & Huberman, 1994). The advantages of using computer software programs to support qualitative data analysis related to better analysis and efficiency (Bringer, et al., 2004). For the purposes of this study the benefits of NVivo to assists with data analysis relates to:

- Back up;
- Save time on organising and handling data;
- Enhance consistency and transparency in the text analysis.

Backup of data is one advantage of using software to assist with qualitative research to protect data from theft and loss. Saving an electronic file of data and up-to-date progress also makes it easier to collaborate and share data with colleagues and retrieve and increase the capacity of data that can be handled (Richards, 1999). NVivo also offers functionalities that enhance consistency and transparency in text analysis. These functionalities include keeping a research journal, writing memos, backtracking data to original sources and making changes in codes (e.g. categorisation or rename) consistently across the whole data set. Handling consistency and transparency manually is possible but time consuming and may lead to errors as the amount of data increases (Bringer, et al., 2004).

Yet, software that assists in qualitative research has also been subject to critical voices as it has the potential to turn qualitative research into rigid and automated analysis (Kelle, 1995). Software programs such as NVivo include functions such as automatic coding of single words and phrases and frequency counts, which may be thought of as substitutes for pertinent interpretations of rich data (Woodman & Hardy, 2001). In this study, automatic coding and frequency counts have not been used as it would not bring any insight into the actual process of how small firms establish and develop relationships with universities. Relevant evidence related to this topic is to be found in rich data that include examples of what actually happened in the relationships and by understanding the contextual settings (Yin, 1989). Bringer et al. (2004) state that software only assists in the process of

analysing data. The researcher is still in charge of interpreting, conceptualising, examining relationships and developing theory from the data set. Another concern raised by research scholars relates to the nature of computer-aided software. These programs were first developed for researchers doing grounded research (Kelle, 1995). However, newer versions of computer-aided software programs (such as NVivo) also include tools suitable for more deductive approaches (Bringer, et al., 2004). These tools include creating initial codes based on theoretical concepts and propositions that can be linked to documents and nodes and even refined by attributes (e.g. attributes of small firm or the actual relationship). These tools that have been applied to this study and will be explained in details later on in this chapter.

Coding in NVivo

NVivo offers a distinct coding system that compensate for some of the challenges related to keeping a balance between existing and emerging concepts. Codes in NVivo are called Nodes and can appear in many forms (nodes, cases, relationships, attributes and matrices) but in this study the analysis is mainly built up around five types of codes:

- **Free nodes** are created ad-hoc and are free of the organisation. Usually used for emergent or 'stand-alone' themes;
- **Tree nodes** are catalogued in a hierarchical structure and are used for more substantial or theoretically driven themes. Tree nodes are also referred to as parent nodes;
- **Child nodes** are more specific sub-themes under the tree nodes (or parent nodes) and therefore follow the hierarchical structure dictated by the tree nodes;
- **Siblings** are used as a category of nodes under a child node.
- **Attributes (dimensions)** are used for more numerical scaled data. Attributes are particularly useful when comparing and contrasting data sets across discrete variables. Attributes are given a value that is normally numerical or discrete.

Figure 7-2 shows a screen-shot from NVivo with tree and child nodes. The tree nodes are the main categories (firm characteristics, founder characteristics, establishing the firm and so forth). Under the tree node *governance mechanisms* a child node *formal governance mechanism* has been created which includes sibling nodes in the form of *collaboration agreement, contract research, employment contract* and so on. Free nodes are not included in the hierarchical structure of tree and child nodes but are kept in a separate folder. The actual process of creating codes and coding will be discussed in the following sections.

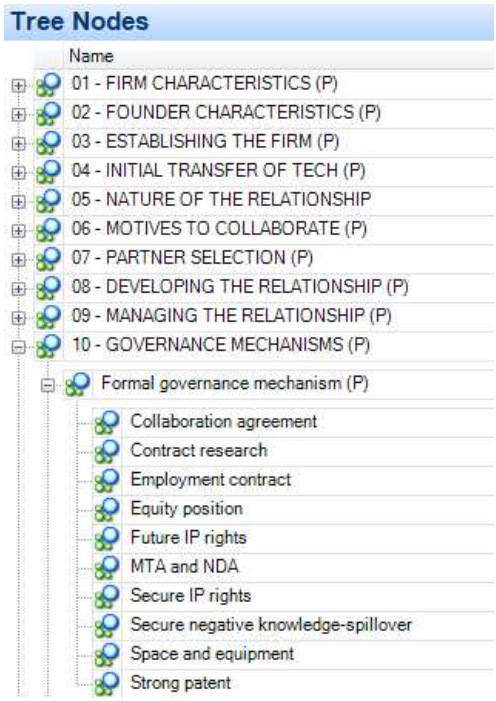

Figure 7-2: Screenshot of node structure in NVivo

In NVivo attributes are stored in a separate cashbook, which allows the researchers to single out one or more attributes at a time and compare and contrast codes across these attributes. For example, how do firms with 1-9 employees compared to firms with 10-49 employees select university partners. Number of employees represents a value attribute and partner selection represents a node. In NVivo, there is no limit to the number of attributes created. Also attributes can be developed prior or during the analysis.

Theoretical coding (pre-coding)

Part of using a hybrid thematic method to data analysis involves creating pre-codes based on theory (Hsieh & Shannon, 2005). The pre-coding largely followed the meta-analysis in chapter 5 that subsequently was used to structure the interview guide (M. Miles & Huberman, 1994). Yin (1989) describes a similar process with codes being created initially based on theoretical propositions and causal relationships. The pre-codes defined in this study were theory-driven (compared to data-driven) based on the themes in the interview guide and research questions (Gibbs, 2002). To be able to differentiate these codes from codes developed later on, I added a letter 'P' after the name of the code to indicate it is pre-coded *[name_of_code (P)].* This would make it easier to compare existing concepts with new concepts later on in the process of analysis.

Glaser and Straus (1967) argued that pre-coding may limit the researcher because the researcher will be looking for existing concepts rather than new concepts. While this is true, pre-coding also helps keeping the researcher on track and not too easily being distracted by interesting and emerging themes unrelated to the original purpose of the research (M. Miles & Huberman, 1994). However, as the list of *pre-codes* indicates, each *pre-code* more or less works as an empty bucket where new concepts are allowed to emerge. Therefore *pre-codes* were all created as *tree-nodes*, which allow for sub-categories to be formed under each main node (different from free nodes, which do not allow for sub-categories to be formed).

Emerging codes

An important part in explorative research is to extend existing knowledge by looking for emergent themes in the collected evidence (E. G. Guba, 1990). Miles and Huberman (1994) emphasises the following techniques for letting new knowledge emerge throughout the analysis process:

- **Bridging** – seeing new or previously not understood relationships within units of a given category.
- **Extension** – returning to materials coded earlier and interrogating them in a new way, with a new theme, construct or relationships.
- **Filling-in** – adding codes (or sub-codes), reconstructing a coherent scheme as new insights emerge.
- **Surfacing** – identifying new categories.

In this study all four techniques were used widely. Bridging was usually applied when emerging relationships between two or more nodes or attributes started to appear. To begin with, the researcher used the memo function in NVivo to describe the emergent relationship in details. The memo function also allowed the researcher to link the original sources or nodes to the memo, which helps with tracing back the evidence (see Figure 7-3 for an extract of memos created in NVivo).

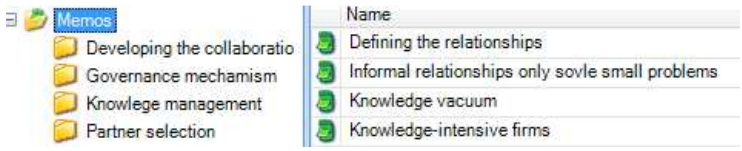

Figure 7-3: Extract of memos created in NVivo

Extension was used when new emergent themes (free nodes) substantiated. The free nodes were then converted into a tree or child nodes. If an emergent theme was established as a child node within an existing tree node, then all evidence already allocated to child and sibling nodes were re-assessed to make sure the new node did not overlap with existing nodes. Filling-in was used when existing codes became overloaded (a lot of evidence assigned to a single code) and needed to be divided into sub-codes (children and siblings nodes). Surfacing related to the creation of free-nodes.

Code saturation

Saturation is referred to as the point in time when bringing in new data to the research reaches diminishing return or nothing new is being added (M. Miles & Huberman, 1994). Charmaz (2003) explains that saturation is when new data fits into categorises already devised, which also indicates data comprehension and completeness. Saturation also helps towards determining the sample size, as there is no need for collecting or extending the existing sample size if saturation has been reached (Strauss & Corbin, 1998).

It can be difficult to determine when saturation has been reached. Often this comes down to the subjective judgement of the individual researchers (M. Miles & Huberman, 1994). Bowen (2008) referred to different techniques. For example, a code category was considered saturated if it is reflected in more than 70% of the interviews. Another technique relates to when the same comments from different participants in different contexts are repeated. Both techniques can be difficult to manage in practice.

In this study saturation was treated as no new codes were created from bringing in more data. The control of new codes created was carried out through regular 'stock-takes' in NVivo. A stock-take is as simple as printing out a full list of all nodes (free, tree, child and sibling nodes) and comparing it from time to time against earlier generated lists.[10] In this study it was chosen to do a stock-take for approximately every 8th firm coded. A stock-take was conducted after 8, 15, 23 and 30 firms had been coded. It was evident that the number of new codes created was the higher between 8 and 15 compared to between 23 and 30. This was a sign that a satisfactory level of comprehension and completeness had been reached in this study.

[10] A stock-take list in NVivo is created by going to the nodes overview, right click and choose print list.

7.5 Chapter summary

This chapter intended to describe the empirical process. The empirical process, however, is tightly knitted with the overall design of this study and therefore cannot be completely accounted for without reference to the overall structure of this study.

The first part of this chapter explained how the empirical design of this study was developed through a process of awareness and recognition of the research topic and its challenges through initial review studies and dialogues with stakeholders working within the field of university-small firm relationships. The research then proceeded through theoretical studies, which eventually led to the development of the research model and the subsequent formulation of research questions.

These initial steps have been highly influential for the choice of research design. The actual research design is based on comparing and contrasting empirical and theoretical evidence with the aim of developing a new theory towards refining the research model. As such the research design consists of inductive and deductive elements taking place as iterative steps throughout the empirical process. This is also reflected in how the participating firms were selected and how, data collected was and analysed. The participating firms were selected through a theoretical sampling and consisted of 30 firms. These firms were interviewed following a semi-structured interview guide. The guide included themes originating from the systematic review, but also allowed for more open-ended themes to emerge. The analysis followed a hybrid thematic analysis method, which also incorporated both existing themes (deduction) and emerging themes (induction) to co-evolve.

The actual analysis and the interpretation of findings take place in the chapters 8, 9 and 10.

8 Paper 1 – Small firms and university partner selection

Partner selection from the perspective of small firms seeking universities as partners for innovation: Strategic considerations or behavioural determination[11] [12]

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Abstract

Small firms and universities often collaborate in order to develop and commercialize products and technologies new to the market (Debackere & Veugelers, 2005; Inzelt, 2004; Lehrer & Asakawa, 2004). However, little attention has been paid to how small firms select which university to collaborate with.

The existing literature suggests that partner selection can be explained from either a strategic or behavioural approach. A strategic approach emphasizes that the organization should assess the potential value of combining complementary resources across organizational boundaries (Das & Teng, 2003; Richardson, 1972). Partner selection based on behavioural determination stresses that an organisation utilise past experiences in selecting their partners as the cost of assessing the potential value and risk or opportunistic behaviour may outweigh the actual benefit of collaborating (Chung, Singh, & Lee, 2000; Doz, Olk, & Ring, 2000; Reuer, Zollo, & Singh, 2002).

It is often impossible for small firms to assess the potential value of collaborating with universities ex-ante. Collaboration between small firms and universities often involves basic research, the outcome of which can be difficult to articulate (Jensen, Thursby, & Thursby, 2003; Veugelers & Cassiman, 2005).The alternative is to consider partner selection as a behaviour based on past experiences, but this seems to leave out the actual consequences of choosing one partner for another (Doz et al., 2000).

This research investigates what factors determine the partner selection strategy of the firm. Explorative studies have been conducted to shed some more light on these factors. The studies indicate that a firm's technological experience can help screening and assessing potential partners. However, partner selection is still based on prior partner experiences, which can help overcome uncertainty related to divergence in organisational structure, research methods and administrative procedures. This means strategic considerations are made, but they are shaped by the path from which the organisation has travelled.

Keywords: *Partner selection, universities, small knowledge-intensive organisations, innovation*

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[12] Work in progress. Not to be cited outside this study.

Introduction

Research on university-industry collaboration is receiving increasing attention lately as this has become an effective way of creating and transferring knowledge in the society (Markman, Phan, Balkin, & Gianiodis, 2005; Rothaermel & Thursby, 2005; Samii, Van Wassenhove, & Bhattacharya, 2002). It is argued in the literature that small firms can enhance their capacity for innovation by collaborating with external partners with knowledge being considered the most important input in the innovation process (Almeida, Dokko, & Rosenkopf, 2003; Arrow, 1962; Rogers & Shoemaker, 1971; Tidd, Bessant, & Pavitt, 2001). Traditionally, suppliers and customers are regarded as the most important types of relationships for knowledge creation and transfer between organisations (Grant & Baden-Fuller, 2004; Gronroos, 2004; Kotabe & Swan, 1995). However, small firms, such as biotech and ICT (Information and Communication Technology) companies, are often involved with developing new products or technologies very new to the market. In many instances this involve integration and commercialisation of basic research from universities (Fontana, Geuna, & Matt, 2006; Laursen & Salter, 2004; Lehrer & Asakawa, 2004). Collaboration between small firms and universities refers to different types of formal and informal patterns of interaction that facilitate knowledge utilisation, creation or transfer between organisations (Belderbos, Carree, & Lokshin, 2004; Debackere & Veugelers, 2005; Inzelt, 2004). However, the question remains unanswered about how small firms choose which university to collaborate with.

From the existing research on inter-organisational collaboration, two different sets of explanations to partner selection emerge. The first approach is based on strategic considerations. It is argued that the organisation can identify the 'right' partner through a structured process of assessing potential synergies and conflicts (Das & Teng, 2003; Gulati, 1999; McCutchen & Swamidass, 2004). The second approach seeks to explain partner selection from a dynamic perspective. This perspective argues that formation of future relationships are determined from the organisation's prior relationships (Reuer et al., 2002; Tsai, 2000; Walker, Kogut, & Shan, 1997).

It is often impossible for small firms to assess the potential value of collaborating with universities ex-ante. Collaboration between small firms and universities often involves basic research, the outcome of which can be difficult to articulate as it tends to be in its early stage of development and without any immediate commercial value (Jensen et al., 2003; Veugelers & Cassiman, 2005). The alternative is to consider partner selection as behaviour based on past experiences. This, however, seems to leave out the actual consequences of choosing one partner over another (Doz et al., 2000),

especially if the organisation has little experience of previous collaboration activities. This is often the case for small firms (Baum, Calabrese, & Silverman, 2000; Yli-Renko, Autio, & Sapienza, 2001).

The purpose of this paper is to explore the partner selection process of small firms choosing universities as a collaboration partner for innovation purposes. The research methodology is based on explorative studies of small firms with previous experience collaborating with universities. The studies reveal that partner selection is based on both strategic considerations and behavioural determination. What is more interesting is what triggers an organisation to use social constructed factors over objective selection criteria when selecting partners for collaboration. These findings will be discussed further in a later section of this paper.

The structure of the paper is as follows: Firstly, partner selection will be defined according to a strategic and behavioural perspective. Secondly, the chosen methodology will be described including an overview of the organisations involved in this study. Thirdly, the findings will be discussed before the final section, which describes contributions, limitations and suggestions to further research.

Literature Review

Partner selection is considered an important component in the process of establishing and managing inter-organisational relationships (Chung et al., 2000; Das & Teng, 2003; Tsai, 2000). Unique relationships with external partners may enable an organisation to reduce transaction costs (Chen & Chen, 2003; Williamson, 1985), get access to, or develop new resources and skills (Hyder & Abraha, 2004; Lorenzoni & Lipparini, 1999) or learn and acquire knowledge residing within other organisations (Inkpen, 2000; Norman, 2004). Yet, establishing and managing inter-organisational relationships can be problematic and lead to negative performance, e.g. exchange partners may pursue self-serving goals (Williamson, 1985), increasing cost to monitoring and control (Reuer et al., 2002) or unrealistic goals defined ex-ante. Therefore, it is not without importance with whom an organisation chooses to collaborate with.

Prior research into partner selection can be divided into two streams. The first stream is based on strategic considerations, which implies that an organisation can identify the 'right' partner through a structured process of screening and assessing potential partners (Balakrishnan & Koza, 1993; Das & Teng, 2003). This stream has been dominated by the resource-dependence theory and the resource-based view (Barney, 1991).

According to the resource-dependence theory, partner selection should be based on interdependencies caused by resource complementarities across organisations (Pfeffer & Salancik, 1978; Richardson, 1972). The theory has proven strong to explain how organisations coordinate their activities within the value chain. Activities within the value chain should be undertaken by organisations with the appropriate set of capabilities. A manufacturer might rely on a marketing agency to carry out the marketing activities or a sub-contractor to supply certain components (Richardson, 1972). Therefore, an organisation is more likely to select a partner with whom they share a high level of interdependence.

The resource-based view elaborates further on the principle of interdependence as selection criteria. The resource-based view recognises that each organisation consists of a bundle of resources (Grant, 1991). Some of these resources may be unique, and thereby a source of competitive advantage, if they are value creating, rare, non-imitable and non-substitutable (Barney, 1991). Organisation specific resources may be shared, combined or transferred between partners, which may evoke potential synergies. For example, combining production facilities across organisations to reach critical mass or combine complementary organisation specific knowledge to create new products or services jointly. According to this perspective, partner selection should be based on highest expected profit generated from sharing, combining and transferring organisation specific resources across organisational boundaries (Das & Teng, 2003).

The second stream of research within partner selection is based on behavioural determination. The steam has been dominated by social structural theories. An organisation's previous direct (Das & Teng, 2003) or indirect relationships play an important role in selecting partners for new relationships (Gulati, 1999; Tsai, 2000). The argument is that under the conditions of imperfect information and bounded rationality, organisations are more likely to establish relationships with whom they have had collaborated with previously (Chung et al., 2000; Reuer et al., 2002). Information about potential partners collected through one's own experiences is considered to be more accurate and reliable compared to second hand information (Granovetter, 1985).

