Facilitating University Spin-Off Ventures – An Entrepreneurship Process Perspective

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Facilitating university spin-off ventures -an entrepreneurship process perspective

Einar Rasmussen

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Abstract

This thesis examines the spin-off firm formation process and how this process can be facilitated within universities. A university spin-off is defined as a new venture which is initiated in a university context and based on technology developed within a university. Spin-off firms are seen as important vehicles for technology transfer from universities into application in society and they are found to play an important role in innovation and industry development. The number of spin-off firms from universities is growing and these firms have attracted significant interest from both policy makers and academics. Facilitating the creation of spin-off ventures has developed into a part of the university's mission and poses new challenges to universities. Still, the existing research on the university spin-off phenomenon is often characterized as mainly empirically driven and a-theoretical in nature. This thesis adds more theoretically based approaches to the spin-off literature by taking an entrepreneurship process perspective and by investigating the university capabilities facilitating spin-off processes. A constructivist perspective emphasizing the entrepreneurial process and the configuration of university resources in this process is used. A qualitative case study approach is found suitable to investigate the entrepreneurial processes within the complex university setting and the many actors involved in the spin-off firm formation process.

This thesis contains four papers based on three empirical studies. The first two studies explore the first research question of this thesis: (1) What initiatives are used by universities to facilitate the formation of spin-off ventures? The first paper examines initiatives to promote commercialization of university research based on an in-depth study of four European universities. The second paper examines how entrepreneurship education can contribute to university spin-off firm formation based on a study of initiatives at five Swedish universities. Related to this research question, this thesis reports a significant increase in the volume of activities aiming to facilitate spin-off generation, and a more concentrated focus on, and more positive attitude towards entrepreneurial activity at all levels in the universities examined. The universities are actively experimenting with initiatives aiming to facilitate spin-off firm creation. The first paper shows the diversity of initiatives and documents that these initiatives

are initiated and based at multiple levels within and outside the university. The second paper shows that entrepreneurship education and the commercialization of research can be linked and that students can play an important role in forming research-based spin-off firms. A model and implications for action-based entrepreneurship education is outlined.

The third paper explores the second research question of this thesis: (2) How does the spin-off venture formation process unfold within a university context? This question is addressed by a longitudinal study of four spin-off projects at two Norwegian universities. Extensive documentation relating to the projects and their development process was collected over a 15 month period by means of a narrative approach. The spin-off process is found to be much less structured, and messier than assumed by many prior studies. The linear models frequently used in prior research are only able to capture a few aspects of the complex spin-off process. The individuals involved and the opportunity or business idea, are not static and the actors involved change during the spin-off firm formation process. Also, the university context plays a dynamic and changing role in providing resources throughout the spin-off firm formation process. The use of single theories provides only partial explanations of the spin-off process and the role of the opportunity, the individuals, the university context, and external events. By using four different process theories; life-cycle, teleological, dialectical, and evolutionary, this study suggests a broader explanation of spin-off processes. The four different process theories explain different aspects of the university spin-off firm formation process at different levels of analysis, and each level of analysis provides unique insight regarding the process. Hence, this thesis adds to the mainly cross-sectional and retrospective studies within entrepreneurship by providing an empirical process study with regard to the opportunity, the individuals, the university and the external context. Moreover, the longitudinal case studies show that the viability of each theory seems to differ at different times throughout the spin-off process.

With reference to the same data, the fourth paper explores the third research question of this thesis: (3) How can university capabilities facilitate the spin-off firm formation process? The capability perspective is chosen in order to take into account the dynamics of emergent processes. Prior research has been more occupied with university characteristics leading to spin-off firm formation,

rather than how the universities can facilitate the spin-off process. This thesis contributes by looking at the particular challenges related to the exploration and exploitation of entrepreneurial opportunities within the university setting and by introducing both de-coupling and integration mechanisms to configure resources for spin-off firm development. The empirical findings from this thesis suggest that the commercial process of creating university spin-offs includes a broader set of activities than emphasized in most of the existing literature on spin-offs. This thesis adds to the university spin-off literature by proposing four specific university capabilities to facilitate new spin-off firm formation within university organizations; the creation of new paths of action; the creation of new knowledge resources; balancing past, present, and future positions; and the reconfiguration and integration of resources. The longitudinal case studies indicate that the role played by each university capability differs at different times throughout the spin-off process.

Further research should acknowledge that university spin-offs emerge as a result of complex processes involving many actors. The core elements of the spin-off process, such as the individuals, the opportunity, and the context, go through a development process making it difficult to address one factor alone without including the interaction with other factors. Static cross sectional studies fails to account for the internal changes in the variables measured. Hence, future studies would benefit from more longitudinal process studies, multiple units of analysis, and constructivist approaches. The application of a broader range of methods, for instance inspired by the work of anthropologists, would lead to a better understanding of the spin-off phenomenon. In order to reveal the complexity of spin-off firm development there is a need for more studies involving a close interaction with the field.

The practical implications of this thesis clearly indicate that the spin-off activity is to a large degree embedded within the other university activities and should not be seen as a separate activity. Policy makers need to carefully consider the context before implementing new measures and allowing the flexibility and time needed for these initiatives to be adapted to the specific location. This thesis has provided a framework showing how the opportunity, the individuals, the university context, and external events all are contributing to the spin-off process. The universities need to consider a broad range of initiatives. This

thesis proposes four university capabilities that may provide directions for policies to facilitate spin-off firms within a university setting. These capabilities are based on multiple levels within and outside the university, and they are embedded in the university operation. Spin-off entrepreneurs need to be aware of the importance of de-coupling from the academic environment and integrating with the commercial world and the challenges involved in this process. Moreover, they need to acknowledge the different competencies needed throughout the spin-off process.

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Bodø, October 2006

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1. Introduction

1.1. Research topic and approach

The following three questions will be explored in this thesis: What initiatives are used by universities to facilitate the formation of spin-off ventures? How does the spin-off venture formation process unfold within a university context? How can university capabilities facilitate the spin-off firm formation process? The main contribution of this thesis is to bring a process perspective into the university spin-off venture literature. For the perspective used in this thesis, a university spin-off is defined as a *new venture initiated within a university setting and based on technology from a university*. While prior research has mainly investigated factors associated with spin-off firm formation and provided descriptive data, the spin-off process is by this thesis seen as inherently complex and dynamic. Hence, the study of spin-off firm formation needs to include contextual issues and the process over time.

The entrepreneurial process has been defined to involve all the functions, activities, and actions associated with the perception of opportunities and creation of organizations to pursue them (Bygrave and Hofer, 1991). In this thesis, the spin-off firm formation process is seen as an entrepreneurial process which is initiated within a university setting and based on technology from a university. The entrepreneurial process is likely to continue independently of the university, but this thesis focus on the initial period of development taking place within the university context. Further, this thesis uses an opportunity-based conceptualization of entrepreneurship, focusing on the development process of a business opportunity, the individuals involved, and the context.

In recent years, research under the university spin-off label has increased exponentially. Still, the studies are often connected to claims that research on the university spin-off phenomenon is mainly empirically driven and a-theoretical in nature (Nicolaou and Birley, 2003b; O'Shea et al., 2005). Shane (2004:2) even state that *"scholarly investigation of this phenomenon is virtually non-existent"*. In addition, many have noted that research on how universities deal with and promote the formation of spin-off companies is still in its infancy (Carayannis et

al., 1998; Mowery and Shane, 2002; Nicolaou and Birley, 2003a; Roberts and Malone, 1996; Shane, 2004; Steffensen et al., 2000; Wright et al., 2004a). The process perspective used in this thesis helps to remedy some of the weaknesses in prior spin-off research by providing a theoretically grounded understanding of the university spin-off process and how it can be facilitated.

One of the major questions addressed in entrepreneurship research is how new ventures emerge (Low and MacMillan, 1988). The role of entrepreneurs in forming new industrial activity based on technological innovations is frequently recognized (Miller and Garnsey, 2000; Schumpeter, 1934), and the study of entrepreneurship is seen as important to spin-off research (Wright et al., 2004a). Definitions of entrepreneurship often include four elements: the individual(s), the opportunity, the context, and the process over time (Bruyat and Julien, 2001; Gartner, 1985; Stevenson and Jarillo, 1990). The literature on entrepreneurship in general and university spin-offs in particular has often elaborated on three perspectives of spin-off process. First, the development process of a technology or business opportunity from being an idea to become an independent new venture (Ardichvili et al., 2003; Gartner et al., 2003; Klofsten, 2005; Vesper, 1989). Second, the role of individual(s) or entrepreneur(s) in the business development process (Franklin et al., 2001; Gartner, 1988; Shane, 2003; Vanaelst et al., 2006). Third, the role of the context and how this influences the venturing process (Etzkowitz, 2002b; Jack and Anderson, 2002; Van de Ven, 1993). In particular, university spin-off literature emphasizes how the institutional context within a university influences the business development process (Lockett et al., 2003; Markman et al., 2004; Roberts and Malone, 1996). These levels are intimately entwined, but few studies incorporate multi-level designs or address the new venture formation process (Davidsson and Wiklund, 2001).