Several scholars view networks and relationships as social structures that develop over time (Gulati, 1995; Koka & Prescott, 2002). Organisations that are embedded in these structures are increasingly affected by the other members in the network. Social embeddedness creates unique opportunities for organisations to interact and exchange resources, product and services (Gulati, 1999; Verspagen & Duysters, 2004). It is even argued that knowledge sharing and transfer cannot take place without

close social relationships between the organisations (Cavusgil, Calantone, & Zhao, 2003; Schmid & Schurig, 2003). On the other hand, the commitment and time required to build up relationships generate sunk costs, which restrict the organisation from terminating existing relationships and building complete new relationships (Duysters & Lemmens, 2003). If partner selection is based on prior social interactions only, it leads to localised networks with only few changes over time (Stuart & Podolny, 1996).

Organisations should find ways to avoid or manage uncertainty caused by information asymmetry. It is argued in the literature that the ability to manage uncertainty is not uniform across organisations, but develops over time as the organisation is learning (Child & Yan, 2003; Dierickx & Cool, 1989; Reuer et al., 2002). Learning is path dependent and builds on prior knowledge (Cohen & Levinthal, 1990). The ability to assess a partner depends to a high degree on the organisation's absorptive capacity. The expectations from the literature are that an organisation develops absorptive capacity over time, which is defined as the ability to evaluate new knowledge, assimilate it, and apply it to strategic purposes (Cohen & Levinthal, 1990). An organisation's absorptive capacity is largely a function of prior experience with the knowledge area (Simonin, 1999), which is accumulated through previous discoveries made by the organisation (Zollo, Reuer, & Singh, 2002). Thereby, an experienced organisation is more likely to be in possession of absorptive capacity, which increases the chances of predicting benefits and detriments relating to collaborating with a certain partner. Various categories of experiences exist in the literature including technological experience (Pangarkar, 2003; Reuer et al., 2002), prior partner experience (Pangarkar, 2003; Reuer et al., 2002) and prior collaboration experience (Child & Yan, 2003; Glaister, Husan, & Buckley, 2003; Hagedoorn, Kranenburg, & Osborn, 2003).

Cumulative technological experiences are a critical factor in understanding new or related knowledge (Cohen & Levinthal, 1990). Technological experience depends on the amount of previous discoveries made of the organisation within a similar domain (Zollo et al., 2002). Several studies indicate that small firms are likely to have high research and development output, which helps them to build absorptive capacity within a specific domain of knowledge (Almeida et al., 2003; Narula, 2004). Prior experiences with the technological domain create familiarity and comfort with both content and context in which the technology appears (Sampson, 2005; Simonin, 1999). If the organisation has developed a strong technological knowledge base it is easier to understand what has been done and what might be done in the future and by whom (O'Dwyer & O'Flynn, 2005; Penner-Hahn & Shaver, 2005). Thus, the more capable the knowledge receiver, the easier it will be

to assess the *technological potential* of a partner's knowledge. This may help reduce uncertainty related to partner selection, because the knowledge receiver can more easily predict the possible outcome of combining, transferring or sharing knowledge with potential partners.

However, one aspect of partner selection is the potential benefits of combining technological domains across organisations, another aspect is the willingness of the partner to do so. Information asymmetry may develop *behavioural uncertainty* both during and after the relationship has been established (Kogut, 1988; Williamson, 1985). A partner may free-ride by limiting its contribution to the collaboration or may even steal a partner's technology. Several scholars argue that prior partner experience may have led to development of inter-partner trust over time, which reduces the risk of a partner behaving opportunistically (Nielsen, 2005; Reuer et al., 2002). Trust works as an informal safeguard mechanism, which reduces the need for cost intensive monitor and control mechanisms (Dyer & Chu, 2000). Tzokas and Saren (2004) even claim that trust is a necessary ingredient in collaborative settings involving high risk, such as developing new products to the market jointly or sharing and transferring knowledge between organisations. Therefore, an organisation is more likely to select a partner with whom they have had previous experience when *behavioural uncertainty* is high.

Prior partner and collaboration experience may become useful not only to reduce the risk of opportunistic behaviour but also to understand *structural uncertainty*, which is caused by partner's different work routines, organisational structure, strategic objectives and specific culture (Zollo et al., 2002). Das and Teng (2003) consider alignment of objectives to be an important part of assessing potential partners. An organisation should avoid collaborating with partners having conflicting objectives or expectations. Chung et al. (2000) stress that conflicts are more likely to arise in relationships among organisations with dissimilar status. This is because it is difficult to evaluate the level of commitment the counterpart brings to the collaboration. Therefore, it is more likely that an organisation will rely on prior partner and collaboration experiences in the process of partner selection when *structural uncertainty* is high.

Strategic considerations and behavioural determination represent two distinctive strategies to partner selection (Doz et al., 2000; Eisenhardt & Schoonhoven, 1996). Despite the fundamental differences between the two approaches, they are not mutually exclusive. Strategic considerations represent a normative view, which create a logical pattern of behaviour relating to partner selection. Behavioural determination is based on descriptive statements, which attempt is to infer better

understanding of the factors moderating the phenomenon, which in this case is partner selection (Parkhe, 1993). In the existing literature it is suggested that partner selection is affected by information asymmetry, which complicates the process of predicting the outcome of collaborating. Information asymmetry is two dimensional. Those that have access to more reliable information ex-ante are in a favourable position to predict the likely outcome of a relationship better than competitors (Peteraf, 1993). At the same time, those that have less reliable information are more exposed to structural and behavioural uncertainty and uncertainty related to the technological potential. The logic is that the perceived uncertainty related to information asymmetry is not uniform across firms. The organisation's absorptive capacity can help reduce uncertainty related to *technological potential*, *behavioural* and *structural uncertainty.* How these factors impact on the partner selection process for small firms seeking universities as partners will be the focus of the discussion to come.

Methodology

The purpose of the research is to explain what factors determine the partner selection strategy of small firms seeking universities as partners for innovation. The research builds to a large extent on existing research on partner selection among private organisations, but which has not been examined for relationships between universities and industry partners.

The research builds on the assumption that behaviour is inhibited by the cognitive mindset of the individuals, which implies that their behaviour is bounded rationally because knowledge is imperfect (Argyris & Schön, 1978; Cyert & March, 1963; Huber, 1991). This is also a precondition for learning, which can only take place if individuals have an imperfect understanding of the environment in which they operate. In line with this view follows the assumption that interaction becomes relevant because individuals are heterogeneous. Based on their background they will have different perceptions of the same piece of knowledge.

Based on these considerations and assumptions, an explorative research approach has been preferred to satisfy the research purpose. Data was collected through in-depth interviews with key staff employed by the respective small firms. One interview with one person was conducted per organisation following a semi structured interview guide. Each interview lasted approximately 1 hour and was recorded and later transcribed.

The interviewed organisations have been selected based on a purposive sampling technique (Eisenhardt, 1989; Shaw, 1999). This technique, compared to random sampling, allows the

researcher to select small firms, which have had previous experience with selecting universities as a collaboration partner. The research focuses on small firms within biotechnology and ICT. The following set of pre-determined criteria was necessarily fulfilled by the participating organisations:

Knowledge-intensive: Knowledge intensive organisations are defined as organisations that are involved with producing qualified products and services based on personal intellectual input delivered from a well-educated and qualified work force (Alvesson, 2000; Starbuck, 1992). It has been argued in the literature that only certain industries are likely to depend on basic research and thereby have interests in collaborating with universities (Debackere & Veugelers, 2005; Laursen & Salter, 2004; Lehrer & Asakawa, 2004).

Small firms: Firm size is an important parameter to include when selecting the samples. It is assumed that small firms are resource restricted compared to larger firms (Almeida et al., 2003; Hunt, 2004). The research focuses on small firms in Denmark, which is defined in this study by organisations with less than 50 employees.

Furthermore, it is required that the interviewees are involved directly in day-to-day operation of the firm. Also, that they have been involved in establishing and maintaining relationships with universities for the organisation.

Table 1 below provides an overview of the involved firms. The first column refers to an allocated ID, which represents each organisation throughout the discussion to follow. The second column describes the organisations including number of employees and year the company was founded. The third column presents the interviewees from their position in the organisation and educational background. The final column describes what type of relationships the organisation had with a given university.

Table 1: Overview of interviewed firms

ID#	Organisation	Interviewee	Collaboration activities
ICT 1	Business Domain: Network analysis Employees: 4 Established: 2006 Nationality: Danish	Position: Director/owner Education: Master degree	Formal: Teaching obligations Informal: Discuss with colleagues
ICT 2	Business Domain: Vision technology Employees: 8 Established: 2000 Nationality: Danish	Position: Director/owner Education: PhD	Formal: Several attempts to raise funding but never succeeded Informal: Transfer of students Discuss with former colleagues Many of these also personal friends

ICT 3	Business Domain: Bio-informatics Employees: 32 Established: 2002 Nationality: Danish	Position: Director/owner Education: PhD	Formal: Several PhD students Informal: Test of beta-versions at universities Discuss with former colleagues Many of these also personal friends
Bio 1	Business Domain: DNA Employees: 5 Established: 2002 Nationality: Danish	Position: Director/owner Education: PhD	Formal: Contract on equipment and laboratories Informal: Discuss with former colleagues Exchange of staff Share results and publications
Bio 2	Business Domain: Protein Employees: 20 Established: 2001 Nationality: Danish	Position: Vice President Education: PhD	Formal: Attempts to raise formal contract, but postponed because of lack of funding Informal: Seminars
Bio 3	Business Domain: Protein Employees: 3 Established: 2001 Nationality: Danish	Position: Chief Scientific Officer Education: PhD	Formal: Teaching and administrative obligations at university Contract on equipment and laboratories and researchers Informal: Share results and publications Discussion with colleagues
Throughout this research paper, all names of organisations, partners and interviewees have been changed to ensure confidentiality.			

Discussion

Consistent with past conclusions, partner selection is based upon both strategic consideration and behavioural determination. The interviews conducted for this research suggest a wide range of situations related to small firms selecting universities as partners for innovation. Some firms attempt to establish formal collaboration agreements, others rely on informal conversations with former colleagues; some firms have many contacts with universities around the world, others try to develop one contact slowly; some firms only intend to rent space and equipment, others see the opportunity to develop new skills and resources. Yet, the results of the interviews also indicate that establishing relationships with universities is a complicated task which involves both structural and behavioural uncertainty as well as uncertainty relating to technological potential. One interviewee gave this explanation as to how information asymmetry affected them:

> *… Well if I think about what is our advantage, and if our advantage becomes an advantage for everybody, then it will become an advantage to nobody. Asymmetric information, which we have access to through our previous engagement with procedures and people [at this university], is our advantage that nobody can copy (Bio 1).*

Information asymmetry creates uncertainty, which affects each of the interviewed firms differently. 'Bio 1' considers their knowledge about University X as an advantage. At least it is an advantage compared to competitors who wish to collaborate with University X but do not have this knowledge.

However, the competitors might have similar knowledge about structures and procedures related to University Y, which may provide them with a similar or even better advantage. It is outside the scope of this paper to compare to what extent specific knowledge about a particular university actually leads to a competitive advantage. However, information asymmetry does exist and does lead to firm specific behaviours relating to partner selection.

Firms do not possess similar levels of technological experience. According to existing theory, the firms with a higher level of technological experience are more likely to understand related knowledge owned by potential partners. One interviewee saw her technological experience as the firm's major strength:

> *I got 17 years of research experience within this field – I think that is our strength – the company's strength (Bio 3).*

In general, the level of technological experience is high among the interviewed firms. This is of no surprise as it was required that the firms are knowledge intensive to be included in this study. Five out of the six firms were founded by individuals with a former academic career (minimum of a PhD). Four out of the six interviewed organisations were (at the time the interviews were conducted) actively involved in publishing in academic journals, which also indicated that they possessed a high level of technological experience within their technological domain. Among these firms, the level of technological experience seemed to have a positive effect on their ability to screen and assess potential partners.

> *Those that possesses the skills – or those that possess the quality – we can easily find… We have a very good technology, which can solve a lot of problems. That opens many doors for us… we are having this University X, University Y and Z [all in Denmark], one in China, Estonia and Israel (Bio 1).*

> *There is no doubt we are recognised… We are having great connections to University X, don't know anyone at University Z, but that would be easy to establish. We also have University Y. We also have contacts with Stockholm and Institute T in France (ICT 2).*

Technological experience is very important to help with assessing potential partners for all of the interviewed firms. However, 'Bio 1' and 'ICT 2' were very confident that their high level of technological knowledge could open doors to potential partners or even attract new partners.

This advantage became more distinct when compared to one of the newly founded ICT companies. 'ICT 1' was the only one out of the interviewed firms without any PhD staff or academic publications behind them. The owner is a part time lecturer at the same university he graduated with a master's degree from some years ago.

> *… If I just went by myself to knock on their [academic staff] door probably nothing would come out of it, because they have not heard about it. On purpose I have moved slowly – well – I want to be ready and up to level. I could imagine that many organisations fear to lose their credibility when dealing with universities… You are talking to the leading experts. If they look down on one's work – that must be very upsetting (ICT 1).*

It is evident that this interviewee has concerns about his technological experience. He expects that collaborating with universities requires a profound knowledge about the technological domain beforehand. However, his motive to collaborate with a university is to develop his knowledge base and keep himself updated with the newest knowledge. He knew that university X was probably not the leading university, but at least it provides him with access to the academic world.

> *… I used to study at this university X and now I am a part time lecturer here – It <u>could</u> be that more leading research is conducted at university Y [which is another university in Denmark]. But I don't know anyone up there. Now I have taken the contact to Michael [an associate professor at university X] instead of Lisa [an associate professor at university Y], even though I have heard about Lisa before Michael. But Lisa is not part of my network – Michael was. That is how it was established. It is very much based on someone you know – even though Lisa was more in the media and visible (ICT 1).*

In this case, lack of technological experience led ICT 1 to rely more on prior social relationships when selecting partners. The more research experienced firms had more confidence in their technology, which automatically made it easier to assess potential partners but also to attract new partners. It can be argued that the nature of universities to some extent eases the process of assessing technological potential. Universities tend to make more information about research objectives and

strategic intent available to the public. Furthermore, research output is normally made available to the public through academic publications. However, technological experience still takes time to develop and those firms employing former academic staff employed seem to have an advantage over those without.

It is generally acknowledged that information asymmetry can lead to opportunistic behaviour. However, it is argued in the literature that opportunistic behaviour is less likely to occur in collaboration between universities and private organisations, because universities to a higher extent are devoted to creating academic science to the benefit of society, rather than profit seeking (Bercovitz & Feldman, 2007; Drejer & Jorgensen, 2005). One interviewee explained that it was safer to collaborate with a university than a private company in the early phase of product development:

> *… Theoretically it would have been possible [to choose to collaborate with a private organisation rather than a university], but practically it would have been problematic for two reasons. Firstly, we would have to collaborate with competing organisations – and – there would be an element of competition, which means we would not feel we could protect our IP [intellectual property] (Bio 1).*

However, several interviewees mentioned that the situation is changing. Universities are becoming more profit orientated. It has become increasingly popular over the last few years that any formal contact between university and industry is specified in a contract prepared by a central office (e.g. Technology Transfer Office, Patent and Contract office) at the university. The office is normally employed by professionals as well as academics, whose purpose is to ensure a fair market valuation of the content in the contract (e.g. licence agreements, rental of equipment and space, R&D projects, commercialisation) (Markman et al., 2005; Siegel, Waldman, Atwater, & Link, 2003). During the spin-out phase, one company had the following experience with the central office:

> *… The university [central office] found out that they have made the wrong valuation of the technology – that the technology actually had commercial potential – then they tried to get it back (Bio 1).*

Another interviewee referred to a situation involving f a contract renewal for the rental of equipment and space.

It is quite complicated to renew the contract. The first contract was no problem at all, but when we needed a renewal it took half a year… Now the university [central office] has seen there is a need – and the need will increase – and now the central office is negotiating. It takes a lot of time and we pay much more this year than we used to (Bio 3).

It can be discussed whether these situations can be categorised as opportunistic behaviour. During the last decade, most universities in the Western world have undergone radical restructuring when it comes to commercialisation of basic research and, hence, interaction with industry partners (Bonte, 2004; Scharle, 2002; Siegel et al., 2003). If this development continues, it will become even more difficult to profit from social relationships when it comes to negotiating new contracts or take out knowledge from universities. Despite these few statements, behavioural uncertainty seemed to be of less importance for small firms selecting universities as collaboration partners.

Uncertainty may also arise from the structural differences that exist between universities and small firms. Public research institutions and small firms differ significantly in organisational structure, purpose and strategic intent, which might deter small firms from forming relationships with public research institutions (Drejer & Jorgensen, 2004). This was also confirmed by most interviewees. A major problem was the research discipline that existed among academic staff:

… You might have one project going and suddenly they [university researcher] get an idea how to develop an article to an academic journal within a research field – then they throw resources after that – they just do it. That destroys the project you were just doing – or the time aspect – the fact that you had to finish the project at a fixed time (ICT 3).

They [universities] do things extremely slowly. They spend months on something that should take no longer than one day… it is the mindset of large bureaucracies (Bio 1).

The interviewees referred to the research discipline of academic staff in general and not to any particular university. This might indicate that the research discipline at universities is not to be changed even if you know somebody well at the respective university.

Other interviewees described the nature of basic research as an obstacle to collaboration between small firms and public research institutions. Basis research is defined as knowledge without any immediate market need in mind and with great knowledge spill-over potential (Drejer & Jorgensen,

2005; Roper, Hewitt-Dundas, & Love, 2004). This means that the outcome of basic research might serve multiple purposes, but is likely to involve high uncertainty as to outcome and customer demand (Jensen et al., 2003; Veugelers & Cassiman, 2005).

> *… You would like to collaborate with universities on projects, which do not require an immediate result – something that is just interesting – and maybe has potential 5-10 years or 20 years in the future – in that case it is interesting to work with universities… But if you have a project, which requires you move from A to B then you cannot use universities (ICT 3).*

The dilemma for most small firms is described by 'ICT 1':

> *It is a question about resources and time. ... Again – it is always about the short and long track… Right now we are on the short track – running very fast to create turnover (ICT 1).*

The balance between short and long term is a well-known dilemma for most organisations. March (1991) claims that organisations need to balance exploration and exploitation for long-term survival. Organisations only engaging in exploration often suffer from high searching costs, without taking advantage of its benefits. On the other hand, organisations only involved in exploitation might end up in a competence trap, because their technologies become redundant over time.

Three out of the six interviewed firms referred to lack of funding as a major reason why it was difficult to establish formal research and development relationships with universities.