The dominant approach in entrepreneurship research, and spin-off firm research, has been the variance approach where the aim is to explore how independent variables are causing changes in a dependent variable (Van de Ven and Poole, 2005). Process theories are distinctive from the variance approach (Mackenzie, 2000; Mohr, 1982) because they take into account mechanisms leading to change over time, and not only associations that exist at one point in time (Van de Ven and Hargrave, 2004). The process approach creates explanations based

on a narrative story outlining how a sequence of events unfolds to produce a given outcome. According to Van de Ven and Engleman (2004), the process approach is necessary to address questions about how the entrepreneurship process unfolds over a period of time. A great deal of sociological research measures correlations between antecedents and consequences and makes assumptions about the process without actually observing it (Abbott, 1992).

Most existing spin-off research is based on variance research, and tends to focus on one aspect of the phenomenon (Shane, 2004) (i.e. the new firm, the academic entrepreneur, or the university context), and very few studies have looked at the spin-off process (Grandi and Grimaldi, 2005). As reviewed in Chapter 2, many prior studies have identified characteristics of the spin-off firm formation process that do not correspond with the assumptions of the variance approach. In Table 1.1 some characteristics of the university spin-off firm formation process are compared with the basic assumptions of the variance and the process approach. In particular, these assumptions might be familiar among practitioners experienced in creating or supporting spin-off firms.

University spin-offs are usually a result of long and complex development paths (Birley, 2002; Roberts, 1991a), which limits the value of positivist approaches and attempts to uncover causal relations and make predictions. Hence, further research on university spin-offs would benefit from using constructivist perspectives taking into account the properties of emergent processes and aiming to provide tools that enable the actors to act in a more intelligent way (Bruyat and Julien, 2001). Such approaches call for in-depth longitudinal data taking into account the system dynamics. This thesis will use a narrative approach to map the spin-off venture development process over time including multiple levels of analysis.

Table 1.1: Assumptions about university spin-offs, variance, and process approaches

Assumptions about university spin-off firm formation	**Variance approach**	**Process approach**
The spin-off idea and the actors involved in the process may change over time	Fixed entities with varying attributes	Entities participate in events and may change over time
Unpredictable events and social processes may shape spin-off processes	Explanations based on necessary and sufficient causality	Explanations based on necessary causality
Spin-offs may occur in a wide range of contexts and no spin-off process is equal	Generality depends on uniformity across context	Generality depends on versatility across cases
Timing may be an important aspect in spin-off processes	Time ordering among independent variables is immaterial	Time ordering of independent events is critical
Prior experience and history of the actors involved may influence the spin-off process	Emphasis on immediate causation	Explanations are layered and incorporate both immediate and distal causation
Actors may change their opinion and characteristics during the spin-off process	Attributes have a single meaning over time	Entities, attributes, events may change in meaning over time

Source: Adapted from Mohr (1982) and Van de Ven and Poole (2005).

The distinct features of this thesis are related to the interest in how the spin-off firm formation process unfolds and how it can be facilitated, rather than its causes and effects. Hence, this thesis investigates a real-time phenomenon as it unfolds in its natural context. This has implications for both the choice of theories and methods, as discussed more in detail in Chapters 2 and 3. Theorizing within the field of organizational change asserts that different process theories may be able to explain different aspects of processes at different levels of analysis. Thus, this thesis addresses the lack of multi-level approaches in entrepreneurship research (Davidsson and Wiklund, 2001). Perspectives used to investigate how universities facilitate spin-off processes should take into account the dynamics of emergent processes, such as the dynamic capabilities approach (Teece et al., 1997). This thesis explores the university capabilities, referring to the ability of the university organization to coordinate and use its resources to facilitate the spin-off venture formation process.

The next section provides an introduction to the university spin-off topic and its importance from several perspectives. Then, definitions and research questions are presented. Finally, a brief outline of the thesis is provided.

1.2. Why is research on university spin-off firms important?

The creation of university spin-off firms has received increased interest among academics in recent years. Prior research has asserted that the study of university spin-offs is important for several reasons. First, researchers in the field of entrepreneurship see the creation of university spin-offs as a specific type of firm formation or entrepreneurial activity (Bird and Allen, 1989; Jones-Evans et al., 1998; Murray, 2004; Oliver, 2004; Reitan, 1997; Samsom and Gurdon, 1993). Second, university spin-offs are often referred to as a special case of technology transfer and a channel for the commercialization of research (Gregory and Sheahen, 1991; Mowery and Shane, 2002; Pérez and Sánchez, 2003; Radosevich, 1995; Samsom and Gurdon, 1993; Wright et al., 2004b). Third, the relation between spin-off activity and the university mission, the academic culture, and the science system has been widely discussed (Etzkowitz, 2002b; Etzkowitz, 2003; Jacob et al., 2003; Lee and Rhoads, 2004; Miner et al., 2001; Stephan and Levin, 1996). Fourth, the economic impact of university spin-offs and their role in innovation have been studied (Bray and Lee, 2000; Brett et al., 1991; Lambert, 2003; OECD, 2001; Pressman et al., 1995; Wallmark, 1997). Fifth, the increased awareness among policy-makers and researchers of the role and impact of university spin-off companies has made the creation of spin-off ventures an important policy objective of governments and universities (Bozeman, 2000; Goldfarb and Henrekson, 2002; Lockett et al., 2005; Lowe, 1993; Slaughter and Leslie, 1997; Slaughter and Rhoades, 1996). The next sections discuss these issues in turn.

1.2.1. A technology-based new firm

There are many examples of highly successful companies that started as spin-offs from universities (Shane, 2004). The university spin-off phenomenon is not new (Etzkowitz, 2002b; Roberts, 1991a) and research related to this type of firms is often found under the label of technology-based new firms (or new

technology-based firms). Technology-based small firms are found to be increasingly important to industrial employment in many countries (Jones-Evans and Westhead, 1996; Storey and Tether, 1998). In a review of research on new technology-based firms (NTBFs) in Europe, Storey and Tether (1998) found the following characteristics: NTBFs constitute only a small proportion of new firms, but they had significantly higher survival rates and grew faster than the average firm. The founders of NTBFs typically had a higher education and longer work experience and NTBFs are also typically clustered in university cities.

Many studies of technology-based new firms include a considerable share of university spin-offs in their samples (Dahlstrand, 1999; Klofsten, 1994; Mustar, 1997). Likewise, a number of studies of university spin-offs are connected to the study of technology-based firms (Autio, 1997; Carayannis et al., 1998; Dahlstrand, 1997; De Coster and Butler, 2003; Fontes, 2004; Radosevich, 1995; Roberts, 1991a). For instance Mustar (1997) found that two of five high-tech enterprises in France were set up by university researchers, while Dahlstrand (1997) found that one-sixth of Swedish high-tech spin-offs originated from universities. A study by Heirman and Clarysse (2004) estimated that nearly four percent of high-tech and medium-tech companies in the Flanders region of Belgum were research-based start-ups. It also seems clear that university spin-offs have played an important role in creating technopoles such as Silicon Valley, Route 128, and Cambridge UK (Saxenian, 1994; Wickstead, 1985).

Important characteristics of university spin-offs are related to the environment in which they are created and the entrepreneurs involved in their creation (Wright et al., 2004a). University-based spin-off firms are found to be very robust, having significantly higher survival rates than other start-ups (AUTM, 2001; Cooper, 2005; Mustar, 1997). For instance, Shane (2004) found that companies founded to exploit MIT inventions were 257 times more likely than average companies to go public (IPO). Hence, a better understanding of the university spin-off firm formation process is of particular interest to the field of entrepreneurship. This thesis draws upon the entrepreneurship literature in order to explore this particular type of new venture creation at micro level.

1.2.2. A channel for technology transfer

Empirical studies indicate that new technology-based firms have an active role in the development and dissemination of technology (Autio, 1994). A university spin-off company is considered as a technology transfer mechanism because it is usually formed in order to commercialize a technology that originated at a university (Rogers et al., 2001). Technology transfer can be defined as the application of information to use (Rogers, 2002), and many have studied the technology transfer interaction between public research and industry (Friedman and Silberman, 2003; Harmon et al., 1997; Mansfield and Lee, 1996; Rogers et al., 1999; Siegel et al., 2004). This logic implies that before academic research results can be commercially applied, the technological innovation has to be moved from an R&D organization to a receptor organization where it is commercialized into a product that is sold in the marketplace (Rogers et al., 2001). This process of university technology transfer can take place through many channels - including published papers and reports, public conferences and meetings, informal information exchange, and consulting (Cohen et al., 2002), but also more directly through contract research, licensing, and spin-offs (Rogers et al., 1999). The research process might generate a considerable share of tacit knowledge which is not possible to write down explicitly, but has to be transferred through personal interaction and learning over time (Jensen and Thursby, 2001). Hence, both publicly available sources and also personal contacts and recruitment are found to be important channels for transferring knowledge from academia (Senker et al., 1998).

The formation of spin-off companies from research organizations is seen as one of the most effective ways of commercializing new knowledge and technology (Bray and Lee, 2000; Brett et al., 1991; Davenport et al., 2002; McMullan and Melnyk, 1988; Roberts and Malone, 1996; Rogers et al., 2001). Furthermore, several studies indicate that the formation of spin-off companies is a more successful route to commercialization of university inventions than licensing (Bray and Lee, 2000; Gregory and Sheahen, 1991; Rogers et al., 2001). It is found that university spin-offs often commercialize early-stage inventions where existing companies failed to commercialize the technology (Matkin, 1990; Thursby et al., 2001) or the innovation or technology might be radical in nature, so that there are no existing companies that find interest in the new technology (Markham et al., 2002). In addition, there is considerable risk associated with

the commercialization of research results because university innovations are often embryonic in nature (Colyvas et al., 2002; Jensen and Thursby, 2001). Thus, there are few economic incentives for single firms to invest in developing early-stage projects with high risk and long payback time.

Many universities see entrepreneurship as an important channel for technology transfer (Markman et al., 2005; Siegel et al., 2003a). In this view, university spin-offs can be a channel for overcoming some of the obstacles in the technology transfer process by using entrepreneurship as a mechanism. This is in line with the argument presented by Audretsch et al. (2005:70), who claims that entrepreneurship is the missing link between investments in new knowledge and economic growth. Hence, university spin-offs are of particular interest in order to understand innovation systems and technological progress. This thesis will explore the university spin-off firm formation process as a channel of technology transfer at micro-level. A better understanding of this process and how it can be facilitated is also of importance to the field of technology transfer.

1.2.3. A part of the university mission

Still another approach to the study of university spin-off firms deals with the impact that spin-off activities have on the other university activities and the science system. Many authors claim that there is a new role for universities in society with respect to commercialization of research results (Etzkowitz, 1998; Martin, 2003). Concepts such as entrepreneurial science (Etzkowitz, 2002b) and academic capitalism (Slaughter and Leslie, 1997) are describing the general shift towards a more commercial orientation in the academic world (Anderson, 2001). This shift has led to more entrepreneurial activity in academic institutions throughout the world (Lehrer and Asakawa, 2004a; Lockett et al., 2005). These discussions are, however, related to a broader set of activities than merely the formation of spin-off firms (Clark, 2004; Clark, 1998). An increasing number of scientists work in interaction with industry (Siegel et al., 2003b), or commercialize their research by starting spin-off companies (Chrisman et al., 1995; Gulbrandsen and Smeby, 2005). In addition, many universities experience increased interest among students in being involved in entrepreneurial start-ups (Nelson and Byers, 2005; Rasmussen and Sørheim, 2006; Vesper and Gartner, 1997).

Some draw attention to the risk that commercial activities and entrepreneurship in universities can have a negative effect on the science system and hamper the advance of science (Bok, 1982; Nelson, 2004; Stephan and Levin, 1996), and also have a negative impact on teaching (Lee and Rhoads, 2004). Nevertheless, most studies of university spin-offs emphasize the positive effects of such entrepreneurial activity. For instance, Roberts and Malone (1996:18) claims that: *"R&D organizations involved in creating new ventures can expect the spin-offs to generate the following advantages: positive influence on research and teaching, a more exciting atmosphere in the organization due to the new career opportunities that are evident, and an enhanced reputation and role in the region"*. Hence, research on the university spin-off firm formation process is important in order to gain a better understanding of the role universities can play in entrepreneurship and technology transfer and how this activity impacts the other functions carried out by universities. This thesis will explore how universities facilitate spin-offs and also how spin-off processes interact within the university setting at micro-level.

1.2.4. The contribution to economic growth

University spin-offs constitute one of several mechanisms by which scientific knowledge is translated into economic growth (Audretsch et al., 2005). Scientific knowledge has become the key input factor to innovation in industry and society (Mayntz and Schimank, 1998). Empirical research and growth models have recognized technological advance as the driving force for economic growth (Feldman et al., 2002; Nelson, 1998). For instance, Coe and Helpman (1995) estimated a very high rate of return from R&D, and Mansfield (1991) found that the rate of return from academic research show considerable benefit to society.

Especially as a result of the success stories from California's Silicon Valley and Boston's Route 128 (Fogarty and Sinha, 1999; Saxenian, 1994), universities are seen as engines of regional economic growth (Candell and Jaffe, 1999). A large share are established nearby their university of origin (Audretsch, 2003; AUTM, 2001; Jaffe et al., 1993; Wallmark, 1997; Wright et al., 2002). It is estimated that MIT spin-offs contributed $10 billion annually and 300 000 jobs to the

Massachusetts economy (Bank of Boston, 1989), Chalmers spin-offs contributes $100 million to the local economy each year (McQueen and Wallmark, 1991), and many of the 450 high-technology companies in Cambridge are local university spin-offs (Wickstead, 1985). Although most of these studies utilize a broad definition of spin-offs, it seems clear that university spin-offs constitute an entrepreneurial activity which contributes significantly to economic development. University spin-offs are found to create more jobs than established company licensees of university technologies (Pressman et al., 1995). Hence, the university spin-off firm formation process is of particular interest to policy makers at both the national and the regional level. The objective of this thesis is to provide a better understanding of the spin-off process and how it can be facilitated. To analyze the economic impact of spin-off activity at the macro-level or the population-level is, however, outside the scope of this thesis.

1.2.5. Policy development

National and regional authorities see a potential for economic growth and increased employment resulting from the resources that are invested in the universities (OECD, 2000a). Gibbons et al. (1994) argue that the relationship between science and its social environment is becoming closer and that science increasingly responds to external expectations of usefulness. Many countries are undertaking university reforms with a view to increased commercialization of the results of public research (Slaughter and Leslie, 1997; Zhao, 2004), both through changes in the academic system and instruments for research funding (Benner and Sandstrom, 2000; Slaughter and Leslie, 1997), and by setting up structures to support such activities (Guston, 1999; Hellström and Jacob, 2003; Mian, 1997; Rasmussen et al., 2006b). The public funding of research has also changed towards a more contractual-oriented approach intending to strengthening competitiveness (Geuna, 2001) and technology transfer (Powers, 2004). Policies have been induced both top-down from the government and its agencies (Lundström and Stevenson, 2005), while other initiatives are emerging bottom-up from individuals and entities inside the university (Goldfarb and Henrekson, 2002; Jacob et al., 2003). Some initiatives are formal, while informal mechanisms are in many cases found to play an even more significant role (Franklin et al., 2001).

Although the history of university spin-offs is probably as old as the university itself, there is less than a hundred years since the first pioneers in the US laid the foundation for how spin-offs are stimulated today (Etzkowitz, 2002b; Hoorebeek, 2004; Mowery, 2005). From being associated with specific institutions and unusual individuals, commercialization of research and spin-off formation has experienced a significant growth during the last two decades. Technology transfer offices have been set up at most US universities (Carlsson and Fridh, 2002), and recently also in Europe, Canada, and Japan (Lehrer and Asakawa, 2004b; Rasmussen et al., 2006b). Statistics show that the number of patents granted from US universities have increased from 589 in 1985 to more than 3340 in 1999 (USP&TO, 2000), partly following the implementation of the Bayh-Dole Act in 1980 (Mowery et al., 2001), and the AUTM-survey show that the number of start-ups from US universities are doubled from 1994, reaching almost 500 in 2001 (AUTM, 2003). The same development is evident in many other countries, where especially the number of spin-off companies is rising. In UK the number of spin-offs from universities has increased significantly up to 175 in 2001 (Wright et al., 2002). Universities see commercialization of research as a possible source of income (Bray and Lee, 2000), but more importantly as a way to strengthen its attractiveness and role in society (Clark, 1998; Leitch and Harrison, 2005).