> *I think we had a formal contract with University Z, but because of funding reasons we had to drop it, because it was a huge amount to put in and we did not have the funding… everything we plan to do has to be related to a milestone and has to be related to exact amount of money, so we can estimate the project – so we cannot really have another pot where we have X amount of money specified for something which we don't specify what is (BIO 2).*

They did not blame the university, because in these cases it was more or less up to the government to allocate external funding to research projects. Sometimes the university even assists the firm applying for funding. One firm had tried three times to apply for funding together with a specific university. The purpose was to establish a research project, but it was turned down by the

government body administrating the funding. The same firm did not have any motivation left to apply a fourth time:

> *We had to allocate many working hours – and who is paying for that? Our customers and so on. It is very very difficult to start up (ICT 2).*

Three firms claimed that external funding was a necessity for a formal research and development relationship to be established. Formal contracts were only defined for rental of space and equipment and teaching obligations. Other than those, knowledge transfer, exchange of ideas and normal communication were kept at an informal level.

> *I just call someone or send an email to one of my friends… It is always through those people we know… It is always at an informal level (ICT 2).*

In this situation the firm chose to collaborate with partners with whom they have had previous interaction.

> *… Our absolute advantage is – we know exactly how things are working here – we know exactly who we should go to – we know how to take shortcuts – we know who to avoid – we know how things need to be formulated to make it go faster through the system and that sort of thing (Bio 1).*

All of the six firms interviewed had informal contacts with former colleagues. When asked how these informal contacts benefited the firm, the answers were very vague.

> *They [University X] have delivered a few candidates to us, and… but… (ICT 2).*

> *Yes, lots of things – some details about stuff – we have not received any things of fundamental importance – we know those things already (ICT 3).*

Nonetheless, these informal contacts did not require much in the way of resources or time to establish. Basically, most of them continued on from the owner's previous engagement at the respective university. Informal contacts provided the small firms with an inexpensive opportunity to keep themselves updated with the newest research. This is very consistent with research on formal

and informal relationships. Dahl and Pedersen (Dahl & Pedersen, 2004) claim that informal contacts are less likely to involve anything more than the sharing of relatively small ideas.

Conclusion

The aim of this research is to understand what factors affect the selection process among small firms seeking universities as partners for innovation. It is argued that the partner selection strategy is affected by information asymmetry, which complicates the process of screening for and assessing potential partners. Each firm applies different strategies to reduce disadvantages recurring from information asymmetry.

First, the theoretical implications of this research are discussed, followed by the managerial implications, limitation of the study and suggestions to further research. The absorptive capacity of the firm depends upon prior technological, partner and collaboration experiences (Cohen & Levinthal, 1990; Reuer et al., 2002; Zollo et al., 2002). Technological experience appears to have a positive effect on the firm's ability to screen for and assess potential universities. This reduces the risk of uncertainty relating to technological potential. The existing literature argues that prior partner experience can help reduce risk of the partner behaving opportunistically (Dyer & Chu, 2000; Kale, Singh, & Perlmutter, 2000). However, none of the interviewed small firms considered opportunistic behaviour to be of any significance when collaborating with universities. This is very different from previous findings in the existing literature, which emphasises the threat of opportunistic behaviour to be the major reason for organisations to select partners known from previous interactions (Chung et al., 2000; Gulati, 1999; Tsai, 2000). However, these primary findings are all related to private firms collaborating with private firms. Prior partner experiences are considered more important for small firms when it comes to establishing informal relationships than formal relationships with universities. Prior partner experience can help small firms to locate who to talk to and who not to talk to within the university. However, the outcome of informal relationships is questionable. The increased focus among universities to commercialise basic research has required them to become more market orientated. Policies and procedures have become more transparent, which decreases the value of prior partner experiences. Consequently, it has become more difficult to benefit from social relationships.

From a managerial perspective, small firms wishing to collaborate with universities can increase their selection options by developing a strong technological knowledge base. This can be done not only through internal education and training but also by hiring or employing staff from an academic background. Informal relationships can be useful to develop as they may allow the firm access to the

newest research within their technological field. These informal contacts are very cheap to establish and maintain if they build on existing relationships. It is more difficult for small firms that do not have prior partner experience with universities to build informal collaborations. However, the academic world is not reserved for some firms only. Most universities are interested in having contact with industry partners, which could be established through attending network groups, seminars, attend conferences, becoming a guest lecturer or supervisor.

Limitations and further research

Despite the increased interest in collaboration between universities and industry partners, only very few studies have been undertaken empirically to test, analyse and clarify the process of selecting an appropriate partner for collaboration. This study provides only explorative results to explain what factors impact on the selection strategy of the firm. Further research is needed to confirm the relationships between these factors and partner selection strategy. Further research might also set out to investigate how different partner selection strategies contribute to different collaboration outcomes. This study focuses only at partner selection from an ex-ante perspective.

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9 Paper 2 – Governance mechanisms

Small firms, university research commercialisation and the need for rethinking governance mechanisms[13] [14]

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Abstract

This paper investigates how increasing focus on research commercialisation at universities has required small firms to rethink how they develop and deploy governance mechanisms in university relationships. Today small firms collaborating with universities often face a dual relationship which involves governing both individual scientists and technology transfer offices (TTOs) at the same time. Especially small firms struggle with developing governance mechanisms towards TTOs as they follow a more transactional perspective (e.g. formal governance in form of contracts and enforcing) than individual scientists who correspond more to a relationship perspective (e.g. informal governance in form of trust or social capital). Small firm can solve part of this problem by developing new competences directed at governance towards TTOs and engage in dialogues and communication with TTO officers and individual scientists simultaneously. The other part of the solution to the problem lies with TTO officers and policymakers engaging in dialogue with small firms and moving away from focusing on generating short-term gains towards developing long-term relationships with small firms. The findings contribute to the existing research on university-small firm relationship by providing a detailed empirical account for how small firms are required to rethink governance when collaborating with universities.

Keywords: *Governance-mechanism, university-small firm relationships, technology transfer offices, research commercialisation*

[13] Earlier version of this paper was submitted and presented at the Triple Helix 6 (conference), Singapore, Singapore 2007. The paper was submitted under the title "*Are small knowledge-intensive firms being squeezed in the quest for research commercialisation and is it changing the need for governance mechanisms?".* This version has an updated introduction and literature view and is based on a more comprehensive set of data.

[14] Work in progress. Not to be cited outside this study.

Introduction

This paper investigates how small firms develop and apply governance mechanisms in university relationships with universities. Universities are becoming increasingly commercially orientated. An important aspect of relationship management is how small firms reduce inefficiencies that arise from information asymmetry and moral hazards in inter-organisational relationships (Pisano, 1991). The current research on university-small firm relationships shows that these types of relationships often fail or underperform because small firms do not have the accurate skills to govern the process of accessing and transferring knowledge and technologies from universities (Jelinek & Markham, 2007; Schmidt, 2008). Most commonly mentioned are problems in managing differences in research objective (López-Fernández, Serrano-Bedia, & García-Piqueres, 2008), ownership of intellectual property (Jelinek & Markham, 2007; O. Jones, 2005) and lack of motivation among university scientists to contribute to commercial projects (Schmidt, 2008). These are all threats to the relationships as either mean the cost of transferring knowledge may be too high because of the evident need for developing and implementing governance mechanism, or the value of the knowledge transferred is insignificant because it has been made publicly available. When it comes to how small firms are governing relationships with universities, there is almost unanimity among researchers that small firms rely on social constructed mechanisms such as trust (Plewa & Quester, 2007; Rappert, Webster, & Charles, 1999; Santoro & Bierly III, 2006), partner familiarity (Fransman, 2008; Sherwood & Covin, 2008) and social capital (Murray, 2004). Also, as stipulated by Shane and Stuart (2002) small firms are often said not to have the resources and power to actually enforce formal governance mechanisms. So the conclusion from the existing research is mainly that small firms apply social constructed mechanisms to govern relationships with universities.

In this paper we argue that this approach, relying on social constructed mechanisms only, is not sufficient any longer as universities are becoming increasingly cautions as to sharing or transferring their intellectual property and assets with industry without receiving economic rewards (Debackere & Veugelers, 2005; Siegel, Waldman, Atwater, & Link, 2003, 2004). The shift towards research commercialisation at universities is reflected in most universities establishing common practices and strict rules for what university scientists and faculties can share with industrial firms, and that all formalised sharing and transfer has to go through the universities' technology transfer office (Debackere & Veugelers, 2005). Prior research has shown that small firms have trouble adapting to the increasing focus on research commercialisation at universities leading to conflicts in university relationships (Siegel, Waldman, et al., 2003).

It is not the aim of this research to assess whether these changes at universities have been suitable to stimulate more commercialisation of research at universities and interactions with industrial firms. Rather the intention of this research is to re-examine how the increasing focus on research commercialisation at universities has required small firms to rethink how they govern their university relationships.

The paper applies an explorative research design based on interview data and documents from 30 small firms collaborating with universities. The findings from this study shows that small firms struggle to adjust their governance mechanisms to the increasing focus of commercialising research at universities. Small firms especially have problems adjusting to the requirement of more formalised relationships as dictated by TTOs. Small firms often end up trying to develop governance mechanisms that on one hand foster a close and trustworthy relationship with the individual scientists, and on the other hand, a more transactional relationship with TTOs.

The paper begins with an overview of the changing discourse at universities before reviewing existing literature on university-small firm relationships and governance issues. This is followed by the methodology of this study, which outlines how data has been collected and analysed. The final section discusses the findings and presents conclusions and implications.

Background to the study - the changing discourse at universities

The traditional role of universities in the Western world has been changing considerably since the introduction of the Bayh-Dole Act in the United States in 1980 (Kenney & Patton, 2009; Rosenberg & Nelson, 1994). The Act granted U.S. universities control of their own research output resulting from government funded research. Similar legislation was introduced by most Western countries soon after (Debackere & Veugelers, 2005; Siegel, Waldman, et al., 2003). At the same time, most governments in developed countries also began to require universities to be more accountable for the public funds that continuous to sustain most research activities at universities (Martin, 2003). In particular, targeted and competitive funds at universities have become more widespread (David, Hall, & Toole, 2000). Faced with tighter constrains on public funding, most universities have become more aggressive in commercialising their own research outputs for profit rather than producing public goods (Jensen, Thursby, & Thursby, 2003; Rosenberg & Nelson, 1994). The tighter public funds makes universities focus more seriously on commercialising academic output leading to: 1) increased knowledge diffusion in society in forms of publications, seminars, workshops and conferences; 2) more academic research being exploited for commercial reasons; and 3) create additional revenue streams from license agreements and contract research that can in turn be used by faculty members

to conduct new research (Phan & Siegel, 2006; Siegel, Westhead, & Wright, 2003). In order to exploit these potential benefits more, most universities have realised the need to change institutional structures, develop organisational capabilities to support commercialisation and implement incentive schemes to encourage participation by faculty members (Debackere & Veugelers, 2005; Markman, Phan, Balkin, & Gianiodis, 2005; Siegel, Westhead, et al., 2003).

Today most universities have established dedicated technology transfer offices (TTOs) to support the commercialisation process of knowledge and technologies from universities (Debackere & Veugelers, 2005). TTOs provide administrative assistance to the faculties and academic scientists in form of legal (patenting and contract preparation), financial (due diligence and legal costs) and marketing support (finding and negotiating with buyers) (Debackere & Veugelers, 2005). Common performance measures for managers of TTOs are number of patents registered, spin-offs created, research contracted, industry collaboration established, degree of utilisation of university equipment and staff and number of university staff engaged in research commercialisation (Markman, Gianiodis, Phan, & Balkin, 2005; Sharif & Baark, 2008; Siegel, Waldman, et al., 2003).

This section has provided the background to this study which is essential in understanding the new challenges faced by small firms collaborating with universities. In summary, this research aims to understand how small firms develop and apply governance mechanisms in university relationships under the conditions that (1) universities are becoming increasingly commercial orientated; and (2) the use of TTOs becoming more widespread and common practice at universities to support research commercialisation.

Governance and university-small firm relationships

The purpose and nature of governance mechanisms

This section of the paper outlines prior research on governance mechanisms applied in university-small firm relationships. The actual issue of governing inter-organisational relationships is a well-known and well-researched area. Governance constitutes a distinct form of managing economic activities in inter-organisational relationships (Powell, 1990; Williamson, 1985). Governance have been used especially to resolve problems of adapting, coordinating and safeguarding economic exchanges (C. Jones, Hesterly, & Borgatti, 1997; Uzzi, 1997). Firms can try to protect themselves from the consequence of information asymmetry and moral hazards through formal or informal governance mechanisms (Dyer & Chu, 2000; Gulati, 1998; Parkhe, 1993). Formal governance mechanisms include third party agreements, relying on ex-ante contracting or ex-post monitoring

arrangements (Das & Teng, 2000; Dyer & Chu, 2000). It requires the partner to specify the intended outcomes and specific expectations towards contributions to the interaction for contractual governance mechanisms to be effective (Pisano, 1991). Contractual governance mechanisms are often relatively cost intensive to implement and maintain (Park & Ungson, 2001). In contrast, informal governance mechanisms refer to social constructed features such as trust and social capital (Kale, Singh, & Perlmutter, 2000; Tzokas & Saren, 2004). Socially embedded governance mechanisms are assumed to be firm specific and can only be developed over time through a series of interactions (Dyer & Chu, 2000; Park & Ungson, 2001).

Referring to the transaction cost theory (e.g. Williamson, 1985), three underlying conditions determine which governance mechanism is more efficient: 1) uncertainty; 2) asset specificity; and 3) frequency. When it comes to high uncertainty, it can be difficult to rely on contractual mechanisms only. Especially when uncertainty to demand is high, firms might have to switch between different suppliers. Asset specific investments, which might lead to too high interdependency, are risky in the sense both parties in the transaction might end up locked-in to a situation. An asset might lose its value if the original partner drops out of the transaction or the asset is applied to another setting. An asset might lose its value if the original partner drops out of the transaction or the asset is applied to another setting. If frequency is high, the condition for developing social mechanisms is high. Firms unable to identify appropriate mechanisms for governing a relation with a university should defer from entering into such a relationship and try to find the needed knowledge elsewhere.

Small firms and use of informal governance mechanisms in university relationships

Governance mechanisms are considered crucial to maximise the advantage of collaborating with universities in inter-organisational relationships. The right use of formal and informal governance mechanisms can help a partner to behave in a desirable way leading to more effective and efficient diffusion of knowledge and technologies in the relationship. Research shows that small firms mostly collaborate with universities to access and transfer technical and scientific knowledge used to advance their core-technology (Barbolla & Corredera, 2009; Hu & Mathews, 2009; Santoro & Chakrabarti, 2002). Especially small firms require access to more knowledge that is often non-codified or even tacit to progress their technology and reduce technical uncertainty (Agrawal, 2006; Jensen & Thursby, 2001). In contrast small firms rarely engage in joint research projects involving basic research or research not related to their core-technology (Santoro & Chakrabarti, 2002). Owing to the relevance of accessing and transferring knowledge and technologies from universities that is often tacit or non-codified, scholars such as Plewa and Quester (2007) and Santoro and Bierly III (2006) found a positive relationships between use of informal governance mechanisms (such as

trust) and knowledge transfer. Further, Sherwood and Covin (2008) showed that partner familiarity was a significant factor for successful technical knowledge acquisition.

Small firms also apply more formal governance mechanisms in university relationships to solve tensions regarding ownership issues as well as providing a method for capturing and allocating economic benefits deriving from intellectual property (Abramovskya, Kremp, López, Schmidt, & Simpson, 2009; Jelinek & Markham, 2007). But small firms prefer to solve potential conflicts in university-small firm relationships through informal governance mechanisms, because they often do not have the financial resources to implement or enforce legal contracts (Rappert et al., 1999).

Challenges for small firms dealing with technology transfer offices

A few studies have also investigated how university-small firm relationships have been affected by the establishment of TTOs at universities. In a study based on 55 qualitative interviews with firm managers, academic scientists and TTO administrators, Siegel et al. (2004) also found the relationship between the firm and TTO as being highly tense. 80% of firm managers replied yes to the question that universities are too aggressive in exercising intellectual property rights. In contrast only 13.3% of the TTO officers thought they were aggressive. Also 80% of firm managers thought bureaucracy and inflexibility of university administrators are barriers to successful knowledge exchange, while only 6.6% of TTO officers thought the same. The authors recommend industrial firms and TTOs engage in developing mutual understanding through training and education of both parties. Similarly, Debackere and Veugelers (2005) recommend that universities should become more active in the scientific knowledge market by increasing transparency and unambiguity with respect to negotiating and ensuring IP ownership when dealing with industrial firms. Drejer and Jørgensen (2004) have a similar argument referring to differences in organisational culture and structure between the parties as potential source of conflicts. Several researchers also emphasise that universities lack incentive structures that motivate faculty members to engage more in commercial activities (Debackere & Veugelers, 2005; Laursen & Salter, 2004; Owen-Smith, 2003).

With universities becoming increasingly commercial orientated, the literature suggests that small firms are facing a number of new challenges when it comes to governing their university relationships. The existing literature points out that small firms prefer developing and applying informal governance mechanisms, but newer research on university research commercialisation and TTO points in the direction that this is no longer sufficient to manage inefficiencies in university-small firm relationships. This study aims to extend our understanding on how small firms develop

and apply governance mechanisms given that universities are becoming increasingly commercial orientated.

Methodology

An explorative research design based on interviews of firm managers was used to study how small firms apply governance mechanisms in university relationships. The participating firms were identified through personal referrals from people working in the space between university and industry (e.g. commercial directors, technology transfer officers, managers of science parks and incubators and investors) (Eisenhardt, 1989). All firms had experiences collaborating with universities in the past and had less than 50 employees. The final sample consisted of 30 small firms from various high-technology industries, including software, nanotechnology, robotics, bio-pharmaceuticals, protein engineering and cell and tissue culture. 18 of the firms are located in the major cities of Denmark (Copenhagen and Odense) and 12 in New Zealand (Auckland and Dunedin) as summarised in Table 1.

Table 1: Overview of participating firms

Attributes	Danish firms	NZ firms
Number of companies in group	18	12
Age of Companies		
Oldest firm	1992	1987
Youngest firm	2006	2006
Number of employees		
1-9 employees	13	6
10-49 employees	5	6
Spin-off		
Direct university spin-off (based on university patents)	8	5
Indirect university spin-off (based on university know-how)	4	3
Non spin-offs	6	4
Other		
Firms located in science parks or at university premises	12	6

The primary data collection centred on conducting interviews with firm managers. Interview data were collected using a semi-structured interview guide which contained thematic themes informed by prior research on university-industry relationships. These themes were translated into questions addressing different aspects of the collaboration process including motives to collaborate, formation processes, type of relationships formed, governance mechanisms applied and performance. The interviews lasted one and two hours each and were all tape-recorded and transcribed. The interview data were complemented by secondary information from company websites and annual reports. For reporting purposes, each firm is identified by an ID code to ensure anonymity. The ID code consists of firstly an ID number (1-30) and secondly the country code (DK or NZ).

The data were coded with assistance from qualitative data software (NVivo). Qualitative data software is particular useful to systematically categorise specific pieces of data into common patterns. The software primarily served explorative and illustrative purposes as the size of the sample is somewhat limited.