The introduction of the Bayh-Dole Act in the US is one of the most influential and well-known policy changes to stimulate commercialization of university research. This Act transferred the ownership of intellectual property (IP) to the universities, and contemporary policy changes stressed the expectations that the universities could contribute more directly to industrial development (Stevens, 2004). The subsequent success in the US in bringing new research findings to the marketplace has, however, inspired legislative changes in many countries all over the world (Mowery and Sampat, 2004). In the UK policy changes towards more commercialization of research were implemented in the late 1980ies (Slaughter and Leslie, 1997). This is now also the case in the Nordic countries where e.g. Denmark in 2001, Norway in 2003, and Finland in 2006 granted the ownership of patentable inventions made at universities to the universities themselves. The logic is to give the universities incentives to support and to build an infrastructure for commercialization of research (Rasmussen et al., 2006a). The growing interest among policy makers and the large amount of

resources used to support spin-offs (Lehrer and Asakawa, 2004a; Lockett and Wright, 2005; Rasmussen et al., 2006b) calls for more research in order to better understand the spin-off firm formation process and how the creation of spin-offs can be facilitated.

1.3. Definitions and research questions

This section starts by looking at definitions and typologies used in prior studies of university spin-off firms and continue by outlining the definition used in this thesis. Further, the three research questions addressed by this thesis are outlined.

1.3.1. Definitions and typologies

There is no common definition of a university spin-off firm, but typical definitions address the transfer of a core technology from the parent organization to the new venture and the transfer of human capital, for example through researchers or students leaving the parent organization to form the new venture. Table 1.2 presents some definitions used in previous studies of university spin-off firms.

Table 1.2: Definitions used in previous studies of university spin-off firms

Definition	Reference
"...a spin-off company is one that produces a product or service originating from research at a university."	(Brett et al., 1991:xix)
"...SMEs set up to exploit research findings"	(Mustar, 1997:38)
"A spin-off is a new company that is formed (1) by individuals who were former employees of a parent organization, and (2) a core technology that is transferred from the parent organization"	(Steffensen et al., 2000:97)
"...new firms created to exploit commercially some knowledge, technology or research results developed within a university."	(Pirnay et al., 2003:355)
"...a venture founded by employees of the university around a core technological innovation which had initially been developed at the university."	(Vohora et al., 2004:149)
"...a university spin-off is a new company formed to exploit a piece of intellectual property created in an academic institution."	(Shane, 2004:4)
"...new ventures that are dependent upon licensing or assignment of the institution's intellectual property for initiation."	(Lockett and Wright, 2005)

Recently, some authors have developed typologies of university spin-off firms designed to clarify the concept. These typologies are also elaborating around the nature of technology or knowledge and the degree of the involvement by university academics and students. Table 1.3 presents three typologies of university spin-off firms. A more comprehensive review of typologies used in prior spin-off research can be found in Mustar et al. (2006).

Table 1.3: Typologies of university spin-off firms

References	Typology	Description
Nicolaou and Birley (2003a)	Orthodox spin-off	both the academic inventor(s) and the technology are spinning out from the academic institution
	Hybrid spin-off	involves the technology spinning out, while the academic(s) retains their university position
	Technology spin-off	technology spins out, while the academic(s) maintains no operative connection with the newly established firm
Pirnay et al. (2003)	Type I	Involving codified knowledge and researchers
	Type II	Involving tacit knowledge and researchers
	Type III	Involving codified knowledge and students
	Type IV	Involving tacit knowledge and students
Radosevich (1995)	Inventor entrepreneur	Laboratory employees who actively seek to commercialize their own inventions
	Surrogate entrepreneur	Entrepreneurs who are not the inventors but who acquire rights to federally-sponsored technology

Even though these typologies are useful for defining the topic, they have two weaknesses. First, many spin-off cases can belong to several types at the same time. This is especially likely for university spin-off firms, as many are team based (Birley, 2002; Vanaelst et al., 2006) and rely on complex configurations of advanced technology (Heirman and Clarysse, 2004). Hence, students, academics, and external entrepreneurs may be involved in developing technologies consisting of both tacit and explicit knowledge. The second weakness is that such typologies do not account for the development over time. Typologies as those presented in Table 1.3 relates to a specific point in time, while the process from research to an independent new venture can take many paths, involving different actors at different times in the process.

The logic of university spin-offs agreed upon is, however, that they are new ventures based on knowledge developed within the university context. For the process perspective proposed in this thesis, a university spin-off firm is defined as a *new venture initiated within a university setting and based on technology from a university*. This definition follows the logic of Shane (2004:4) who define "a *university spin-off as a new company founded to exploit a piece of intellectual property created in an academic institution*". In addition, the definition used in this thesis requires that the spin-off venture process should be initiated within the university setting. Spin-offs often commercialize research results where existing firms show little interest of applying the knowledge (Jensen and Thursby, 2001; Matkin, 1990). The situation might be that the knowledge is of a kind that can not be directly sold in the market due to high uncertainty, tacit nature, and heterogeneous expectations (Dew et al., 2004). Thus, spin-offs are special by the fact that the entrepreneurial process is initiated inside the university organization. Based on this definition, the university context is of particular interest in order to understand the creation of new spin-off ventures. The role of the university and the university employees may, however, differ throughout the development path of the new spin-off venture.

The main focus of this thesis is the process leading to the establishment of a university-based spin-off venture and how this process can be facilitated within the university context. The contribution of this thesis is related to three more specific research questions. These are outlined in the following sections.

1.3.2. University initiatives to facilitate university spin-off firms

Significant changes are currently going on in the university sector world-wide as a result of numerous policy changes in order to facilitate the commercialization of research (Clark, 2004; Slaughter and Leslie, 1997). Policy makers at the national, regional, and university level have allocated a substantial amount of resources to promote the creation of university spin-off firms (Lehrer and Asakawa, 2004a; Rasmussen et al., 2006b). Within universities, several institutional arrangements, like technology transfer offices (TTO) (Carlsson and Fridh, 2002), incubators (Mian, 1997), and internal seed funds (Jacob et al., 2003; Moray and Clarysse, 2005) have been set up to facilitate spin-offs. Very

few institutions have, however, managed to get a positive revenue from commercialization activity (Carlsson and Fridh, 2002; Geuna and Nesta, 2006).

The majority of studies on university initiatives to promote spin-off creation have focused on university patenting (Agrawal and Henderson, 2002; Mowery et al., 2001; Mowery et al., 2002; Nelson, 2001; Nerkar and Shane, 2003; Owen-Smith and Powell, 2003; Pressman et al., 1995; Shane, 2002a; Wallmark, 1997) and the operation of technology transfer offices (TTOs) (Chapple et al., 2005; Jensen et al., 2003; Markman et al., 2005; Rogers et al., 2000; Siegel et al., 2003a). These issues have rarely been seen in connection with other initiatives to stimulate spin-off creation from universities. Little is known about the range of initiatives used by universities to actively stimulate to the creation of spin-off firms, especially outside the US. A few years ago, Agrawal (2001) even claimed that there was virtually no scholarly research that had directly investigated the characteristics of the non-patent channels of commercialization.

In spite of the numerous studies of different outputs from universities such as patents, licensing agreements, and spin-off ventures, there is limited knowledge about how to handle critical resources and the managerial challenges facing the university spin-off process (Lockett et al., 2005). Few studies have investigated how the universities adjust to these new expectations asked for by politicians and government (Martin and Etzkowitz, 2001), by taking a more direct role as actors in regional and national economic development. As commercialization activities may affect both teaching and research, there is a potential for conflict and resistance, as well as mutual benefits among the activities.

Despite some reports from single cases (Chrisman et al., 1995; Jacob et al., 2003; Leitch and Harrison, 2005; Smilor et al., 1990), little is known about the diversity of university initiatives to promote spin-off firm formation. As a platform to understand the formation of university spin-off firms, the studies in this thesis starts by investigating how universities operate in order to facilitate this activity. This is done by taking a broad perspective, looking at a range of different initiatives, including the role that students may play in the creation of research-based spin-off firms. Hence, the first research question of this thesis is:

Research question 1: What initiatives are used by universities to facilitate the formation of spin-off ventures?

1.3.3. The process of university spin-off firm formation

In order to provide knowledge on how universities can facilitate the creation of spin-off firms, a better understanding of the micro-level processes leading to spin-off firm formation is needed. There is a lack of understanding of the process leading to new enterprises in general (Davidsson and Wiklund, 2001; Van de Ven and Engleman, 2004), and university spin-offs in particular (Grandi and Grimaldi, 2005). More multi-level and process research on the university spin-off phenomenon have been requested (Lockett et al., 2005; Mustar et al., 2006; Wright et al., 2004a). Lockett et al. (2005) assert that a focus on knowledge gaps in the research on university spin-offs would be a viable approach to a better understanding of this phenomenon. Knowledge gaps can be assessed at different levels of analysis or actors, and at different stages of development. Hence, the knowledge gap approach includes both a multi-level and a process approach in one matrix.

This thesis focuses on the initial phases of the entrepreneurial process. Existing studies assert that the initial development process of university spin-offs played a critical role for their further development (Vohora et al., 2004). Business models are modified as the entrepreneurs' improve their knowledge about opportunities and resources (Druilhe and Garnsey, 2004). Findings substantiate that the entrepreneurial team of academic spin-offs evolves over time and change in composition (Clarysse and Moray, 2004; Vanaelst et al., 2006) and resource configurations (Vohora et al., 2004) are modified as the spin-offs develops. According to Mustar et al. (2006), a dynamic view on how business models of university spin-offs evolve over time is largely absent from literature. Hence, there is a need to go beyond studies of the factors and conditions influencing the process by making more detailed investigations of the process as it unfolds over time.

Most spin-off studies rely on data consisting of only successful spin-offs that have overcome the initial phases of development. The preparatory phases leading to the creation of a new venture are seen as a neglected issue both in the

spin-off literature (Druilhe and Garnsey, 2001) and in entrepreneurship theory (Phan, 2004). Moreover, Druilhe and Garnsey (2001) claim that no adequate conceptual framework including the initial stages of seeing the commercial potential in university inventions has been developed. Heirman and Clarysse (2004) found that the start-up process differed highly depending on heterogeneity in initial resources, and that many start-ups have no clear idea about the business model or significantly change their business model during the start-up process. Hence, in order to explore the spin-off process, it seems necessary to include the initial phases of development and follow the process as it unfolds over time within the university setting.

One of the main goals of this thesis is to explore the process of spin-off venture formation within a university context. Better knowledge of the processes at the micro level would also help increase the understanding of how to facilitate such processes at university and national policy level. Here, both the new venture creation process and the university context are of particular interest. The process approach taken by this thesis is particularly suited to investigate questions on how processes unfold in real time contexts. The second research question of this thesis is:

Research question 2: How does the spin-off venture formation process unfold within a university context?

1.3.4. University capabilities to facilitate spin-off firm formation

The first research question addressed the initiatives found in universities to facilitate spin-offs, while the second research question focuses on the spin-off process itself. The last part of this research will look at the university capabilities to facilitate the spin-off process. The university spin-off process is initiated inside the institutional context of a university which constrains and facilitates the spin-off process, both formally and informally. Another distinct feature of the university as the context for entrepreneurship is that universities are often considered a part of the public sector. Hence, other stimulants and constrains to entrepreneurship than in the private sector may apply (Sadler, 2000). The academic culture values publishing and disinterested research, while commercial and entrepreneurial activity may be a sensitive issue within

universities (Ndonzuau et al., 2002). Thus, the difference in culture and work practice between university and industry is substantial (Anderson, 2001) and constitutes a challenge for spin-off processes (Argyres and Liebeskind, 1998; Meyer, 2003; Miner et al., 2001; Stephan and Levin, 1996).

Universities are characterized by a high degree of complexity and a large set of loose couplings (Weick, 1976). Diverse goals and outputs such as teaching, research, societal utility, and a combination of non-profit and commercial activity add to this complexity (Lee, 1996; Navarro and Gallardo, 2003). The internal complexity is due to the highly specialized competence and autonomous work practice of the employees, the creative nature of work tasks, and the norms and structure of the science system (Merton, 1973b; Stephan, 1996). The external complexity is evident from the many stakeholders such as students, funding agencies, industry, and other adopters of research results, combined with the changing operational contexts and expectations to universities (Clark, 2004; Etzkowitz et al., 2000). This calls for a need to expand the entrepreneurship and spin-off literature by investigating the specific challenges of new venture formation within the university setting.

Taking the process of spin-off firm formation as a starting point, the capabilities of the university to facilitate such processes are crucial (Wright et al., 2004a). In spite of the numerous studies of different outputs from universities, such as patents, licensing agreements, and spin-off ventures, little is known about how the institutional context affects the spin-off process (Lockett et al., 2005). Recently, several studies have used a resource-based perspective to investigate the role that universities can play in facilitating spin-off firm formation (Druilhe and Garnsey, 2001; Druilhe and Garnsey, 2004; Heirman and Clarysse, 2004; Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005b; Vohora et al., 2004). Moray and Clarysse (2005) found that the resource endowments of spin-offs are influenced by the way technology transfer is organized in the parent organization, but also that the organizational policies change in a learning process. The resource-based theory tends to be equilibrium oriented (Lewin et al., 2004) and may not be fully able to explain how universities may deal with dynamic processes such as spin-off firm formation. Hence, there is a need for more in-depth understanding of the organizational capabilities (Dosi et al., 2000) that facilitate commercialization of research and

new venture creation within a university setting. The third research question of this thesis is:

Research question 3: How can university capabilities facilitate the spin-off firm formation process?

1.3.5. Research focus

The connection between the three research questions in this thesis is illustrated in Table 1.4.

Table 1.4: Research questions and approach summarized

Research question	Purpose	Unit of analysis	Theoretical foundation
1	Overview and characteristics of university initiatives to facilitate spin-off firm formation	University/ University initiatives	Spin-off literature/ Entrepreneurship
2	Investigate the spin-off firm formation process at micro level	Spin-off process (multi-level)	Entrepreneurship/ Process theories
3	Investigate how the spin-off firm formation process can be facilitated within universities	University (multi-level)	Management/ Capabilities

Some delimitations of this thesis should be noted. Although the understanding of micro-level processes may provide insight which can shed light on macro-level development, issues related to outcomes from the spin-off activity such as revenue and employment generated, university-level effects, contribution to regional development, or other societal benefits are not specifically addressed by this thesis. Furthermore, this thesis deals mainly with the creation of spin-off firms. Hence, other channels of technology transfer and other types of entrepreneurship within a university context are not directly addressed by this thesis. The impacts of spin-off activity on the university or on the academic system are not directly addressed by this thesis. Moreover, this thesis focuses on the initial part of the university spin-off process where the university context still has a significant influence on the venturing process. Hence, assessments of the efficiency or outcome from the spin-off process or comparisons with other technology transfer channels are outside the scope of this thesis.

1.4. Outline of the thesis

This thesis proceeds as follows: Chapter two presents a theoretical framework and literature review related to the study of spin-off firm formation processes taking place within universities. First, a framework for studying entrepreneurship within universities is outlined. Second, the process of spin-off formation and theories suitable for studying processes are discussed. Third, the characteristics of the university setting and theories about how to facilitate entrepreneurial processes in this setting are reviewed. Chapter three presents the overall perspective, research design, and methodologies applied in this thesis. The procedures for design, data collection, and analysis used in the studies in this thesis are reported. Then, research quality issues are discussed and the individual papers are introduced. Each of the four papers is found in Chapters four to seven, respectively. Chapter eight provides the conclusions and implications based on the three studies reported in this thesis. First, the main findings and contributions related to each of the three research questions of this thesis are presented. Next, the limitations of the studies and suggestions for further research are presented. Finally, the implications from this thesis are given by outlining the implications for policy makers, universities, and spin-off entrepreneurs.

2. Theoretical framework

2.1. Introduction

This thesis aims at adding more theoretically grounded approaches to the spin-off literature. This chapter develops the theoretical perspectives used to explore the three research questions that were outlined in Sections 1.3.2-1.3.4. Research question 1 is mainly addressing the current status of support initiatives for spin-off firm formation at universities. Such descriptive data are important for classification and provides a broader knowledge about the phenomenon and the context (Mohr, 1982). Together with reviewing the existing empirical literature related to the spin-off phenomenon, these data provide an important basis for further theory development.

Research question 2 addresses how the spin-off venture formation process unfolds at the micro-level. Prior spin-off and entrepreneurship research has, however, not paid much attention to how the spin-off process unfolds. Most theories of processes do not address how change occurs, but look at the causes of the processes (Poole et al., 2000). This is also the case with entrepreneurship research which firstly has a long tradition of investigating causes of new venture creation, and secondly having as its dominant approach outcome-driven research based on cross-sectional variance methods (Van de Ven and Engleman, 2004). As shown in the review in Sections 2.2.2-2.2.4, prior spin-off studies show a variety of results including a great number of variables that might explain what leads to the creation of university spin-off firms, such as characteristics of the technology, the entrepreneur, and the university context. Although, the search for causal relations to explain the emergence and development of university spin-offs has provided many results, these studies have not provided any theoretical explanations on how the spin-off process unfolds.

According to Pettigrew (1990), theoretically sound and practically useful research on change should explore the contexts, content, and process of change through time. There are frequent calls for more event-driven process research on entrepreneurship in order to develop explanations of entrepreneurial dynamics (Aldrich, 2001; Davidsson and Wiklund, 2001; Low and MacMillan, 1988;

Shane and Venkataraman, 2000). Event-driven explanations are built forward, from recorded events to outcomes (Aldrich, 2001).