Findings

The following section presents the findings on how small firms interpret and experience the managing of governance mechanisms in relation to the increasing focus on research commercialisation at universities. The findings illustrate the nature of the collaboration with universities can usually can be regarded as a dual relationship involving the individual scientist or faculty on one side and the TTO on the other side. Difficulties in governing the dual relationships impede the ongoing exchange of knowledge and impose challenges on managers of small firms.

The nature of the relationship

The following describes the nature of the relationship. Firstly, the section will first present findings relating to the relationship between the firm and the individual scientist/faculty before turning attention to the relationship between the firm and the TTO.

In accordance with existing research (i.e. Perez-Perez & Sanchez, 2003; Santoro & Chakrabarti, 2002), small firms in our study mainly collaborate with universities to access or transfer critical knowledge and resources to advance core technologies. The firms that already had their first product on the market, or were close to, usually continued R&D leading to second or third generation technologies. In most cases, the firms' original technology was an off-spring of academic research transferred to the firm in the form of a patent, license agreement or know-how. This strongly supports the argument that small firms are important vehicles for commercialising academic output.

To access and transfer critical knowledge and resources from universities, small firms deploy a myriad of channels. Most commonly these channels involve personal interaction in the form of technical consultancy and contract research. These were seen as effective and efficient methods to tap into critical knowledge at universities required to solve immediate or short-term technical problems. However, in most cases knowledge transfer was not viewed as one-way, with the expectations that academic scientists always have the answer ready. As revealed by some of our interviewees, it was often a mutual learning process:

"It requires that you pick up the phone at least half an hour every week and chitchat forth and back – and if you come across something new then you send it over and vice versa. So if you do come across something then you have a dialogue going on continuously" [DK-5];

"Like every single day, you know, we've got a couple of high developers [firm developers] that have to walk up there or people [academics] coming in here and doing testing and that sort of thing" [NZ-19].

It is also common for firms to invite academics to sit on their advisory boards. Academics often take up the position out of curiosity and self-interest rather than for economic remuneration. As a representative of one firm, with five academics sitting on their advisory board, describes:

"*We shared the same fascination – and when you do contact a university [scientist] – you do not need much more than that" [DK-3].*

Besides consultancy and contract research, small firms use a variety of other channels to exchange knowledge with universities. These include leasing of equipment, teaching at universities, co-supervising students, publishing articles, attending conferences and giving seminars. Therefore, the average relationship with universities usually consists of a myriad of channels for knowledge sharing that often are mutual and reciprocal. Most firm managers describe the relationship as give-and-take where shared interests foster and prosper:

" *Jerry [academic scientist] dances the same borderline as I do. He just dances it from the other side. I believe that there is value in academic research that is untapped and needs to be (a) understood and (b) intelligently applied. And Jerry believes that there are opportunities in commercial science that can be solved and helped with academic research as long as that academic research is tailored to those problems... So, we are able to work together and provide different pieces of the puzzle" [NZ-23].*

While this insight well represents the general view that small firms shows towards academic research, it also provides an interpretation about how small firms perceive themselves as being on a mission of contributing to the creation of new knowledge through application of academic research.

Now attention will be directed towards the relationships with TTOs as described by the firms in this study. One may argue that a TTO is only a facilitator or moderator to the actual relationship. Yet, the increasing orientation towards research commercialisation at universities means that the role of TTOs in university-industry relationships is becoming more influential. This is also evident in the findings of this study. All firms in the sample had experiences dealing with TTO as part of establishing relationships with universities. Especially those firms that were founded on university technologies had been through negotiations with TTO regarding transfer of technologies and knowledge to the firm. Here negotiations refer to the process of reaching an agreement between the firm and university and may include other types of contracts such as lease arrangements, research and training and education. Some firms, especially university spin-offs, also had a relationship with TTOs in form of shared ownership of patents or TTO taking ownership in the firm in return of passing on intellectual property rights. In a few cases, the firm and academic scientist also worked closely with the TTO during the process of taking out the patent:

"*Thomas [firm scientist] works very closely with South University – together with Henry [university scientist] and with the TTO – around everything – one thing is having an idea and raise capital and build the right team – that is hard enough – but to take out a patent [interviewee expressing that this would be impossible for the firm to do alone]" [DK-5].*

Among the firms in the sample, the interactions with TTOs were often: (1) negotiating IP and other contracts, (2) take out joint owned patent, (3) shareholder, (4) advice on how to structure relationship.

Some firms also experience the increasing focus on research commercialisation at universities affects the relationship:

"*We experience that [North] University – I am not sure if it is a TTO or what sort of office – but we experience that they are more aggressive and more formalised – not really aggressive – but more formalised than earlier" [DK-4].*

"*The first contract was no problem. But as we tried to renew it – it took half a year to sort out. Obviously the University has seen there is a need and it is increasing" [DK-11].*

As a consequence of universities becoming more commercially orientated, most firms picture their relationships with universities as a dual relationship requiring management of both TTOs and academic scientists. Small firms could no longer just focus on managing one side of the relationship. The dual relationship is illustrated in Figure 1 below.

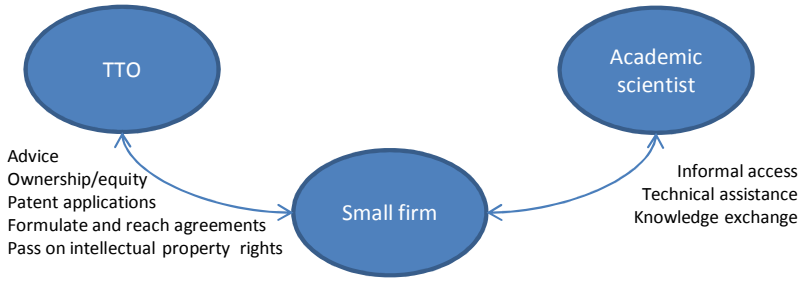

Figure 1: Relationships between TTOs, small firms and universities

Tensions in managing the relationship

In most cases, establishing and developing relationships with universities requires a continuous interaction process with both the individual scientist and the TTO. While often the role of the TTO (as specified previously) was to facilitate the actual relationship, it was very evident from the analysis, that negotiating and dealing with TTOs cause numerous managerial challenges to the firms. In almost all cases, the firms report having difficulties interacting with TTOs which in many cases impede or demoralise further collaboration between the firm and the scientist. As one manager expressed:

"*We decided to park negotiations with the university. Because one of the things that actually stalled [Rob] making much progress with [this technology] was he trying to negotiate a license with [the TTO] for access to the intellectual property and that just ended up being a never ending process to the firm" [NZ-23].*

This experience with hard and long negotiations with TTOs was very common among most firms in the sample. In the case of NZ-23 the firm eventually got a contract with the TTO but it took 12 months to conclude. Another manager from DK-7 also referred to problems with negotiating with TTO. A joint invention between a firm employee and an academic scientist proved to have a commercial potential. They inventors agreed to a 50/50 ownership and reported the inventions to the TTO. To the frustration of the firm, it took the TTO five months to set up the first meeting to negotiate a further plan for the invention. The TTO was willing to pass on the intellectual property to

the firm for DKK 100,000. In this case the firm had to carry all the expenses of patenting and further development. But the firm decided not to and the invention was never patented. The manager argued that the problem was the TTO wanted a lump sum up-front and not take part in the risk of developing the invention further. Many firms in the sample referred to TTOs asking for up-front payments to be a huge obstacle for further collaboration. As two mangers pointed out:

"*The University would prefer to do an early license deal that gives them a cash payment, or an annual license fee, than to try to do drug development" [NZ-21];*

"*The response from the TTO was a very clear, if you want to work through the university path [access to laboratory and equipment], then you pay the university NZ$200 an hour to do so. We didn't have any money" [DK-24].*

A problem for most small firms was limited financial resources, which in many cases made it impossible for them to agree to the terms put forward by the TTO. In these cases, the firm downsized their relationship with the university or simply tried to substitute the universities by establishing relationships with customers or suppliers. Some firms even felt neglected by the TTOs because they were perceived as being too small. This was even more common amongst those firms founded by young entrepreneurs. As one firm expressed being perceived by the TTO:

"In the beginning, the view was in the sense "you guys are just too small for us to care about. You're a group of students with an idea and that's all and that's not what we're interested in" [NZ-24].

It was also a problem amongst most firms that they did not have any experience in negotiating intellectual property rights with TTOs. As one manger highlighted:

"*I am not lawyer, I have a background in mathematics and engineering" [NZ-32].*

This was also connected with anxiety and the considerable time spent on preparation prior to negotiation meetings with the TTOs for most inexperienced firms. Several firms also gave examples of how they felt TTOs actually use information asymmetry to improve their bargaining power in the negotiations. For example, TTO officers might refer to agreements made with other firms as 'university standards' that could not be deviated from – basically telling the firm to 'take-it or leave-it'.

Another problem managing the relationship with universities was caused by blurred institutional boundaries. Often in the case of university spin-offs the founders continued to be affiliated with the host universities in his or her existing position. As such there was only an employment contract and trust between the founder/academic and the employee to govern the relationship. Some small firms were located in close geographic proximity to the main university partner at either nearby incubators/science-parks, or at university premises. This also led to blurred institutional context in which it was difficult at times to separate university and firm. As one firm that was located nearby the university and mainly hired staff from that university, revealed:

"There is lots of information and knowledge that flows forth and back [university to firm], as many of them [employees] are taken directly from the academia.... they have real troubles sometimes distinguish between what belongs where" [DK-9].

The main problem with blurred institutional boundaries mainly relates to ownership of IP. If something was created within the grey areas of the relationship, a potential conflict with the TTO could arise. A few firms had secured future IP through signing an agreement with the TTO but in most cases it was interpreted by the researcher that most firms just accepted the risk and tried to avoid any issues related to negotiating with TTOs regarding IP unless absolutely necessary. But this assertion was treated very carefully as it was difficult for the firms to discuss these issues openly.

However, when it came to smaller things, such as borrowing equipment or getting some free advice, it was evident that informal relationships and acts of friendships were often used to circumvent formal contracts.

"*You can say – if you get stocked then you can get some advice – there is advice and then some equipment or other things. But again – well it is at the informal level and I believe that no one has actually approved that we borrow some equipment" [DK-2].*

While most firms did use informal relationships to access certain resources, it was not looked at as doing something wrong. Rather it was part of the reciprocal and mutual relationship, described earlier. As one manager put it:

"*At 11:15 today I am going down to the [University] and I am giving a seminar on commercialisation. I am not charging for that" [NZ-25].*

Firms even felt an obligation to pay back as they become more established and resource consolidated:

"What I'm trying to do is sort of give back as well, by taking on students and spending time and working with some of their programmes and that sort of thing. Which I think is important" [NZ-19].

Yet, the reciprocity in the relationship appeared to be a matter between the firm and the scientist/faculty and ignored by TTO.

Several firms also articulated contractual problems when formulating knowledge exchange in relationships with universities. Many firms consider their relationships to be mutually beneficial, ongoing, and built on trust rather than control and monitoring. As one manager expressed:

"*We have chosen not to set up a contract because it is basically not possible to do so. The only way that we can progress the research is to have the trust that all of us, and our organisation will share, and I will use this word suitably, in the rewards for those efforts. Without that trust no work would occur, no grants would be pursued and the research would have essentially no application" [NZ-23].*

In this particular relationship, which is not much different from what other firms reported, both parties worked together to advance knowledge to the benefit of both parties. Several firms also took active part in publishing results with university partners, supervising PhD students, giving scientists access to the firm as part of the reciprocal exchange of knowledge. And when it came to knowledge (as being something tacit and difficult to quantify and specify) most firms did have trouble formulating that in contracts including 'who can meet', 'where to meet', 'when to meet'. As one manager described:

"If you start with the know-how, which is something that resides within people's head, the mode of transferring is not necessarily through a lot of documents" [DK-8].

Summing up, almost every firm in this study has experienced complications in managing relationships with universities and in particular with TTOs. In the eyes of the firms, the problem is

mainly caused by the transactional approach to university-industry relationships applied by most TTOs. This leads to hard and often long negotiations focusing on short-term revenue rather than developing long-term relationship aimed at mutual knowledge exchange. The small innovative firm also lacked experience and competences in negotiating and dealing with TTOs which often causes anxiety and distrust. Blurred institutional contexts and use of informal relationships also makes it difficult at times to distinguish between what belongs to the firm and what belongs to the university. However, knowledge exchange and progress in innovation are seen as almost impossible at times to quantify and specify in contracts, which causes an obvious conflict between the objectives of most TTOs, the firm, and individual scientist.

Solving tensions in relationships with universities

While there was much evidence describing the tensions in relationships between small firms and TTOs, some firms also have good experiences collaborating with both TTOs and academic scientists at the same time and within the same relationship. These experiences are also important to report ,as it is important to understand, at least from a managerial perspective, if tensions are self-inflicted and can be solved through appropriate management practices.

While most firms did express their frustration around interacting with TTOs, some firms also recognised the value of research commercialisation becoming more widespread at universities. A significant amount of the firms in the sample were founded on academic knowledge from universities that, via the competences of the TTO, had been properly protected. There was also a general credence among the firms that knowledge and resources transferred to the firm should be charged for as part of handing over ownership:

"In the cases where a technology is transferred from the university to us, I find it natural that there will be negotiations about price and terms" [DK-4].

When firms reported positively about their relationship with TTOs, it was often when each party utilised their unique competences to progress innovation for mutual benefit. In several cases, the patent was owned jointly by the firm and university, which created a more balanced relationship as the universities also were interested in helping the firm to succeed by strengthening the patent. As one firm explained:

"*And the patent is passed on from one bureaucratic unit to the other. But what TTOs have, which is why we collaborate with them, is how to take it from the European to the International [patent*

regimes] – that is where they have knowledge on how things work and they are in control of that. So to say, that is very positive for us that we do not have to be involved in that" [DK-2].

In this particular situation, the firm worked closely with academic scientists to advance the technology and the TTO contributed with legal advice and support through being responsible for taking out the patent. A few other firms had similar arrangements, which led to better utilisation of complementary skills in the relationship. Of course this did not always work without creating other complications as this often required the university to take an equity share in the firm or only provide the firm with a license agreement. But the lesson to be learnt here is that TTO often can bring complementary resources to the relationships if managed appropriately.

A few firms also reported a continuing dialogue with the TTO after the contract had been signed to smooth out any conflicts arising in the relationship. As one firm expressed:

"*In terms of ongoing management it's about, it's like anything, you know, you actually have to continually manage the relationship, talk. And just when you've actually signed an agreement that's the start, that's not the end. And you have to continue to make sure that what you went into the relationship for is what you're getting and that the understanding hasn't changed" [NZ-25].*

Another firm, DK-5, even invited representatives from the TTO to visit the firm and get demonstrations on how the technology had progressed. In this case, the manager argued that visits were important to keep everyone motivated to continue working together in the relationship. However, it was very sporadic with examples in the data on how efforts were made to actually fostering a long-lasting and mutual relationship between the firm and the TTO. Of course this might be because the TTOs are not very receptive towards developing mutual relationship with firms and vice versa.

Finally, some of the firms more experienced in dealing with TTOs also referred to a learning effect. One firm had entered several contracts with domestic and international universities over the years. When reflecting over the process, the manager pointed out:

"I*t means that I am more aware – for example how an agreement should be made and what elements, especially related to IPR, that I have to be sure are incorporated" [DK-3].*

Learning and reflecting became even more important as some firms also started to collaborate with other universities. Not only could experiences be utilised in setting up new agreements with new universities, they could also be used to identify potential conflicts or opportunities. One firm, NZ-26, described how positively surprised they were to find how well structured another university´s TTO was compared to what they had been used to. While a newly established firm might be more dependent on a host university, especially for spin-offs, it is also important to extend one's network to allow for more opportunities to find other partners if a satisfactory agreement cannot be reached with the original one.

There was only sporadic evidence to describe how tensions can be solved in relationship between small firms and universities. It is an important avenue to include as it shows that there are advantages of considering TTOs as being part of the relationship that is to be managed.

Conclusion

The findings in this study describe how small firms are struggling with adjusting their governance mechanisms to the increasing focus on research commercialisation at universities. The struggle seems to have amplified by small firms needing to govern both the individual scientists and the TTO. Often small firms are left to play as the mediating role between the TTO and the individual scientist, which means they have to develop and apply governance mechanisms to satisfy both parties. This is a complicated task as this requires more diverse skills than those usually held by small firms.

This is even more complicated as the approach governing both scientists and TTOs is somewhat different and almost conflicting. The individual scientist is best managed through more informal mechanisms such as trust and social capital. This equals a more relationship orientated approach to managing governance. On the other hand, the TTO requires a different approach which seems to be more transaction related. Often TTOs try to maximise profit (sometimes even short term) to satisfy self-interests. This study shows that small firms struggle with managing both sides of the equation.

This study also gave some examples of how small firms can develop and apply governance mechanisms successfully in university relationships. Small firms need to become more aware of the increasing need for them to deal with formalised governance mechanisms (e.g. contracting, negotiating and monitoring). To some extent the need for more formalised governance mechanisms could be eased by small firms being better communicators and trying to combine the interests of both the firm, TTO and individual scientist into one. The small firm, however, can only do so to the

extent their resource situation allows them. This leaves this study to suggest that these findings also have some implications for university management and policymakers.

Universities should also try to solve some of the tensions in the university-small firm relationships by engaging in dialogue with small firms and scientists, moving away from being transactional and focus more on the benefits of building and developing strong and long-term relationships. Policy makers can also learn from this study by trying to put less pressure on universities to secure short-term gains, invite more small firms to collaborate with universities through grants and funding to create opportunities for small firms to gain more experienced with university collaboration.

In short this study contributes to existing theory by firstly empirically and theoretically accounting for the challenges of small firms governing university relationships in the context of research commercialisation at universities and secondly outlining a number of implications of these findings to managers and policymakers.

Research on university-small firm relationships can benefit from a more detailed account on how small firms can collaborate with TTOs and university scientists simultaneously. This can be achieved through further explorative studies. Explorative studies can aim to uncover the role TTOs play in university-small firm relationships when it comes to producing new knowledge and advancing long-term relationships. Also more research is required on best practices when it comes to governing university-small firm relationship in general.

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10 Paper 3 – Developing university-small firm relationships

Capturing university relationship value through social capital: the perspective of small firms[15] [16]

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Abstract

This paper shows that altering social capital to fit with the strategic focus can be a challenging task for small firms collaborating with universities. Through an explorative study of 30 small firms it is found that small firms start out with different configurations of social capital providing them different advantages and disadvantages. As small firms proceed with their research and development, their configurations of social capital are changing. However, initiating these changes are more challenging for some firms than others. This leads this study to conclude that there are both necessary and critical paths for small firms in developing social capital when capturing value in relationships with universities.