Recently, some studies have looked at the spin-off firm formation process. These studies have mainly relied on stage-models (Clarysse and Moray, 2004; Vohora et al., 2004) or used a resource-based view of spin-off formation (Druilhe and Garnsey, 2001; Heirman and Clarysse, 2004; Moray and Clarysse, 2005). Neither the stage models nor the resource-based view seems able to capture the irregular and complex patterns described in qualitative spin-off studies. As asserted by Eckhardt and Shane (2003), theories that allow for disequilibrium are required to explain entrepreneurship. This thesis leans on the process frameworks developed by Mohr (1982) and Van de Ven and Poole (1995) in order to develop an explanation of the spin-off firm formation process. Some strengths and weaknesses of the stage-models, the resource-based view, and the process approach are outlined in Table 2.1.

Table 2.1: Strengths and weaknesses of perspectives on the spin-off process

Theory	**Purpose**	**Strengths**	**Weaknesses**
Stage-models	Show the progression of steps in a process and the characteristics of each step	Simple, show typical characteristics at different stages	Do not account for path-dependency, human agency, or critical events
Resource-based	Identify the resources which contributes as drivers of the process	Deals with heterogeneity	Equilibrium-oriented, do not explain how resources are developed
Process	Explain how a process proceeds	Designed to explore processes (how questions)	Not very well developed, tends to be complicated

The third research question investigates how university level capabilities contribute to the spin-off firm formation process. Prior research has, however, been more occupied with university characteristics leading to spin-off formation (Link and Scott, 2005; Roberts and Malone, 1996; Shane and Stuart, 2002), rather than how universities can facilitate spin-off firm formation. Most factors found to explain university spin-offs are endogenous. That is, they explain the characteristics of environments that facilitate spin-offs, but fail to explain how such environments are created. For example, it is found that universities with older technology transfer offices (TTO) (Powers and McDougall, 2005b),

investing more resources in TTO personnel (O'Shea et al., 2005), have a culture that supports spin-offs (Franklin et al., 2001), and have a history of frequent spin-off formations (Kenney and Goe, 2004), are more likely to have a high spin-off rate. Such factors may not facilitate spin-offs, but rather be a result of a historically high spin-off rate (Shane, 2004).

A large portion of studies at the university level are based in a realist tradition seeing universities as a system having certain characteristics. This is in accordance with the widespread strategic choice theory of strategy and organizational change (Stacey, 2003). Such studies usually recommend that an increase in the characteristics associated with spin-offs will lead to more spin-offs. This knowledge might be useful to predict spin-off formation and give important insights about favorable conditions, but does not explain how spin-offs are created. Spin-offs are also formed under less favorable conditions (Degroof and Roberts, 2004), and favorable conditions seem not to be a guarantee for a high spin-off rate (Henrekson and Rosenberg, 2001). In addition, some studies show contradictory results based on the same variables (Siegel and Phan, 2005). Hence, a too static view on the factors influencing the spin-off process seems to put limitations on the development of theories to explain spin-off firm formation.

Recently, a number of studies aimed at explaining how universities can facilitate spin-off formation have relied on a resource-based approach (Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005a; Rothaermel and Thursby, 2005; Shane and Stuart, 2002). There is, however, a need for more research showing the relation between the activities within a commercialization process and the university capabilities or routines needed to facilitate such dynamic processes (Lockett and Wright, 2005). The dynamic capabilities perspective (Teece et al., 1997) is a further development of the resource-based view aiming at the inclusion of the organizational routines shaping change processes, not only the characteristics of the organizational setting. In order to incorporate the dynamics of processes, this thesis will use a university capability perspective to explore how spin-off firm formation processes can be facilitated within universities. The strengths and weaknesses of this perspective compared to the causal or descriptive approach and the resource-based view are outlined in Table 2.2.

Table 2.2: Strengths and weaknesses of perspectives on university capabilities

Theory	Purpose	Strengths	Weaknesses
Causes (descriptive)	Identify characteristics and causes that are associated with spin-off firm formation	Simple, reveal typical characteristics	Do not provide any theoretical explanations of the findings
Resource-based view	Identify the university resources leading to spin-off formation	Deals with heterogeneity in spin-off processes	Equilibrium-oriented, do not explain how resources are developed
Capability	Identify organizational routines and processes to facilitate the spin-off firm formation process	Adapted to idiosyncratic spin-off processes Incorporates change	Not very well developed, tends to be complicated

As a starting point for investigating the university spin-off firm formation process and how it can be facilitated, this thesis relies on prior research and concepts developed within the field of entrepreneurship. According to Sarasvathy (2004) entrepreneurship is about firm design, and the firm can be viewed as an artifact which is socially created, rather than a result of external objective conditions (Barth, 1972; Simon, 1996). This view asserts that new ventures are created in an unpredictable process, and that the process itself is decisive for the final outcome. In particular, the opportunity-based conceptualization of entrepreneurship, emphasizing the opportunity, the individuals, and the context are used to capture the key elements of the spin-off process (Bruyat and Julien, 2001).

Together, the theoretical approaches used in this thesis cover three fundamental terms in human science; people, space, and time (Poole, 2004). The role of human agency is central to entrepreneurship research, but also a key topic within management literature. Space refers to the level of analysis, which in this thesis is addressed both at the individual level, the spin-off project or opportunity level, and the university level. Finally, the role of time has been incorporated by applying a process approach to spin-off firm formation.

This chapter proceeds as follows: First, a framework for studying entrepreneurship within universities is developed and prior research related to spin-off firm formation is reviewed. Second, a review of prior spin-off research

on process and the theoretical foundations of the process approach used in this thesis are presented. Third, perspectives for studying how universities may facilitate entrepreneurial processes are discussed. Finally, the theoretical perspectives used in this thesis are summarized. A further presentation of the specific theoretical perspectives used in this thesis can be found in each of the four papers in Chapters four to seven.

2.2. *University spin-off firm formation – an entrepreneurship perspective*

Wright et al. (2004a) argue that the study of entrepreneurship is important to spin-off research. The creation of a university spin-off is clearly an instance of entrepreneurial behavior and the majority of university spin-off research is connected to the field of entrepreneurship (Shane, 2004). This section starts by developing a framework for studying the entrepreneurship process within a university context. Further, prior research related to the role of the opportunity, the individuals involved, and the university context is reviewed. Finally, barriers to entrepreneurship within universities are discussed.

2.2.1. Entrepreneurship within universities

Explaining how new ventures emerge is one of the major questions addressed in entrepreneurship research. Entrepreneurship is used as a label for the study of a wide variety of behavior in different settings by different actors. Shane and Venkataraman (2000) propose three reasons for studying entrepreneurship in general. First, entrepreneurship is a mechanism by which society converts technical information into products and services. This corresponds well with the technology transfer perspective on university spin-offs. Second, entrepreneurship is a mechanism through which temporal and spatial inefficiencies in an economy is discovered and mitigated. Third, innovation in products and processes driven by entrepreneurship is a crucial engine in driving change processes in the society. Research within universities receives substantial public funds, based on expectations for future results. Mitigation of inefficiencies in the market and changes from innovation in products and processes may indeed be examples of such results emanating from university research and brought forward by entrepreneurial processes. In addition, Zahra

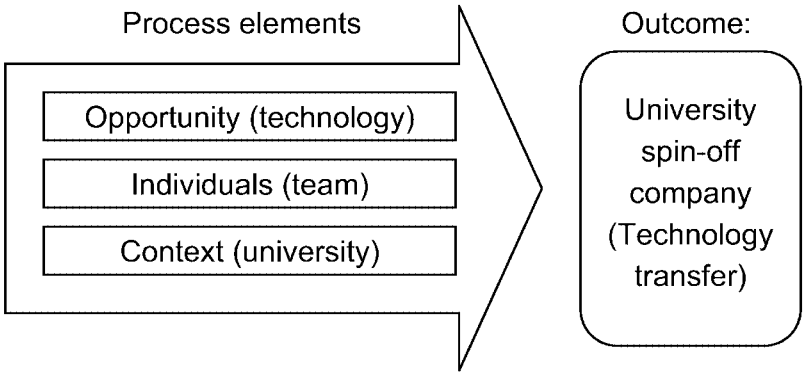
and Dess (2001) propose a fourth reason for studying entrepreneurship. That is how entrepreneurship contributes to the development of human capital and enhancement of intellectual capital. Hence, entrepreneurship may contribute to the university mission of education.