Keywords: *University-small firm relationships, social capital, strategy in SMEs, innovation*

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INTRODUCTION

Social capital is of huge importance for small firms to capture university relationship value. Social capital in relationships between universities and small firms promotes knowledge sharing behaviour (2006), motivates favours and informal exchanges (Kreiner & Schultz, 1993), to substitute need for formal governance mechanisms (Rappert, Webster, & Charles, 1999), resolves tensions of ownership of intellectual property (Jelinek & Markham, 2007) and provides an effective mechanism to allocate economic benefits in the relationships (Abramovskya, Kremp, López, Schmidt, & Simpson, 2009).
Social capital has also been identified as an effective facilitator of university-small firm relationships. Small firms prefer to continue collaborating with universities with whom they already share social capital (Izushi, 2003; Sternberg, 1999). Small firms also prefer to collect information about new university partners through their existing social network (Al-Laham & Souitaris, 2008). Social capital becomes even a stronger facilitator when small firms and universities also share technical interests together with personal and social interests. Overlap in technical knowledge and capabilities have been found to promote richer interactions between universities and small firms (Daghfous, 2004). In contrast, Fransman (2008) argues that social capital is a pre-condition for small firms to collaborate with universities in the first instance.

It has been well established in the literature that social capital substantiates and facilitates university-small firm relationships. Insight, however, into the evolution of social capital remains very limited. The prevailing view in the literature on social capital and university-small firm relationship is rather biased towards *´the more social capital the better´*. This bias exists despite knowledge that social capital may also lead to inertia or turn relationships into social liabilities (Maurer & Ebers, 2006).

In this paper I propose that managing the evolution of social capital for small firms is of crucial importance to continue capturing university relationship value. Small firms are not static but highly dynamic entities who advance through different technological stages over a relatively short time period. Throughout each of these stages, the firms require access to different resources and competences to progress (Hite & Hesterly, 2001; Kazanjian & Drazin, 1989). With social capital substantiating and facilitating relationships with universities, it becomes important how small firms manage their social capital to provide them with access to required resources and competences as they progress their technology. Therefore, this paper intends to clarify what configurations of social capital are most likely to benefit small firms collaborating with universities during research and development orientated stages; how small firms manage the evolution of social capital within and

between these two stages; and what are the critical managerial challenges involved in managing this evolution. These questions are explored through explorative empirical studies of 30 small firms working with universities.

This study finds that small firms start out with various configurations of social capital providing them different advantages and disadvantages. The various configurations also create different paths from which social capital subsequently evolves leading this study to conclude that there are both avoidable paths and necessary paths to follow for small firms developing social capital when capturing value in relationships with universities. This study contributes to the existing literature on university-small firm relationships through insight into the dynamics of how small firms can manage their social capital to ensure value-capturing in relationships with universities.

The concept of social capital and its value to the firm

This section outlines the concept of social capital. The first part of the section describes the positive and negative impact social capital might have on the firm. The second part focuses on conceptualising social capital into a conceptual framework guiding the empirical study. The conceptual framework consists of two dimensions: the first dimension sub-divides social capital into *structural, relational* and *cognitive* capital. The second dimension presents, *the research* and *development stages*, which represent two distinct stages in the life cycle of small firms working with science-based innovations. The section concludes with a presentation of the research questions linked to the proposed conceptual framework.

The value of social capital

Social capital has proved to be a powerful concept in explaining the success of the firm in many areas. This includes formation rates of start-up firms (Myint, Vyakarnam, & New, 2005; Walker, Kogut, & Shan, 1997), as a facilitator of inter-organisational relationships (Chung, Singh, & Lee, 2000; Wenpin Tsai, 2000; Walker, et al., 1997), for external knowledge acquisition (Yli-Renko, Autio, & Sapienza, 2001), promoting inter-organisational learning (Kale, Singh, & Perlmutter, 2000), creating intellectual capital (Nahapiet & Ghoshal, 1998) and human capital (Coleman, 1988). Social capital may also have negative impact on the performance of the firm as building social capital requires investments of time and resources to maintain relationships with other firms (Hansen, Podolny, & Pfeffer, 2001; Maurer & Ebers, 2006). These investments can be considered as opportunity costs because they tie up resources that could potentially be applied to developing alternative relationships (Hansen, et al., 2001). In this situation, social capital constrains the firm from changing its portfolio of relationships and thus creates inertia (Gulati, 1998). The negative aspects of inertia is

underperforming relationships that turn into social liabilities (Hansen, et al., 2001; Maurer & Ebers, 2006). Further the existence of mutual trust, reciprocity, and intense interaction inhibits the ability and incentive for a firm to change partners (Burt, 1992; 1997; Maurer & Ebers, 2006). Other researchers argue that similar routines and understandings between partners can lead to locked-in situations limiting learning potential and competence development over time (Maurer & Ebers, 2006). Hence, re-investing in existing relationships is not always ideal for firms (Hite & Hesterly, 2001).

Configurations of social capital

The notion of social capital has long been established in the inter-organisational literature (Burt, 1992; Coleman, 1988). Although social capital has been defined in many different ways, the general understanding behind the concept is that it emerges as an intangible asset that is differentiated from other types of assets by the specific dimension of social structure that underpins it (Adler & Kwon, 2002, p. 18). Nahapiet and Ghoshal (1998) offer a comprehensive conceptualisation of social capital which has been widely adopted in the literature. They divide social capital into three distinctive dimensions: *cognitive, relational* and *structural capital.* Cognitive capital refers to the state of having consistent worldviews, language, working methods, belief, common goals and attitude among actors in relationships, which allows efficient communication and learning (Maurer & Ebers, 2006; Nahapiet & Ghoshal, 1998). The relational dimension of social capital is associated with trust between actors in the relationships which Lui and Ngo (2004) divide trust into *goodwill* and *competence trust.* Goodwill trust refers to the expectations that partner has the right intention to fulfil their role in the relationship (Boersma, Buckley, & Ghauri, 2003; Dyer & Chu, 2000; Gulati, 1995; Lane & Backmann, 1998). Competence based trust is related to the expectation that the partner has the ability to fulfil their role in the relationship (Lui & Ngo, 2004). Structural capital refers to the configuration of the firm's relationships/networks such as the presence of strong/weak ties, density, connectivity and hierarchy (Ahuja, 2000; Burt, 1992; McEvily & Zaheer, 1999; Rowley, Behrens, & Krackhardt, 2000; Tsai & Ghoshal, 1998; Walker, et al., 1997). These sub-divisions of social capital represent the first dimension of the conceptual framework pictured in Figure 1.

Social capital and life cycle of small firms

In this paper it is argued that the configuration of social capital needs altering to accommodate the need of small firms to access the appropriate resources and competences required to progress their technology. Research on university-small firm relationships shows that small firms usually collaborate with universities around early stage technologies that need substantial further research and development before being introduced to the market (Jensen & Thursby, 2001). The research

stage refers to the activities related to discovery of the initial invention, invention disclosure and intellectual property protection and the need for research leading to a 'proof of concept' (Jensen & Thursby, 2001). Focus is on transferring and sharing tacit knowledge between the inventor and the firm (Agrawal, 2006) and gaining access and building strategic resources such as laboratories, reputation and human capital (Kreiner & Schultz, 1993). Relationships with universities often evolve around individuals and stem from prior relationships with family members, friends or former colleagues. They tend to be path dependent, informal and less diverse (Hite & Hesterly, 2001; Kreiner & Schultz, 1993). To capture value in relationships with universities during the earlier research stage, it is assumed that social capital is characterised as being *behavioural.*

The subsequent development phase to the initial research phase refers to improvements to proof of concept or initial technology, development of prototypes, clinical trials, testing, validation and initiating second generation technologies (Jensen & Thursby, 2001). For these improvements, the firm often requires a more diverse set of competences to proceed compared to the earlier research stage (Hite & Hesterly, 2001). Relationships during the development stage tend to provide greater resource availability and mitigate environmental uncertainty. A relationship is more focused at satisfying purposeful functions or tasks (Hite & Hesterly, 2001). To capture value in relationships with universities during this stage, it is assumed that social capital is characterised as being *strategic* (Fontana, Geuna, & Matt, 2006; Izushi, 2003). The relationship between social capital and small firms collaborating with universities is illustrated in Figure 1.

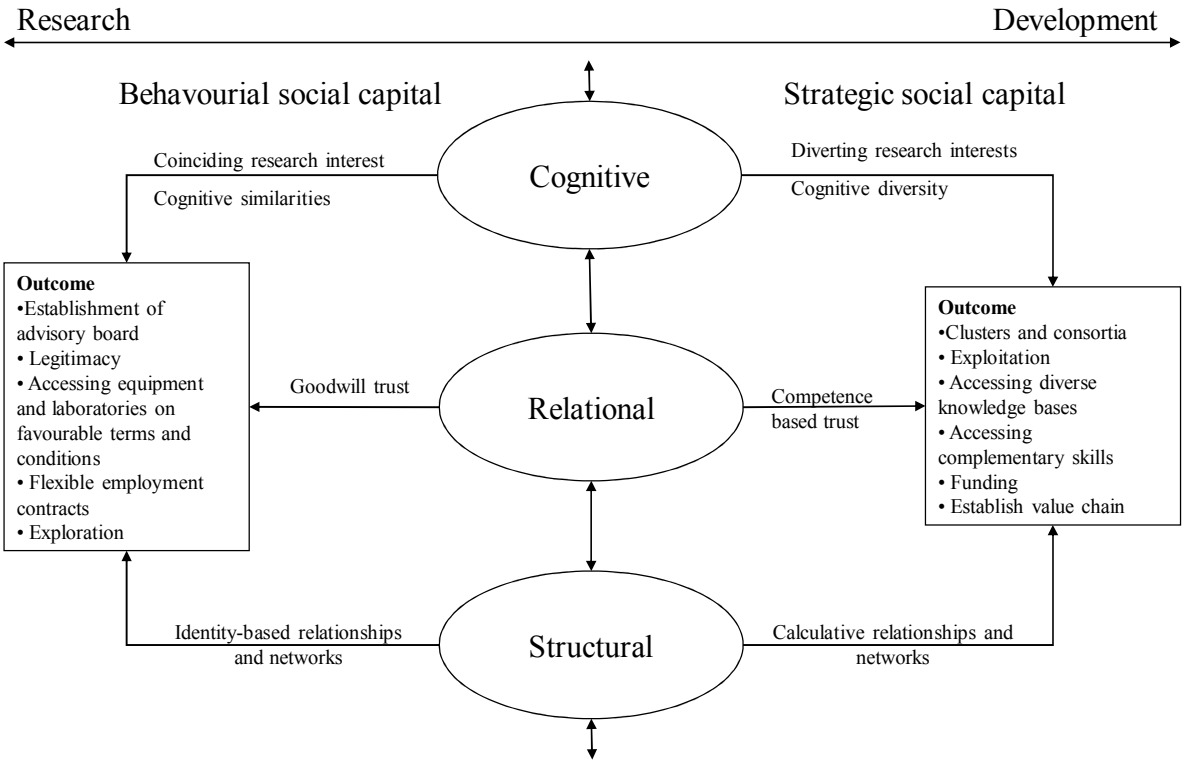

Figure 1: Conceptualisation of social Capital and life cycle

As suggested by the existing research, social capital in the research stage leans towards being more *behavioural,* while during the development stage it becomes more *strategic*. Based on this conceptual framework, this paper intends to answer the following research questions: How and through what mechanisms do small firms develop social capital to fit with behavioural and strategic social capital? How do small firms manage the transition from no social capital to behavioural social capital and from behavioural to strategic social capital?

Method

An explorative research design based on in-depth interviews is identified as particularly useful when capturing dynamics that develop over time – in this instance social capital (Langley, 1999; Shaw, 1999). Using a theoretical sampling method (Eisenhardt, 1989), the selection criteria for the firms was: (1) the firm is or has been involved in relationships with universities and (2) the firm has less than 50 employees.

The primary source of data was in-depth interviews with business managers from the firms. This was supplemented with secondary data from company websites, newspapers and university and investor newsletters. The secondary data was particular useful to establish if the firm was still in the *research*

stage or has moved on to the *development* stage. The interviews were conducted following a semi-structured interview guide.

The sample consists of 30 small firms from Denmark and New Zealand that currently or in the past have been collaborating with universities. The sample consists of firms from various high-tech and biotech industries including software, nanotechnology, robotics, bio-pharmaceuticals, protein engineering and cell and tissue culture. The firms were located in the major cities of Denmark (Copenhagen and Odense) and New Zealand (Auckland and Dunedin). All firms had relationships with at least one domestic university.

Table 1: Overview of participating firms and their attributes

Attributes	Danish firms	NZ firms
Number of companies in group	18	12
Age of Companies		
Oldest firm	1992	1987
Youngest firm	2006	2006
Number of employees		
1-9 employees	13	6
10-49 employees	5	6
Stage in Commercialisation Process		
Firms having products at market	8	4
Firms in research stage	2	1
Firms in development stage	8	7
Spin-off		
Direct university spin-off (based on university patents)	8	5
Indirect university spin-off (based on university know-how)	4	3
Non spin-offs (usually founded by industry professionals)	6	4
Other		
Firms located in science parks or at university premises	12	6

For reporting purposes, each firm is coded with an ID code to ensure anonymity. The ID code consists of (1) ID number (1-30), (2) country code (DK or NZ) and (3) industry code (biotech or high-tech).

The process of analysing the data was assisted by qualitative data analysis software (NVIVO). All data (transcripts, various websites, newspaper articles and field notes) were imported into NVIVO as text documents. Attributes (age of firm, nationality, industry, number of employees, spin-off/non spin-off, founder characteristics etc.) related to each firm are indexed. Other data are segmented into pattern codes based on the overall themes of the interview guide and the conceptual model of this research (Miles & Huberman, 1994). The next step included comparing and contrasting evidence

across the research and development stage. This was followed by analysing evidence across firms to match similarities and identify what caused variations. As recommended by Miles and Huberman (1994) this part was conducted by taking the prior indexed attributes and comparing those to pattern codes

Findings

In correspondence with the existing research and conceptual model, this study shows that the configuration of the firm's cognitive, relational and structural capital shows remarkable differences between the research and development stage. Small firms usually move from being predominantly research orientated towards being primarily development orientated.

Configuration of social capital within the research and development stages

During the research stage, it was evident that small firms strived to develop behavioural social capital to capture value in relationship with universities. The value usually related to informal discussions and conversations with former colleagues, access to laboratories and equipment at favourable conditions, receiving small favours from former academic colleagues and gaining legitimacy through academic member joining the advisory board of the firm. The actual relationship usually consisted of close personal ties between the founder/manager of the firm and academic scientists.

During the development stage it was evident that small firms were most likely to benefit from relationships with universities if they had transformed their social capital from being behavioural to strategic. The benefits of strategic social capital to the firm were often related to having access to more diverse and resourceful relationships and networks, stronger and more sustainable network positions, improved funding opportunities and higher specialisation of skills.

Various levels of initial social capital

Differences across the firms, however, appear in the level of their initial social capital. These different levels of social capital lead to different challenges, both during the research stage and during the development stage.

Those firms with high amount of behavioural social capital where typically founded by former academic staff with a long academic career behind them. Relationships with academic scientists were established through the firms' founders/scientists prior experiences with the university

community. These firms also tended to capture the highest value in relationships with universities both in terms of accessing and sharing valuable resources and knowledge. For example:

> *"In a lab where it happens you don't know people in advance – maybe it won't be possible to come around within the normal hours, because they also need access to the equipment"* (17-DK-Bio); and

> *"We knew them personally [members of advisory board], so we didn't just pick them and ask them sort of without them knowing us as well, and understanding initially what we were trying to do"* (27-NZ-High).

Those firms with little social capital were typically founded by former students. Former students were limited to their former lecturers or supervisors as their contact with universities. Firms with no social capital were typically founded by industry professionals who had not previously been engaged with the academic community.

Building behavioural social capital

During the research stage it was critical to small firms with no or only little social capital to develop more behavioural social capital to capture value in relationships with universities. Especially small firms founded by former students often perceived their own technical knowledge as insufficient to approach academic scientists outside of their previous lectures and supervisors.

> *"… I used to study at this university X and now I am a part time lecturer here – It could be that more leading research is conducted at university Y [which is another university in Denmark]. But I don't know anyone up there. Now I have taken the contact to Michael [an associate professor at university X] instead of Lisa [an associate professor at university Y], even though I have heard about Lisa before Michael. But Lisa is not part of my network – Michael was. That is how it was established. It is very much based on someone you know – even though Lisa was more in the media and visible"* (17-DK-High).

Eventually this small firm (17-DK-High) managed to extend its social network, however, this occurred over a significant time period and required several steps. It is found to be common that firms with less behavioural social capital try to develop social capital by first offering to help out with teaching or supervision. This also serves to upgrade the knowledge base of the firm to enable richer discussion with academic scientists around technical and scientific issues relevant to the firm.

The firms founded by industry professionals tend to apply a different strategy to develop behavioural social capital than those of former students. Compared to student- and academic-founded firms, firms founded by industry professionals tend to have stronger financial resources to begin with, which probably explains their choice of strategy when it comes to developing social capital. Industry professional founded firms often attempt to shift staff from academia into the firm through full time or part time employment. The benefit of this strategy in terms of social capital is

that the firm also gained access to the new employees' personal social network. For example, one firm hired a graduate master student who had been supervised by the academic inventor of a licensed technology. In this case all technical communication between the firm and the university took place as part of the personal relationship between the former student and supervisor. Another firm hired an academic on a part-time basis while that person continued being affiliated with the university in his remaining time. This created a win-win situation as the firm could tap into new technical knowledge at universities through their employee, while the employee learned from working with the technology in a more applied context.

The transformation or development of behavioural social capital during the research stage constitutes a critical but necessary path to follow for small firms. Firstly, it can be a lengthy process as it takes time to get to know each other's strengths and weaknesses and for mutual trust to evolve. Secondly, it can be a costly process if the firm only depends on developing social capital through acquiring human capital.

The transition from behavioural to strategic social capital

While the ideal scenario for small firms is a smooth transition from the research to the development stage, it is evident that this is hardly ever the case. The required adaptation from predominantly behavioural to strategic social capital is often a lengthy process that requires several organisational changes. In the development stage it is not sufficient any longer to only interact with academics sharing the same research interests. There is an increasing need to access academics with complementary knowledge bases that could no longer be identified through personal contacts only. Thus several firms described how they had to change their partner selection procedure:

> *"I have not considered the people that I know already – I have given priority to the particular qualifications that I need – and then I have acquired them"* (3-DK-Bio);

Parts of transforming the organisations also require changing the mindset of firm staff to become more commercially-orientated. Some firms find it necessary to relocate away from universities to stimulate a more commercial mindset.