Many concepts have been used to describe entrepreneurial activity among university faculty, such as professorial entrepreneurship (Kenney and Goe, 2004), faculty entrepreneurship (Bird and Allen, 1989; Chrisman et al., 1995), academic entrepreneurship (Glassman et al., 2003; Powers and McDougall, 2005b; Shane, 2004; Weatherston, 1993), and entrepreneurial scientists (Oliver, 2004; Samsom and Gurdon, 1993). Louis, Blumenthal, Gluck, and Stoto (1989) distinguish between five types of academic entrepreneurship: 1) engaging in large scale science (externally funded), 2) earning supplemental income, 3) gaining industry support for university research, 4) obtaining patents or generating trade secrets, and 5) commercialization –forming or holding equity in private companies based on a faculty member's own research. A narrower definition of academic entrepreneurship is provided by Chrisman, Hynes, and Fraser (1995:268): *"the creation of new business ventures by university professors, technicians, or students"*.

New ventures initiated in the context of an existing organization have also been defined within the corporate entrepreneurship concept (Dess et al., 2003; Stopford and Baden-Fuller, 1994). Academic entrepreneurship can, however, be seen as a distinct form of corporate venturing. When the technology, the entrepreneur(s), or both have their roots in academic research, the company is probably set up to commercialize a product or service with high knowledge content and which is technologically at the forefront. Thus, the university technology transfer process is distinctive from the study of independent entrepreneurship and corporate entrepreneurship because of the many stakeholders involved and their complexly interwoven objectives, which in turn affect the start-up process (Jones-Evans et al., 1998). Sharma and Chrisman (1999) provide a wide definition of corporate entrepreneurship, including both the process of creating a new organization and efforts to instigate renewal or innovation taking place within an organization. Further, they use the term corporate venturing to refer to efforts that lead to the creation of a new business organization, and finally, they use the term external corporate venturing when

the effort is leading to the establishment of an autonomous organizational entity outside the existing organization. By these definitions, a university spin-off company may be labeled an external corporate venture.

Another concept is intrapreneurship, which may be defined as entrepreneurship within an existing organization. According to Antoncic and Hisrich (2003), intrapreneurship research has evolved into three focal areas; the individual intrapreneur, the formation of new corporate ventures, and the entrepreneurial organization. This is consistent with research and theorizing within the field of entrepreneurship, where several authors have pointed to the individual(s), the business opportunity, the context, and the process over time as the central elements (Bruyat and Julien, 2001; Phan, 2004). For instance, Stevenson and Jarillo (1990:23) provide the following definition of entrepreneurship: *"entrepreneurship is a process by which individuals –either on their own or inside organizations –pursue opportunities without regard to resources they currently control"*. Hence, the opportunity, the individuals, and the institutional context can all be seen as central for the creation of university spin-off firms. In this thesis, the creation of a university spin-off firm is seen as a process where an opportunity based on technology developed in a university, an individual or a team, and a context create the necessary properties for a new organization to emerge (Rasmussen, 2006b), as illustrated in Figure 2.1. The following sections review factors associated with spin-off creation within each of these three areas.



Source: Adopted from Rasmussen (2005)

Figure 2.1: A framework of the entrepreneurial process of university spin-off creation

2.2.2. The opportunity

Entrepreneurial opportunities can be defined as situations in which new goods, services, raw materials, markets, and organizing methods can be introduced through the formation of new means, ends, or means-ends relationships (Eckhardt and Shane, 2003). There is a debate within the entrepreneurship literature whether opportunities are discovered (Shane and Venkataraman, 2000), or if opportunities under many circumstances can be enacted (Gartner et al., 2003; Sarason et al., 2006). The latter view emphasizes that opportunities are not objectively existing and static, but are developed throughout the entrepreneurial process. Compared to entrepreneurship in general, the opportunity plays a particularly central role for university spin-offs because the source of the entrepreneurial opportunities for these firms is university research. Some studies point to what kind of opportunities that are common for university spin-off firms. Findings from these studies are summarized in Table 2.3.

Table 2.3: Opportunity characteristics and university spin-off firm formation

Opportunity characteristics	**Main findings and authors**
Field of research	Commercial potential differs between field of research (Bird and Allen, 1989). Spin-off most common in engineering, medicine, and science (Chrisman et al., 1995); biotechnology and computer software (Shane, 2004).
Technology characteristics	Shane (2004:136) review several factors that makes technologies more likely to become the basis for a spin-off company: radical, tacit, early stage, and general purpose technologies with significant costumer value, major technical advance, and strong intellectual property protection.
IPR protection	The protection if IPR, for example by patenting, may in some cases be an important condition for creating business opportunities from university research because it provides incentives for commercial interests to make investments in further development of a new technology (Granstrand, 1999; Monotti and Ricketson, 2003; Shane, 2001). Shane (2002b) found that university inventions are more likely to be licensed when patents are effective, and then generally to non-inventors. When patents are not effective, it is more likely that the inventors themselves commercialize the innovation. Inventions that can be effectively patented might be easier to transfer directly to an external organization or entrepreneur, while no or weak patent protection increase the role to be played by the inventor(s) in the commercialization process.
Tacit knowledge	Several authors claims that spin-offs are particularly feasible for commercialization of tacit knowledge (Chiesa and Piccaluga, 2000; Nicolaou and Birley, 2003b; Pirnay et al., 2003).
Financial resources available	A challenge for the entrepreneurial process is related to the financial resources needed (Westhead and Storey, 1997; Wright et al., 2006). Funding for spin-off ventures may be obtained through the entrepreneurs' and the university's internal funding, or through debt and equity finance (Wright et al., 2006). New research findings often need large investments in further development before they can reach the marketplace as new products or services (Colyvas et al., 2002; Jensen and Thursby, 2001; Moray and Clarysse, 2005).

There seems to be a connection between spin-off firm formation and characteristics related to the opportunity, such as field of research, technology characteristics, IPR protection, tacit knowledge, and availability of funding. Little is, however, known about how the initial research result within a university is perceived as an entrepreneurial opportunity and how the perceived opportunity is developed into a viable business concept. The findings reviewed in Table 2.3 show that the opportunity characteristics and their development plays a key role in the spin-off firm formation process. Hence, it appears to be

difficult to provide explanations of entrepreneurial processes without taking the development of the opportunity into account (Eckhardt and Shane, 2003). Still, the opportunity is rarely included as the unit of analysis in studies of the entrepreneurship or spin-off process. This gap in knowledge can be addressed by including the opportunity as a unit of analysis in the study of the university spin-off process.

In addition to the discovery of an entrepreneurial opportunity, there has to be someone taking the role as entrepreneur or new venture champion (Greene et al., 1999). Several studies point to the risk that advanced knowledge-based ideas may fade away if the idea is separated from the creator or researcher (Henrekson and Rosenberg, 2001; Stankiewicz, 1986). Jensen and Thursby (2001:241) found that most licenses from US universities comprise technologies that *"...are so embryonic that additional effort in development by the inventor is required for a reasonable chance of commercial success"*. The product of research can only be utilized when it is codified in a manner that others can understand or apply (Rogers, 2003). Arguably, a large share of research findings consists of tacit knowledge, making it important that the researcher(s) possessing this knowledge are involved in the commercialization process (Jensen and Thursby, 2001).

2.2.3. The individuals

The individual-opportunity nexus is suggested as the key elements when trying to explain the origin of new ventures (Shane, 2003). The individual entrepreneur and the characteristics and traits of entrepreneurs have been a dominant issue in entrepreneurship research (Erikson, 2002; Kolvereid, 1996; Markman and Baron, 2003; Westhead and Wright, 1998). Different individuals may play different roles throughout the entrepreneurial process. As pointed out by Ardichvili et al. (2003), some people excel at invention, others at creating business models, but few at both. At the individual level, many studies have examined the traits or characteristics of academic entrepreneurs (Oliver, 2004; Radosevich, 1995; Samsom and Gurdon, 1993; Weatherston, 1993) and several studies have used theoretical perspectives, such as human capital (Audretsch and Stephan, 1999; Zucker et al., 1998), social capital (Murray, 2004) or network theory (Nicolaou and Birley, 2003a; Nicolaou and Birley, 2003b). The findings

related to the role of individuals in spin-off firm formation are summarized in Table 2.4.