> *"It is also correct that we moved from the lab to our present facilities, because we sort of needed to distance ourselves from the academic environment and become more business orientated – getting away from the academic society gave us a chance to direct our culture towards a more business-like environment"* (11-DK-High).

There are several examples that the process of transforming social capital is driven by managerial actions. Firms change their procedure to search for (using for example journal articles or

conferences) and screen (for example second hand information or simply by talking to potential partners over the phone) potential university partners to identify new competences. They hired people with diverse network contacts that included both the academic and industrial world. People with more diverse network contacts could take advantage of their ability to manoeuvre in the space between the industry and university sphere. These people also took active part in applying for funding to establish clusters and consortia. This often required contact to universities outside their existing network.

The transformation from behavioural towards strategic social capital is necessary for the prosperity of small firms. The transformation is a process that requires careful management, organisational changes and a move away from an academic towards a more commercial mindset.

The problem of transforming behavioural social capital into strategic social capital

While most small firms seem to be aware of the managerial actions required to transform social capital from the research to the development stage, it is also observed that some firms chose not to while others simply did not know how to. The lack of transformation of social capital was mainly due to the mindset of the founder. Especially among firms founded by former academics there were examples of how too much behavioural social capital turned into social liabilities impeding growth and commercial orientation. Some firms were managed by the founder who still worked full- or part-time at a university. These founders often considered their firm more as a 'side-line' business that might one day generate additional income. Others seem reluctant to leave their comfort zone at universities to devote their time and energy to more commercial activities. Additionally they considered publishing in academic journals, supervising students and attending conferences as important activities to continue developing their network to the benefit of the firm and their academic career. For example at one firm it took 14 years to move from research to start focusing at developing actual products. The firm was a spin-off based on a university patent. The founder continued research to strengthen the patent base, but never really engaged in commercialising any of these. One day he was contacted by professional investors who removed him as CEO and installed a new management team and board of directors. The company grew in few years from a one-band company to 43 employees.

Small firms that do not manage to convert their behavioural social capital to strategic social capital as they try to pursue more development orientated activities delay growth and turn social relationships into social liabilities. Yet this study found that to utilise behavioural social capital during the development stage leads to disadvantages.

Discussion and conclusion

Based on this analysis, the dynamic role of social capital for small firms collaborating with universities is pictured in Figure 2. The figure shows (1) the typical scenarios for how small firms build social capital during the research and development stage; and (2) the necessary and critical paths for developing social capital towards the research and between the research and development stage of the firm. These critical paths outline the managerial implications of small firms when altering their social capital to fit with their strategic focus.

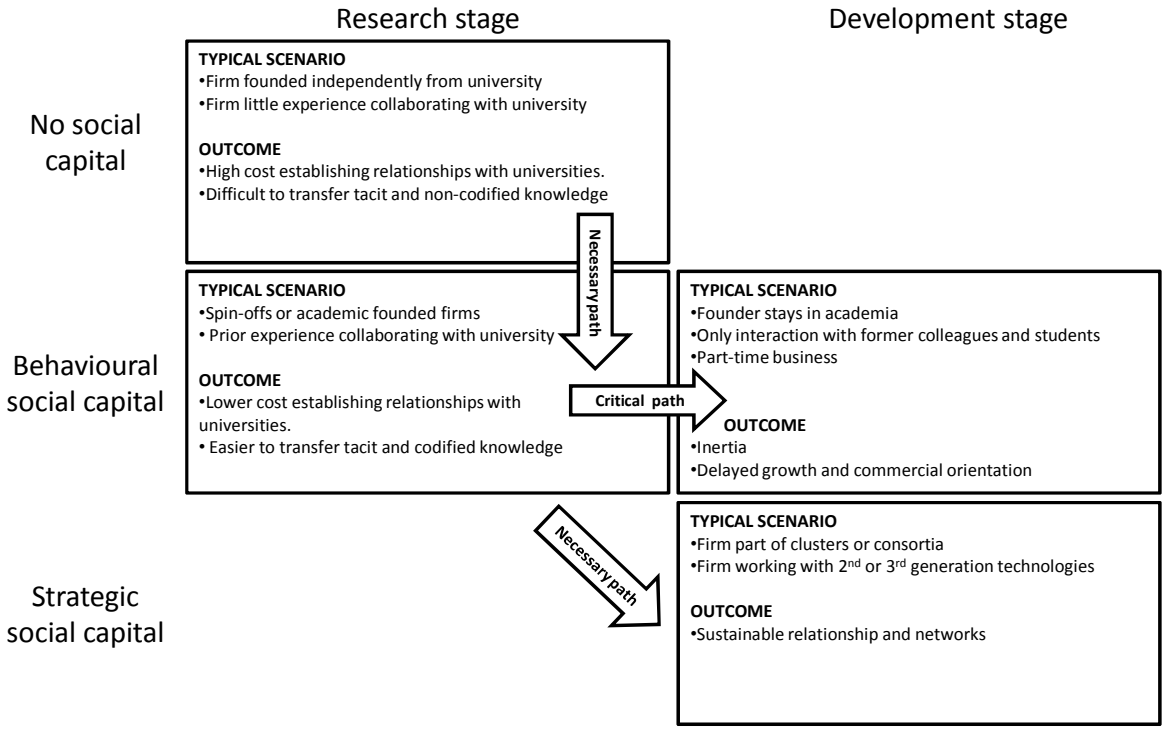

Figure 2: Social capital in the research and development stage

This study makes contributions to the understanding of social capital and university-small firm relationships. It establishes that the shift from the research to the development stage leads the formation of relationships, but it is in fact social capital that determines the outcome of the relationship. For small firms collaborating with universities this can be difficult to manage as having no behavioural social capital prevents them from establishing relationships with universities in the first place, while too much behavioural social capital or failure to convert into strategic social capital can lead to delays or demise of the business. The study emphasises that social capital of small firms is often equivalent to the founder's social capital to begin with, which is heterogeneous and means

that small firms have different starting points from which they need to develop their social capital. This also makes it difficult to generalise across small firms about what actions are required to adjust social capital to fit their strategic focus. In this study, high variation in social capital and how they reply to this variation is found to exist across the three groups of firms founded by former academics, former students and industry professionals. Moreover, it is found that the challenge of adjusting social capital is often driven by the personal mindset of the managers (intentionally or unintentionally). While managerial actions are necessary to adjust social capital, these actions are usually of more generic character such as networking with industry people, consciously stepping out of one's comfort zone and allocating more time to develop one's business rather than academic career.

This study has both theoretical and managerial implications. Theoretically, the findings demonstrate the salience of social capital as a concept to analyse how small firms can capture value in relationships with universities. From a managerial perspective, small firms need to be aware of the opportunities and restrictions relating to different configurations of social capital. Founders also need to consider to what they aspire, as it can be difficult to combine an academic and entrepreneurial/business career.

This study is based on evidence from 30 firms collaborating with universities. However, it is inherently problematic to generalise from explorative case studies alone. Further research is needed to confirm the robustness of the findings presented in this paper. This may be achieved by applying a quantitative or longitudinal research design.

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11 Conclusion

This final chapter concludes the study with a summary and a discussion of contributions, implications and future research opportunities.

11.1 The purpose of this study

The purpose of this study is to answer the main research question: *How can small firms succeed in establishing and developing relationships with universities?* The research question is explored through detailed theoretical and empirical studies (Dubois & Gadde, 2002). This study commenced with a comprehensive review of research related to university-small firm relationships. The review concluded with the development of the research model and subsequent sub-research questions. Based on the research model and sub-research questions, this study progressed through empirical studies. The empirical studies are presented in three separate research papers (chapters 8, 9 and 10). Each of these research papers addressed one of the previously developed sub-research questions. Collective findings from each of these research papers led to the development of an research model on university-small firm relationships.

The chapter is organised as follows. It begins with a summary of the review chapters used for deducting core causal relationships in research on university-small firm relationships, the research model and the subsequent sub-research questions. This is followed by a discussion of the conclusions from the individual research papers and how these conclusions lead to the development of a more robust and empirically tested research model on university-small firm relationships. This also includes a discussion of the theoretical and managerial implications deriving from this study. Finally this chapter concludes by outlining the future research opportunities within university-small firm relationships when applying the research model developed in this study.

11.2 Conceptualising university-small firm relationships

On the outset of this study, initial investigations of the research phenomenon began by reviewing existing research first of all. These initial investigations revealed that research on university-small firm relationship are often pursued from various theoretical disciplines such as strategic management (Lhuillery & Pfister, 2009), innovation management (Kleyn, et al., 2007), knowledge management (Wang & Lu, 2007), learning theories (Santoro & Bierly III, 2006), social network theories (Carayannis, et al., 2000), strategic alliances (Carayol, 2003), entrepreneurship (Yang, et al., 2009) and innovation economics theories (Inzelt, 2004). While this might contribute to the richness and diversity of the research field, it also constitutes a problem as university-small firm relationships

have become a broad term for which a mix of theoretical and conceptual perspectives has been applied. This complicates an advancement of the research field as it is difficult to create an overview of what is already known and what is still to be discovered. It also makes it more difficult to understand, how different theoretical and empirical approaches contribute to the field overall. Thus, this study commenced with a comprehensive review of prior research on university-small firm relationships with the aim of organising the existing literature into a research model. The review was divided into four chapters (chapters 2-5). Each chapter intended to cover a distinct dimension of the research phenomenon. The review chapters led to the development of the research model and subsequent research questions guiding the empirical work of this study.

Identifying key dimensions in university-small firm relationships

The first of the review chapters (chapter 2), '*The innovation landscape',* covered aspects of how knowledge is produced and distributed in society. The review emphasised the increasing complexity and inter-connectivity in producing and distributing knowledge in society (Gibbons, et al., 1994). For many decades the linear model of knowledge production has been the most recognised model in terms of explaining successful innovation in society (Godin, 2006). The linear model depicts knowledge production to go through a pre-determined chain of basic research → applied research → development. The model has since been challenged by several scholars who argue that knowledge production for innovation is more likely to be motivated by a market potential and solved through combining existing knowledge (internally or externally) and feedback loops in a continuous manner (Kline & Rosenberg, 1986). As it was observed that knowledge production depended increasingly on social relationships and context, several scholars in the 1980-90s started to picture innovation as a product of organisations being embedded in systems of innovation (Freeman, 1987; B-Å. Lundvall, 1992). As knowledge production is an ongoing process that never ends, it is also suggested that these systems of innovation evolve in a similar way (Etzkowitz & Leydesdorff, 2000). Systems of innovation evolve through organisational and tri-lateral transformations and emerging new organisational forms (Giesecke, 2000). Consequently it is argued that systems of innovation never reach an equilibrium, but will constantly evolve (Etzkowitz & Leydesdorff, 2000). Provided that knowledge production and distribution progress dynamically and non-linear suggest that small firms need to manage their relationships with external partners in a similar fashion (H. Chesbrough, 2003; Etzkowitz & Leydesdorff, 2000).

The second review chapter, '*University and research commercialisation',* outlined the ongoing transformation of universities from teaching and scientific units towards becoming more commercially orientated (Etzkowitz, et al., 2000; Goldfarb & Henrekson, 2003; Rosenberg & Nelson,

1994). This transformation has seen universities focusing more on managing and selling academic generated output to industry. To facilitate this focus, most universities have introduced new incentive structures to motivate commercial activities and mindsets among academic staff; established dedicated technology transfer offices; and built supporting surrounding structure in the form of science-parks, incubators and investor networks (Goldfarb & Henrekson, 2003; Magnus Gulbrandsen & Smeby, 2005). The extent and the pace whereby universities are transforming towards research commercialisation are, however, not uniform (F. T. Rothaermel, et al., 2007). The opportunities for small firms to collaborate with universities can be affected by the extent to which the particular partner university is commercially geared. The ongoing transformation of universities also puts pressure on small firms to develop new competences to assists them when dealing with universities. Today, small firms not only need scientific knowledge to be able to collaborate with universities, they also need competences within negotiating contracts, managing intellectual property and engaging with university managers (Drejer & Jorgensen, 2004; Donald S. Siegel, et al., 2004).

The fourth review chapter, '*Small firms and innovation',* explained that research on university-industry relationship need to differentiate between large and small firms (D. Audretsch, 1999; R. Rothwell, 1989). The nature of small firms compared to large firms suggests that the small firms pursue relationships with universities in their own distinct way (Bougrain & Haudeville, 2002). At the same time it is argued in the chapter that the variation among small firms is high. This constitutes a challenge in research involving small firms as these variations need to be accounted for. In this chapter, it is proposed that small firms' industry belongingness (de Jong & Marsili, 2006; Pavitt, 1984), resources and capabilities (Almor & Hashai, 2004; Barney 1991) or growth patterns (Hite & Hesterly, 2001; R. K. Kazanjian & Drazin, 1989) are three different approaches that can explain variations in the ways that small firms pursue relationships with universities.

The fifth and final review chapter, '*A review of university-small firm relationship'*, was dedicated to research specifically according to the actual relationship. The review was undertaken by applying systematic processes to screen, select, assess and present relevant evidence published in peer-reviewed journals within the past 10 years (Petticrew & Roberts, 2006). The review included a total of 74 articles. Based on these articles it was established that research on university-small firm relationships is growing and also constitutes a world-wide phenomenon. The systematic review highlighted the research field to be (1) growing measured in articles published per year from 1999 and beyond; (2) multi-disciplinary based on the variety of journals covering this phenomenon; and

(3) a worldwide phenomenon based on the empirical evidence used in these studies. The systematic review continued by presenting the evidence following a meta-analysis. The evidence was divided into three distinct themes (1) relationship logic; (2) forming relationships; and (3) managing relationships.

Conceptualising research on university-small firm relationships into a research model

In the previous section, four distinct dimensions representing university-small firm relationships were derived from the comprehensive literature reviews. These dimensions were brought together in a research model. It was argued that these dimensions are inter-related and inter-dependent as illustrated in the reinstated research model in Figure 11-1.

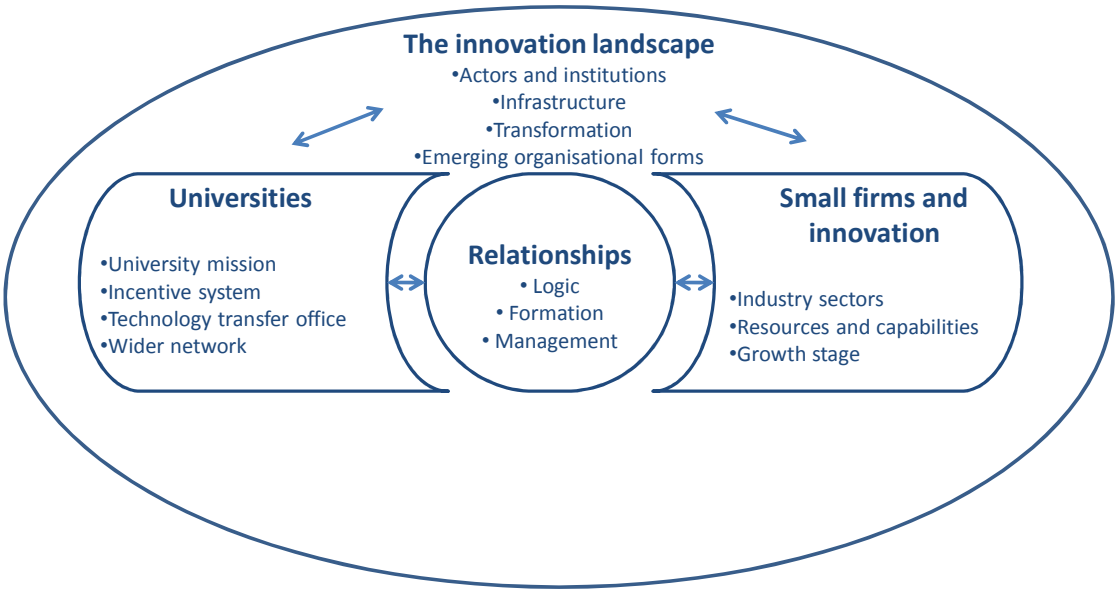

Figure 11-1: Reinstated research model

In this thesis, it has been argued that the contextual circumstances listed above directly affect how small firms establish and develop successful relationships with universities. Provided that production and distribution of knowledge progress dynamically and continuously, it is proposed in this study that small firms manage their relationships with universities in a similar fashion in order to succeed (Etzkowitz & Leydesdorff, 2000). The challenges related to studying university-small firm relationships from a more dynamic and nuanced perspective is inherently complex. The complexity is caused by factors, internally and externally, that are constantly changing. These constant changes cause instability in systems of innovation and complicate control and optimisation for the individual actor in these systems (B.-Å. Lundvall, et al., 2002). Thus, small firms are required to manage their

relationships with universities in a more dynamic fashion to adjust and adapt to ever-changing internal and external conditions – an area that has received only little attention by scholars in the existing literature.

The thesis progressed through empirical studies. These empirical studies were undertaken with the purpose of developing answers to the earlier developed research questions. The empirical work involved 30 small firms that have or have had experiences collaborating with universities. These experiences were collected through interviews (primary data) and publicly available data (secondary data). Relevant data was categorised using a thematic method to analyse data. The actual analysis and discussion of findings took place in the individual research papers and presented in chapters 8, 9 and 10.

11.3 Conclusions reported in the research papers

I have been particularly interested in exploring how changes to some of the constructs within and between dimensions affect how small firms establish and develop relationships with universities. For example, the first paper intended to explore whether small firms become more strategic in the partner selection process as they accumulate more experiences collaborating with universities (Karlson, 2006b). The second paper attempted to understand how the increasing focus on research commercialisation put pressure on small firms to rethink governance mechanisms (Karlson, 2010b). The third paper investigated how small firms can capture university relationship value by adjusting their social capital over time (Karlson, 2010a). In this section, I intend to (1) recapitulate the contributions from each of these papers and (2) to collate these papers to show how they contribute jointly towards a more robust and rigorous theoretical and empirical research model on university-small firm relationships.

11.3.1 *Three individual contributions*

The three individual studies can all be related to the proposed research model in chapter 6 from which the subsequent sub-research questions also originate. Each sub-research question was attended to in separate research papers.

1. *How do experiences affect how small firms select which university to partner up with?*

The first paper, *Partner selection from the perspective of small firms seeking universities as partners for innovation: Strategic considerations or behavioural determination*, attempted to investigate the processes of selecting which university to partner up with for small firms. Strategically determined

partner selection refers to a rational decision of who to partner up with based on highest expected return generated from sharing or combining organisation specific resources across organisational boundaries (T.K. Das & Teng, 2003). A behavioural perspective on partner selection, however, emphasises that partner selection is subject to bounded rationality and imperfect information. Bounded rationality and imperfect information have been identified to cause (1) technical uncertainty in terms of what knowledge and competences a potential partner actually does possess; (2) behavioural uncertainty related to a partner behaving opportunistically; and (3) structural uncertainty caused by a partner's different work routines, organisational structure, culture etc. High uncertainty requires implementation of control and monitoring and costs in that connection may potentially outweigh the actual outcome. If high uncertainty prevails, small firms tend to rely on prior experiences collected through the firm's direct or indirect relationships with universities. This paper intends to explore whether partner selection becomes more strategic as the firm accumulates more experiences from collaborating with universities (prior partner and collaboration experience) and being engaged with a particular technological domain (technical experience).

Through the empirical study of six small firms it was revealed that certain types of experiences were more influential in determining partner selection and reducing technical, behavioural and structural uncertainty than others. Behavioural uncertainty was not reported by any of the firms to be of major concern when selecting which university to partner up with. This was consistent among both experienced and inexperienced small firms. Technical uncertainty appeared to be of more serious concern than behavioural uncertainty. Small firms with more technical experience appeared to be more likely to understand the technical potential of partner's knowledge stock. High level of technical experience also helped towards attracting potential partners and thereby lowering cost of searching for partners. The main problem, however, with technical uncertainty did not relate to the partner's potential, but more to the difficulties of assessing the technological progression. Most of these firms related that to a technology progression that is not necessarily planned through well-defined steps, but more often than not through trial-and-error and learning-by-doing. It was difficult to establish ex-ante what was needed to progress the firm's technology. While behavioural uncertainty had only little influence and technical uncertainty some influence, all of the interviewed firms mentioned structural uncertainty as a major obstacle for collaborating with universities. Particularly the small firms reported that divergences in research methods between academic and industrial scientists were high and could not be avoided despite prior partner and collaboration experience. On the other hand, bureaucratic structures and regulations could be eased by having prior partner experience. Out of the three types of uncertainty in partner selection, structural

uncertainty appeared to be the most dominant reason for small firms did not rely more on strategic consideration when selecting which partner to collaborate with.

These findings are relevant in order to understand how small firms establish relationships with universities. More specifically, this paper contributes with a more nuanced understanding on what role prior experiences (technical and prior partner and collaboration experiences) play in partner selection. These findings suggest that small firms should develop a high level of technical experience. It is harder for small firms to reduce structural uncertainty on their own. Structural uncertain is more likely to be reduced by increasing transparency at universities and reduce bureaucratic structures to allow knowledge and technologies to flow more freely between universities and small firms.

2. *How does the increasing focus on research commercialisation at universities affect how small firms apply mechanisms to govern their relationships with universities?*

The second paper, *Small innovative firms, university research commercialisation and the need for rethinking governance mechanisms,* is focusing on how small firms and their application of governance mechanisms are affected by universities becoming commercially orientated to a greater extent. One important aspect of inter-organisational relationships is how small firms reduce inefficiencies that arise from information asymmetry and moral hazards (Pisano, 1991). The current research shows that university-small firm relationships often fail because small firms do not have the accurate skills to govern university relationships. Most commonly mentioned in the literature is difficulties in terms of governing differences in research objectives, securing the proprietary right of intellectual property and negotiating contracts and intellectual property with university technology transfer offices (Debackere & Veugelers, 2005; Jelinek & Markham, 2007; D. S. Siegel, et al., 2003). Further research suggests that small firms are getting into even more disadvantageous positions, as universities are becoming increasingly commercially orientated. The increase in research commercialisation at universities tend to favour more formalised relationships such as license agreements, contract research and joint patenting - activities that are traditionally avoided by small firms due to financial restrictions. While prior research has mainly been drawing up the picture that small firms are being squeezed by the increasing research commercialisation taking place at universities, this research aims at understanding how small firms actually respond to these changes by developing new strategies to govern the university relationships.

A detailed empirical study of 30 small firms and how they govern relationships with universities showed some interesting aspects of university-small firm relationships. Small firms are struggling with adjusting their governance mechanisms as universities are becoming increasingly commercially orientated. Small firms are facing a dual relationship as they need to govern both the individual academic scientists as well as managers from technology transfer offices. Governance becomes even more complicated as small firms are required to develop and apply two almost conflicting approaches to governance in university relationships. The individual academic scientist is managed through informal governance mechanisms such as trust and social capital. This corresponds more with a relationship approach to governance. The managers of technology transfer offices require a more transactional approach consisting of formalised governance mechanisms to maximise profit, minimise moral hazards and secure intellectual property rights. The small firms in this study have major difficulties in dealing with the transactional approach to governance in particular.

Some small firms were in a better position to govern these dual relationships as they had developed specific competences within negotiation, contract formulation and intellectual property management. Also, they spend more time facilitating dialogue between managers of the technology transfer office and the individual academic scientist. This somewhat helped steer the dual relationship in a more positive direction.

The paper contributes to research on university-small firm relationships in the following ways. Firstly, the paper shows that the increasing focus on research commercialisation at universities affects how small firms develop and apply governance mechanisms to university relationships. Secondly, the paper suggests that the increasing presence of technology transfer offices alters the university relationship into a dual relationship. Small firms struggle with developing and applying governance according to a more transactional approach, which causes severe conflicts in dealing with technology transfer officers. These conflicts are likely to impede collaborating with universities for small firms. Thirdly, small firms can overcome some of these conflicts by developing new competences and engage in dialogues. These contributions extend our current understanding on governance and university-small firm relationships by providing a more nuanced account for what causes small firms to struggle with developing successful relationships with universities.

3. *How can small firms use their social capital to continue capturing value in the relationships with universities?*

The third paper examines how small firms can continue capturing value in relationships with universities from a social capital perspective. Prior research shows that existing social capital is a pre-condition for small firms to collaborate with universities (Fransman, 2008); or social capital leads to increasing knowledge-sharing and learning (Murray, 2004). This paper builds on these studies to understand how small firms with no or only little social capital can develop social capital, but also how social capital, if not managed appropriately, over time can lead to inertia or turn university-small firm relationships into social liabilities. This question is explored in the context of how social capital and growth stages affect strategies of small firms to manage their relationships with universities.

The empirical work of this paper is based on qualitative data from 30 small firms. The data shows that small firms are having difficulties altering their social capital to fit their strategic focus. Small firms do start out with different configurations of social capital, which initially provide them with different advantages and disadvantages. Small firms with no or only little social capital are especially disadvantageous in the earlier research stage, where social capital is a pre-condition to collaborate with universities. During the later development stage, some firms have developed too much social capital, which eventually turn relationships with universities into social liabilities or causes inertia. This leads this study to conclude that there are both necessary and critical paths from small firms developing social capital as they progress through research and development.

This paper contributes by applying a dynamic perspective to social capital and evolution of university-small firm relationships. This perspective is an extension of existing research as it provides detailed accounts through empirical studies on how social capital contributes to value-capturing in university relationships over time. It is not sufficient for small firms to develop social capital only. Small firms also need to make sure social capital is managed according to the firm's strategic focus and resource requirements. This can be challenging for some small firms.

While each of the research papers produces a contribution on their own, they also contribute towards the development of a more robust and rigours theory on university-small firm relationships. This will be discussed in the next section.

11.3.2 *Extending the research model on university-small firm relationships*

While each paper focuses narrowly on one aspect of university-small firm relationship, these aspects are in reality tightly interwoven aspects of the same phenomenon. In this sense they also can be

combined to provide a more accurate and nuanced picture of the nature of university-small firm relationships that would have been difficult to draw by looking at each study isolated.

In the assessment of prior research on university-small firm relationships (chapter 5) it was concluded that the focus has mainly been on (1) descriptive features of university-small firm relationships such as motives and structures, or (2) causal relationships between firm antecedents and certain relationship outcomes (Perkmann & Walsh, 2007). It was argued that one of the main problems with prior research is that it pictures university-small firm relationships as static entities which success is predetermined by the firm's initial conditions. The overall understanding of university-small firm relationships from this thesis is different and more aligned with contemporary research on innovation as reviewed in chapter 2. In chapter 2 it was argued that knowledge production and distribution in society is increasingly non-linear, context dependent and integrated in reflexive and dynamic systems of innovation (i.e. Etzkowitz & Leydesdorff, 2000; Gibbons, et al., 1994; Kline & Rosenberg, 1986; B-Å. Lundvall, 1992). These trends in knowledge production and distribution were assumed to also be reflected in how small firms attempt to establish and develop relationships with universities. Prior research on university-small firm relationships is, however, very scarce on both theoretical and empirical research to suggest if this is the case or not (Perkmann & Walsh, 2007). This need for more empirical research to understand the dynamic and non-linear aspects of university-small firm relationships got further attention when addressed in a special section of *Research Policy* published in February 2011. The section, containing eight articles, was edited by Magnus Gulbrandsen, David Mowery and Maryann Feldmand and named *Heterogeneity in university-industry relations.* The editors argued that more emphasis should be devoted to understand heterogeneity in university-industry relationships (M. Gulbrandsen, Mowery, & Feldman, 2011). Heterogeneity is the common theme across the eight articles and refers to a shift in both level and unit of analysis to a more disaggregated level to understand the finer details and nuances of university-industry relationships. While the special section focuses on different aspects related to university-industry relationships (e.g. faculty participation, develop academic entrepreneurship, university-industry and absorptive capacity, team-based university-industry interaction) none of the articles focused specifically on small firms. Therefore, I see an opportunity to add to the understanding of the aspects of dynamism (Etzkowitz & Leydesdorff, 2000), non-linearity (Kline & Rosenberg, 1986) and heterogeneity (M. Gulbrandsen, et al., 2011) in university-industry relationships as these concepts also appear strongly in this thesis. Overall it is the aim with this section to combine insight from the individual papers (summaries in the previous section) to extend the research model from chapter 6 on university-small firm relationships.

Dynamic aspects of university-small firm relationships

The impact of university-small firm relationships being embedded in reflexive and constantly changing systems of innovation was evident throughout this study and also reflected in the findings presented in the research papers. Starting with the dynamic aspects of university-small firm relationships, it came down to how these types of relationships were adjusted to constantly changing environments – both internal and external to the firm. In accordance with existing research on university-small firm relationships (Harryson, et al., 2007; Perez-Perez & Sanchez, 2003; Santoro & Chakrabarti, 2002), this thesis also found that small firms organise their relationships to their strategic focus (Karlson, 2010a). Harryson et al. (2007) referred to the use of strong and weak ties to foster exploitation and exploration respectively. Perez-Perez and Sanchez (2003) argued that university spin-offs become less dependent and more distant to universities as their technology matures. Findings from this study are aligned with the existing research as it is an advantage to small firms to keep their relationships with universities dynamic to be able to adjust them according to changing internal requirements. This thesis, however, also provides further insight into the challenges of keeping relationships dynamic as it was found that organising university relationships according to a particular strategic focus is not like turning on/off a switch. In the third research paper, *Developing university-small firm relationships,* it was found that small firms need to adjust their social capital to avoid turning university relationships into social liabilities or cause inertia (Karlson, 2010a). This suggests that keeping university relationships dynamic comes down to developing new or adjusting existing competences for small firms. The second research paper, *Governance mechanisms,* provided a different take on dynamic university-small firm relationships as in here it was described that the wider context also plays a significant role in how small firms can actually manage their relationships with universities dynamically (Karlson, 2010b). Small firms preferred to collaborate with universities informally as this was seen as a less cost and risk intensive collaboration form. Also informal relationships are easier to adjust to changing internal requirements (Rappert, et al., 1999). This thesis, however, showed that as universities are becoming increasingly commercially orientated, small firms are forced to apply more formal structures and mechanisms to university relationships. To some extent this need for more formal structures and mechanisms is in this thesis proven to prevent dynamic university-small firm relationships. The consequence of universities becoming increasingly commercially orientated is also reflected in the first paper, *Small firms and university partner selection,* as it is becoming more difficult for small firm to select new university partners as they are becoming increasingly bureaucratic and formalised (Karlson, 2006a).

Non-linear aspects of university-small firm relationships

The second aspect of university-small firm relationships that stands out from this thesis is the non-linearity observed in how small firms collaborate with universities. As in accordance with contemporary theories on knowledge production and distribution (Gibbons, et al., 1994; Godin, 2006), small firms in this thesis mostly engage with universities in two-way knowledge transfer and exchange. The idea of a more linear innovation pattern might come from research focusing on university spin-offs as they are typical new ventures created with the purpose of commercialising academic research (Clarysse, et al., 2007; Perez-Perez & Sanchez, 2003). This thesis, however, shows that even spin-offs are often taking the lead of undertaking research leading to second or third generation technologies in collaboration with both their host university and new universities at a later stage in their lifecycle (Karlson, 2006a, 2010a). Small firms also frequently engage in typical academic activities such as teaching and publications as a means of engaging in a dialogue with the academic community as described in the third research paper (Karlson, 2010a). Some small firms in this paper also gave examples on how innovation cannot always be controlled but often is a product of unplanned social interaction and on-going dialogues and exchange of ideas and information between firms and universities' scientists. These characteristics of innovation were in sharp contrast to how small firms experienced how technology transfer offices at universities pursued innovation and research commercialisation. One major obstacle reported in this thesis with using university-small firm relationships to advance innovation came down to small firms having to be accountable for the input and output of innovation to TTOs when innovation is most likely to advance in a non-linear and unplanned fashion (Karlson, 2010b).

Heterogenic aspects of university-small firm relationships

The third and final feature that characterise university-small firm relationships in this thesis is heterogeneity. To begin with, it was argued in chapter four, *Small firms and innovation,* that small firms and their innovation patterns are highly diverse and impossible to label as a single category (P. Almeida, et al., 2003; de Jong & Marsili, 2006; Yehuda, 1997). Chapter 3, *Universities and research commercialisation,* also argued that the transformation of universities towards research commercialisation and entrepreneurial activities is not uniform across all universities (Etzkowitz, et al., 2000; R. Nelson, 1994). Alone these two dimensions speak for high heterogeneity to be reflected in university-small firm relationships. The importance of heterogeneity in university-small firm relationships is also highly recognised in this thesis. First of all, this thesis has showed that small firms have very different starting points (initial resources and competences) when they enter into

relationships with universities (Karlson, 2006a, 2010a). These starting points provide the firm with a set of unique advantages. These unique advantages do, however, not persist automatically as described in how small firms can also turn social capital into negative advantages over time (Karlson, 2010a). In the same paper, it was also found that there are many different ways for small firms to develop social capital, which add to the diversity of university-small firm relationships. Heterogeneity is also a result of the context in which small firms are embedded and the culture at the university with whom they collaborate. This was especially evident in the second paper (governance mechanism), which showed that not all universities are equally aggressive in optimising revenue from research commercialisation (Karlson, 2010b). Some universities are very focused on formalising relationships with industry partners which lower heterogeneity in university-small firm relationships. This is a problem as it appears that most small firms value heterogeneity or at least an innovation system that recognise that not all small firms are equal but need different opportunities to engage with universities according to these differences.

Extending the research model

When comparing findings across the findings of the three individual studies it was argued in the previous section that dynamism, non-linearity, and heterogeneity are all desirable feature of university-small firm relationships. This also corresponds with contemporary research on knowledge production and distribution (i.e. Etzkowitz & Leydesdorff, 2000; Gibbons, et al., 1994; Kline & Rosenberg, 1986; B-Å. Lundvall, 1992).

The figure below illustratively demonstrates how the empirical findings from this thesis (reported in the three research papers in chapters 8 -10) have helped towards extending the original research model deriving from the literature reviews. The extensions to the original research model are in grey and also include features of small firms and universities that promote or hinder small firms from collaborating with universities successfully. This thesis focused on three aspects in particular: (1) partner selection, (2) governance and (3) organising university relationships. The focus of this thesis has been on university-small firm relationships from the perspective of small firms.

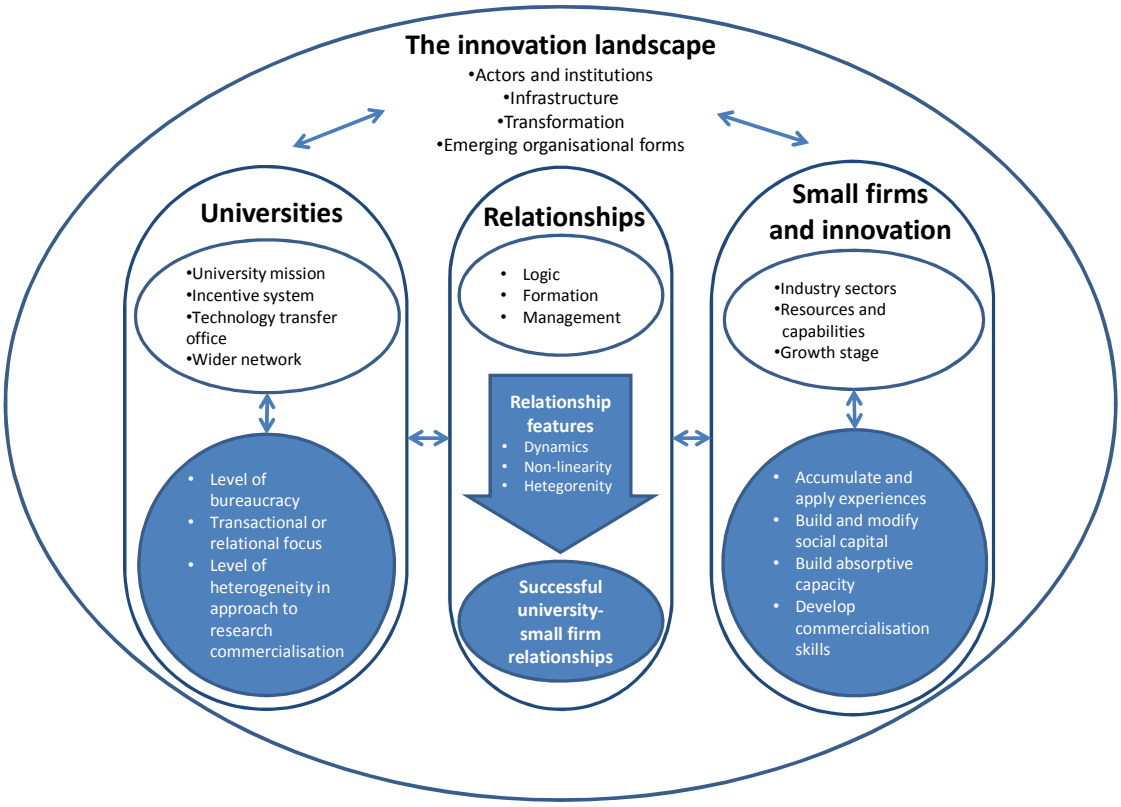

Figure 11-2: Establishing and developing successful university-small firm relationships – an extended research model

From this thesis it can be concluded that university-small firm relationships are highly dynamic, non-linear and heterogenic in nature and need to be managed accordingly to enable success for small firms. Small firms need to focus on competence development and ability to adapt and adjust existing competences to the increasing need for being flexible and adaptive in innovation. This includes but is not limited to building and modifying social capital; accumulating and applying experiences; developing commercialisation skills; and building absorptive capacity. On the other hand, this thesis also shows that the options that small firms have to establish and develop relationships with universities are highly influenced by the level of bureaucracy, to the extent the university applies a more transactional or relational focus; and to what extent they can accommodate a high level of heterogeneity in how they approach research commercialisation.

11.4 Implications

The findings from this study contribute to the multi-faceted and complex process of establishing and developing university-small firm relationships. While this study has been pursuing the research topic from the perspective of the firm, the findings from this study affect not only managers of small firms, but also university management and policymakers. The following section is dedicated to outlining the most important theoretical and managerial implications deriving from this study.

Implications for theory and research on university-small firm relationships

- A system of innovation approach to understand university-small firm relationships
- Heterogeneity over generalisations

To consider university-small firm relationships as being embedded in reflexive systems of innovation can serve as a useful reference point to study the nature and complexity of these constellations (Etzkowitz & Leydesdorff, 2000; B-Å. Lundvall, 1992). This thesis confirms that university-small firm relationships are an integrated part of systems of innovation and are subject to constantly changing environments. By considering how also external factors influence how small firms establish and develop relationships with universities has in this thesis been an important approach to create new insight and understanding of the phenomenon. It has also been an important approach used to differentiate the research field from other more traditional research fields such as strategic alliances or social network theories (Perkmann & Walsh, 2007). One important message from this thesis is that the pressure on small firms to constantly rethink how they manage relationships with universities persists as long as the system of innovation, in which they are part of, continue to transform (Etzkowitz & Leydesdorff, 2000).

This thesis has also proven that it is hard to make general conclusions about how small firms can collaborate with universities. Another important message from this thesis is that great heterogeneity exists in how innovation and research commercialisation is taking place in society, firms and by individuals. Heterogeneity fosters great differences in how small firms choose to or can establish and develop relationships with universities. This thesis conducted empirical research involving a variety of small firms from different sectors, resource endowments, geographic locations and growth patterns. This prior research mainly focused at university spin-offs (Clarysse, et al., 2007; Debackere & Veugelers, 2005; Perez-Perez & Sanchez, 2003), biotech firms (Al-Laham & Souitaris, 2008; Lehrer & Asakawa, 2004; Michelle & Bruce, 2003) or firms located in science-parks (Colombo & Delmastro, 2002; Löfsten & Lindelöf, 2002; Phillip H. Phan, et al., 2005). Especially this research found that firms founded by industry professionals in contrast to academic founded firms often pursued different

strategies to establish and develop relationships with universities (Karlson, 2006a, 2010a). Based on the conclusion from this study, it is recommended that future research uses the concept of heterogeneity to extend understanding further.

Implications for small firm management

For managers of small firms this study produces a number of recommendations when it comes to establishing and developing successful relationships with universities. These are:

- Small firms need to focus on competence development to enable successful relationships with universities;
- Small firms need to allocate time and resources to understand the context in which their relationships with universities are embedded.

The first aspect is linked to small firms and competences. Throughout the research papers, continuous development of competences and resources has been paramount to successful university relationships. Small firms often rely too much on their initial resources and competences when entering university relationships. This can be explained by many small firms being founded by former academic staff or students. These types of founders normally have a high level of scientific understanding but lack more commercially orientated skills. Small firms need to focus on developing new competences as early on as possible. While existing research often refers to absorptive capacity, relationship skills and learning capabilities as being essential to collaborate with universities successfully (e.g. Fontana, et al., 2006; Izushi, 2003; Murray, 2004), this study has contributed further by looking into how some of these essential skills evolve over time. Moreover, this study has also emphasised that small firms need to develop new skills (e.g. negotiation skills, formulation of contracts, intellectual property management) to fit with the growing awareness for research commercialisation at universities.

The second recommendation relates to small firms being embedded in reflexive systems of innovation. This research confirms that public authorities are generally interested in promoting more relationships between universities and small firms. In spite of the difficulties with establishing and developing these relationships presented in this study, there seems to be an increasing number of infrastructural improvements to the system of innovation that can benefit small firms who wish to collaborate with universities. These infrastructural improvements include science parks, incubators, funding, free advice etc. Universities have also become more open in terms of scientific outputs

being published or made public. Small firms also need to look into some of these new opportunities to access scientific outputs or engage in dialogue with universities in terms of innovation.

Implications for university management

This study also provides the basis for recommending the following issues for university management and technology transfer officers:

- Small firms are inherently different from large firms. Small firms need special attention when it comes to formulating practices for collaborating with industries;
- Small firms are more than university spin-offs.

The first aspect refers to some of the problems with small firms collaborating with universities because the set-up costs are too high. If universities wish to collaborate more with small firms they ought to think of new ways to invite those with only limited financial resources to come along. This can be achieved first of all by making new policies that are directed specifically towards small firms. Existing research seems to be pre-occupied with studying how universities can optimise economic value from research commercialisation (Debackere & Veugelers, 2005; Goldfarb & Henrekson, 2003; Kenney & Patton, 2009). This study, however, clearly shows that efforts by universities to optimise short-term profit from selling academic output often conflict with those interests of small firms.

The second aspect relates to the high diversity that exists across small firms. Universities cannot categorise all small firms into one homogenous group of firms. This study has shown that the differences between academically founded and small firms founded independently from universities are high. Universities are not often geared up to deal with this high diversity of firms with most of their attention being directed towards university spin-offs (Clarysse, et al., 2007; Mustar, et al., 2006; Ndonzuau, Pirnay, & Surlemont, 2002; Perez-Perez & Sanchez, 2003). This narrow focus might impede university managers to accommodate other types of small firms on equal terms.

In existing research there also seems to be a dominance of articles focusing on new ventures (e.g. spin-offs) (Clarysse, et al., 2005; Heirman & Clarysse, 2007; Myint, et al., 2005). These articles focus mostly on how universities and governments can make improvements to systems of innovation in the form of science parks, incubators or clusters to stimulate more entrepreneurial activities among students and academic staff. The problem is, however, that most of these improvements to the infrastructure are directed towards early stage firms. This study has shown that small firms face different challenges as they progress. Governments and universities should direct more resources

towards assisting small firms developing more sustainable collaboration between small firms and universities as they grow.

On a final note, while the transformation of universities appears to have had positive effects on the amount of academic research being commercialised, it is time to evaluate these efforts and consider how to move on from here. This study clearly states that the effort by governments to increase research commercialisation at universities might have stimulated more collaboration with large firms. But to what extent small firms have also benefitted from the increasing focus on research commercialisation from universities is questionable and needs further discussion in the public forum.

11.5 Suggestions for further research

The research model above provides a holistic view on university-small firm relationships. The holism is represented by the inter-related four dimensions that cover both internal and external aspects of the research phenomenon. It is proposed that research on relationships between small firms and universities cannot be comprehensively described, nor can its complexity be adequately accounted for without considering all four dimensions. The four-dimension research model can be seen as a kaleidoscope through which to view the enormous research opportunities within university-small firm relationships. In this sense, the proposed research model becomes a reference point to analyse past and guide future research on university-small firm relationships.

The research model provides a way of analysing past research. Each study can be located within the research model depending on whether they apply the perspective of the innovation landscape (e.g. governments), universities, small firms or the actual relationships. The research model can then be useful in identifying those dimensions, or variables within the dimensions, that have been neglected or omitted from the particular research. For example, Perez-Perez and Sanchez (2003) study of how university-small firm relationships evolved only by including a narrowly selected sample of 10 university spin-offs all originating from the same university in Spain. Although Perez-Perez and Sanchez (2003) describe their sample explicitly, one is not sure whether the findings from their study applies to small firms in general or only to spin-offs; or whether the particular university was likely to influence spin-offs to evolve in certain patterns; or the support from the Spanish government towards university-small firm relationships only focuses on the early spin-off stages etc. This is not to say that the particular study referred to in the above should have addressed all these issues. Rather it suggests in here that the presented research model provides a reference point from which past

research can be analysed but also to guide future research topics. The research model provides ways of guiding future research on university-small firm relationships.

- **Theory development through extension of dimensions or exploration of correlations across dimension** – the conceptual framework contains four dimensions. Each of these dimensions is subject to further research that may extend the boundaries of the conceptual framework. There are several examples in the literature on how these dimensions have changed over time. For instance the introduction of systems of innovation and Triple Helix and the inter-connected paradigm of innovation in society, the establishment of TTOs and growing commercial orientation at universities and the increasing number of small firms being involved in innovation requiring scientific input. As new variables are revealed or new concepts emerge, research is also required to explore correlations across dimensions. For example, several researchers have investigated the impact of new intermediates such as science-parks, incubators or technology transfer officers to facilitate university-small firm relationships and enhance firm performance (Frank T. Rothaermel & Thursby, 2005a; D. S. Siegel, et al., 2003).

- **Theory testing of boundaries of dimensions or correlations across dimensions** – The conceptual framework also provides opportunities for theory testing both within and across the dimensions. In past research, this approach has been popular among quantitative studies aiming at predicting 'who' collaborate with universities and 'why'. Well-defined and measurable variables such as firm size, certain inputs and outputs of innovation and external factors like available government funds makes it possible to set up a research model of dependent and independent variables (Keld Laursen & Salter, 2004; Bruce S. Tether & Tajar, 2008). As more variables or relationships between variables within the conceptual framework are made explicit, the opportunities for theory testing increases.

The research model also presents opportunities to pursue research on university-small firm relationships from a number of different levels.

- **Individual level** – Small firms are often highly influenced by the founder. Often the knowledge-base and resources available to the firm are generated through the founder's social network or prior experiences. At the same time, it can be necessary to take individual preferences and cognitions into consideration when trying to understand how university-

small firm relationships are being established and developed. For example, academic founders often face a trade-off between pursuing reputational academic science and operate a profit-orientated business (Scott Shane, 2002). Possible future research can look further into how different career trajectories and economic incentives of founders affect how they pursue relationships with universities.

- **Firm or university level** – Small firms vary considerably in terms of resource endowments, capabilities and strategic focus. Firm level analysis is required to uncover how small firms pursue strategies to establish and develop relationships with universities. Universities are also experimenting with designing and implementing new organisational forms and strategies to promote research commercialisation and interactions with industry. Researchers applying to the university as a level of analysis can explore or measure how these experiments or strategies affect the interface towards industrial firms or small firms in particular.

- **Institutional level** – On an institutional level, research on university-small firm relationships is also confined to be embedded in a system of innovation. There is a need to look further into how structural changes including incentive structures, TTOs, research focus and government funding procedures affect the conditions for university-small firm relationships. There is lots of evidence to suggest that the commercial orientation at universities have led to more academic research being commercialised. But there is some evidence to suggest that universities, especially TTOs, have become more aggressive in pursuing research commercialisation, which has increased transaction costs related to creating knowledge jointly from universities, or transferring and accessing knowledge from universities to the firm. Often these transaction costs are relatively higher for small firms than for large and more resourceful firms. How changes to the institutional environment affect opportunities overall for small firms to collaborate with universities constitute another potential research approach within research on university-small firm relationships.

In this chapter it is claimed that research on university-small firm relationships can benefit from a reference point in here presented as a research model consisting of four distinct and inter-related dimensions. The research model will help facilitate a shift towards recognising research on university-small firm relationships as a distinct research field, but also towards appreciating the complexity and variation that abounds the research topic in this study.

12 Appendix

12.1 Interview guide

Company specific questions

Background

- Purpose
- Industry
- Current ownership structure (not a subsidiary)
- History (reasons for establishment, evolution, growth pattern, change in ownership structure)
- Current number of employees – and their background (academics, admin, technicians etc)

If a spin-off firm

- Is the spin-out based on a specific license (direct spin-out)?
    - Who was the inventor of the technology?
    - Who was the entrepreneur?
- Is the spin-out based on know-how of the founder (indirect spin-out)?
- Was the inventor/entrepreneur the same?
- How was the technology disclosed and assessed?

If an independent formed firm

- Was the company established independently from universities
- How the initial technology (that the company was based on) was discovered?
    - Developed externally
    - Developed internally

Ownership and other stakeholder's role in the company

- What other stakeholders played a role in the establishment phase?
    - Venture capitalists
    - Government bodies (EU, national, regional)
    - Other funding organisations
    - Technology transfer offices

Product/Service

- Does your company have products/services in the market?
    - For how long?
    - How many?
    - Where are they sold?
- Does your company have products/services in development?
    - How many?
    - At what R&D stage?

Interviewee

- Position in company
- Description of previous positions and education
- Member of networks or industry groups

Relationship logic

Nature of current relationship

- Describe the current relationship(s) your company has with public research institutions
- In what way does the relationship with the university contribute to the innovativeness of your company?

Motives to collaborate

- What was the reason(s) for your company to start collaborating?
- To what extent do your company anticipate in the creation of new knowledge with universities?
- Do your company anticipate in any activities with universities that relates to basic research?
- Do you company anticipate in any activities with universities that relates to applied research?
- Have the company's motives to collaborate changed?
    - If so, how and why?

Obstacles to collaborate

- Did your company meet any barriers when undertaking these activities?
- Did your company face any problems after these activities where undertaken?

Forming the relationship

- Why did your company choose to collaborate with this particular university?
- Before starting collaborating with this particular university, did your company consider other potential partners (searching)?
    - Yes – how did you do that and what were the alternatives?
    - No – why not
- How did you know beforehand that this particular university could be a potential beneficial partner to your company (screening)?
- Do you have contacts at that university?
    - If yes, what positions are they in (research, admin) and what is the nature of your relationship (friendship, professional, weak, strong)?
- How did your company initiate a relationship with this particular university to collaborate with your company and not to consider others (signalling)?
- What role did it play in the partner selection process that you have worked/studied at this particular university in the past?

Managing the relationship

Developing the relationship

- For how long has the relationship existed?
- Has the relationship been intensified over time?
    - If yes - What determine the intensification and reasons for it?
    - If No - why not?
- Has the relationship with the university been important for your company in...
- In the unbounded search of scientific breakthroughs (1st generation R&D)?
- In the process of converting technologies and knowledge to commercial purposes (2nd generation R&D)?
- To establish a foothold in the market place – gain access to potential customers or understanding potential customers (3rd generation R&D)?

Governance structures and mechanisms

- How do your company access knowledge (PhDs, students, exchange of staff, informal conversations, publications, seminars, contract research etc.)?
- Does the relationship involve other partners than the firm and the university?
- When sharing or creating knowledge with scientists – do you consider the risk of sensitive information being made available to competitors – for example through research publications, seminars, workshops, consortia or scientists sharing knowledge amongst scientists?
- Do your company in general consider universities as positive towards sharing and creating knowledge with industry partners?
- Is the scope of the relationship defined in a contract?
    - What role does the technology transfer office play in this process?
    - What role does the department/individuals play in this process?
- What is the importance of trust in establishing and developing the relationship?
    - What role does the technology transfer office play in this process?
    - What role does the department/individuals play in this process?

Technology transfer office

- Have your company been in contact with TTOs
- What is your general experience of TTOs

External environment

Incubator/science park

- Why did your company choose to establish themselves in a incubator/science park?
- Did you consider different incubators/science parks or completely other alternatives?
- What kind of support do you get from the incubator/science park?
    - Upstream (research – better access to universities)
    - Downstream (market development)
    - Administration only

Policies, funding etc.

- Can you mention any government policies or frameworks that have had an impact on your company's opportunities to collaborate with universities?
- Can you mention any national factors that contribute to a more effective and efficient innovation system in Denmark compared to other countries?
- Have you received any funding that directly relate to the formation or developing of relationships with universities?

Performance

- What has been the outcome of your company's relationship with the university?
- How do you measure the outcome?
- How do you keep track of the outcome?
- Does the relationship contribute to the overall performance of the firm in a short or long term perspective?

_____

End of interview guide

12.2 Participant information sheet

Management of Employment Relations
Private Bag 92019, Auckland
Phone 3737599

PARTICIPANT INFORMATION SHEET

Public-Private Partnerships

My name is Brian Karlson. I am a PhD student at The University of Auckland Business School. I am studying knowledge utilisation in collaborative arrangements between public research institutions and small and medium sized enterprises.

You have been selected to participate, because your organisation has been or currently is involved in public-private collaboration. The interview would take about an hour to an hour and a half. To ensure accurate collection of information, and with your permission, I would like to make audio recordings of our meetings. You are under no obligation at all to participate and you can withdraw your information at any time without giving a reason. You may also withdraw any information gathered from this interview until 31 of December 2007. The data collected will only be used for the purpose stated above. There will be no alternative use for the data.

Participants from both private and public organisations will be interviewed for this study. Every care is taken to ensure no individual person or organisation will be able to be identified in any output of the study. All information gathered, including consent forms, audio tapes and any transcripts, will be separately and securely stored on university premises for a period of 6 years.

If you consent to an interview, please fill in a consent form and fax it to me or phone me. Thank you very much for your time and help in making this study possible.

If you have any queries or wish to know more please do not hesitate to contact me by phone (+64 9 373 7599 ext. 89636), fax (+64 9 373 7566) or email (b.karlson@auckland.ac.nz). For overseas participants, please contact me by email for urgent matters and I will get back to you as soon as possible. You can also take contact to my Head of Department and supervisor Professor Kenneth Husted by phone (+64 9 373 7599 ext. 86829), fax (+64 9 373 7566 or email (k.husted@auckland.ac.nz).
If you have any concerns of an ethical nature you can contact the Chair of the Human Participants Ethics Committee at University of Auckland by phone (+64 3737599 ext. 87830) or in written to Private Bag 92019, Auckland 1020.

Yours sincerely

Brian Karlson
PhD Student

Approved by Human Participants Ethics Committee on April 2006 for a period of 3 years, from 21/04/2006, Reference 2006/093

12.3 Participant consent form

Public-Private Partnerships

Participant consent form for interviews

Researcher: Brian Karlson

I have been given and have understood the explanation of this research project.

I have had an opportunity to ask questions and have them answered.

I understand that I am free to withdraw from the research at any time without giving a reason. I also understand that none of the information I offer will be communicated within the organisation or elsewhere without my explicit consent.

I understand that audio recordings may be made of interviews as this is commonly expected of qualitative research and ensures greater accuracy.

I understand that the present research project is part of a long-term study of public-private collaboration. Therefore, data collected in the present project may be used for future research in that broad line of inquiry. You may also check or withdraw any information gathered from this interview until 31 of December 2007.

All information gathered, including audio tapes and any transcripts, will be securely stored on university premises for six years. This consent form will be held for a period of six years.

I agree to take part in this research. I agree/do not agree to being audio-taped.

Even if I agree, I may choose to have the recorder turned off at any time.

_____

Name of the Participant:

(Please print clearly)

_____

Date Signed:_____

Approved by Human Participants Ethics Committee on April 2006 for a period of 3 years, from 21/04/2006, Reference 2006/093

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