Table 2.4: Individual characteristics and university spin-off firm formation

Individual characteristics	**Main findings**
Motivational pull factors	Independence, financial, and challenge (Roberts, 1991a); desirable and manageable activity (Reitan, 1997); wish to apply results (Chiesa and Piccaluga, 2000; Smilor et al., 1990); validate the usefulness of new discoveries (Shane, 2004); 'the love of the puzzle' (Kuhn, 1962; Stephan and Levin, 1996); attract more research funding from industry (Rasmussen et al., 2006c); contribute to employment and national economic development (Rosenberg and Nelson, 1994).
Motivational push factors	Independence, dissatisfaction in current position, monetary (Chiesa and Piccaluga, 2000; Smilor et al., 1990).
Star scientists	The presence of star scientist in a university is positively associated with university spin-off performance (Di Gregorio and Shane, 2003; O'Shea et al., 2005; Powers and McDougall, 2005b; Zucker et al., 1998).
Lack of business experience	Lack of business experience and management skills is recognized as potential barriers to success for venturing scientists (Bird and Allen, 1989; Radosevich, 1995; Samsom and Gurdon, 1993; Vohora et al., 2004).
Networking activity	Network activities with the university, customers, suppliers, and the regional innovation network seem important for spin-off development (Bower, 2003; Grandi and Grimaldi, 2003; Pérez and Sánchez, 2003). Founders of university spin-offs having prior relations to venture capitalists are more likely to receive venture funding and less likely to fail (Shane and Stuart, 2002). A source of resources to develop the business concept is strategic alliances (Carayannis et al., 2000). Faculty consulting activity is a bridge to the commercial world, inducing contact and research arrangements with industry that subsequently might lead to product development and new venture formation (Bird and Allen, 1989).
Research group characteristics	Research groups may be as important as individual academics in initiating entrepreneurial actions (Etzkowitz, 2003). Prior joint experience among the academic founders might be positive for creating successful university spin-offs (Grandi and Grimaldi, 2005).
Entrepreneurial team characteristics	Studies show that knowledge-based new ventures are often developed by teams, rather than by single individuals (Chiesa and Piccaluga, 2000; Clarysse and Moray, 2004; Roberts, 1991b). An entrepreneurial team consisting of both the academic inventor and experienced entrepreneurs is common among university spin-offs (Birley, 2002; Vanaelst et al., 2006). The use of external entrepreneurs from outside the university (surrogate entrepreneurs), are found to be a viable strategy for spin-off creation (Franklin et al., 2001; Radosevich, 1995).

A number of factors, ranging from individual motivation factors, human and social capital, to group characteristics, are suggested as being related to spin-off firm formation. The creation and exploitation of opportunities may involve academics, students, or other university employees. Also, individuals from outside the university may take on central roles in identifying opportunities and performing the entrepreneurial action. University spin-off projects are often characterized by a dynamic interaction of different individuals throughout the start-up process (Chiesa and Piccaluga, 2000; Clarysse and Moray, 2004; Roberts and Malone, 1996; Vanaelst et al., 2006). Contact between persons with technical and market knowledge may induce the identification of entrepreneurial opportunities.

Many characteristics of academic entrepreneurs have been investigated, but few have studied what these entrepreneurs actually do in order to develop the spin-off firms. Knowledge about why, when, and how the action of university researchers leads to the creation and exploitation of opportunities is vital in order to understand how the university spin-off firm formation process unfolds. Hence, it would be dubious to study the spin-off firm formation process without including the role and actions of individuals in this process. This is in line with recent theorizing suggesting that the field of entrepreneurship deals with the 'individual-opportunity nexus' (Shane, 2003; Venkataraman, 1997) or the 'individual <=> new value creation dialogic' (Bruyat and Julien, 2001).

In a constructivist perspective, individuals are fully recognised as competent and purposeful actors who can make a difference, but they seldom make it alone (Bouchikhi, 1993). Contextual factors such as environmental effects (Klofsten, 2005), external pressure (Davidsson et al., 2006), and social context (De Koning, 2003) are found to influence the development of new ventures. According to Sarason et al. (2006), entrepreneurial ventures are created by purposeful actions through unique co-evolutionary interaction between the entrepreneur and the socio-economic system. This view emphasise the ability of entrepreneurs to reflect upon and shape the environment, while they at the same time are an integrated part of their environment. In the case of a university spin-off firm, the initial part of the start-up process takes place within a university context.

2.2.4. The university context

Academic entrepreneurs are embedded in a university context which both facilitates and constrains the venturing process (Glassman et al., 2003; Kenney and Goe, 2004; Murray, 2004; Nicolaou and Birley, 2003a). Smilor et al. (1990) found in their survey that the university played an important or very important role in 56% of the spin-off company formations, a highly more significant role than any other organization. The most important role of the university was as a source of personnel. Academic entrepreneurship is found to be considerably higher in some research departments than others, even within the same field of science (Louis et al., 1989). Thus, the specific university context seems to play an important role for the spin-off process. The findings from studies related to the role of the university context in the spin-off firm formation process are summarized in Table 2.5.

Table 2.5: University characteristics and university spin-off firm formation

University characteristics	**Main findings**
University as resource provider	The university might be a source of personnel (Smilor et al., 1990), credibility (Grandi and Grimaldi, 2003), and infrastructure (Mian, 1996). A relation between start-up generation and intellectual eminence at universities is frequently detected (Di Gregorio and Shane, 2003; O'Shea et al., 2005; Rogers et al., 2000; Thursby and Kemp, 2002).
University culture	Environment support (Reitan, 1997), local group norms (Louis et al., 1989), and a supportive university culture (Chrisman et al., 1995; Franklin et al., 2001; Louis et al., 1989) is found to affect the behavior of academic entrepreneurs. Based on their study of professorial entrepreneurship, Kenney and Goe (2004:679) suggests that "*being embedded in an academic department and disciplines with cultures that are supportive of entrepreneurial activity can help counteract the disincentives created by a university environment that is not strongly supportive of these activities*". This indicates a complex structure where academics is part of different cultures in their discipline, department, university, and external environment. Academic entrepreneurs are dependent on networks and integration between a wide variety of actors (Mustar, 1997).

University policies	Well defined strategies (Lockett et al., 2003), the use of surrogate entrepreneurs (Franklin et al., 2001), a low inventor share, and equity investments (Di Gregorio and Shane, 2003) are found to be related to university spin-off formation. Comprehensive support to selected spin-offs is associated with a high growth potential (Degroof and Roberts, 2004; Roberts and Malone, 1996). Studies have found that the most significant barriers to the adoption of entrepreneurial friendly policies at universities are cultural and informational (Franklin et al., 2001). Chrisman et al. (1995:277) concluded that "*supporting research and sending a message that faculty entrepreneurship will be valued is perhaps more important than the specific programs designed to foster economic development*". On the contrary, many studies show that university policies have only a limited effect on commercialization and spin-off formation (Louis et al., 1989), that institutional structures can slow down the spin-off process (Steffensen et al., 2000), and that badly targeted support mechanism can have a negative impact (Meyer, 2003). The internal development in university organizations to become more entrepreneurial has been studied (Clark, 2004; Clark, 1998; Etzkowitz, 2002b; Jacob et al., 2003). Such transformations are found to be both formal and informal induced by both bottom-up and top-down initiatives (Goldfarb and Henrekson, 2002).
Network	Networks are reported to be important for spin-offs (Harmon et al., 1997; Pérez and Sánchez, 2003) and universities (Lockett et al., 2003) when it comes to spin-off formation. Spin-offs may benefit from university networks (Grandi and Grimaldi, 2003). A greater proportion of industry funding is positively associated with university spin-off performance (O'Shea et al., 2005).
Support programs and boundary organizations	Boundary organizations (Hellström and Jacob, 2003) like incubators (Autio and Klofsten, 1998; Etzkowitz, 2002a; Lee and Osteryoung, 2004; Mian, 1997), technology transfer offices (Guston, 1999), entrepreneurship centers (Autio and Klofsten, 1996; Dill, 1995; Jones-Evans and Klofsten, 1998; Klofsten, 2000), and science parks (Link and Scott, 2003; Siegel et al., 2003c; Stankiewicz, 1998; Westhead and Storey, 1995) are reported to play a role in university spin-off creation. Mian (1996) found that university technology business incubators added value to their tenant firms, specifically through university related inputs such as university image, laboratories and equipment, and student employees. Age of TTO (Carlsson and Fridh, 2002) and number of TTO staff is associated with spin-off formation (Rogers et al., 2000; Thursby and Kemp, 2002).

In addition to the focus on individuals and opportunities, entrepreneurship is also seen as a collective process (Mezias and Kuperman, 2001; Van de Ven, 1993). The studies reviewed in Table 2.5 show that the university setting plays an important role in several ways, by being a resource provider and through policies, culture, networks, and specific support arrangements. Although many contextual factors influence the entrepreneurship process, this thesis focuses on the initial part of the spin-off venture formation process taking place within a

university. Thus, the university setting plays a particularly important role and needs to be included in research aiming to provide an explanation of the spin-off firm formation process.

2.2.5. Characteristics of the university setting

In order to understand how the university setting affects the spin-off firm formation processes it might be necessary to examine how the university setting differs from other settings when it comes to entrepreneurship. The difference in culture and work practice between university and industry is substantial (Anderson, 2001) and constitutes a notable obstacle to spin-off creation in the university setting (Mustar et al., 2006). University spin-off projects are emerging from university research and undergo a transformation where they become an independent business entity. During this process, the technology and the persons working with the project change the scene from an academic to an industrial setting. This transformation may pose challenges for both the spin-off project and the context in which it operates. For the academic wanting to pursue a commercial idea, this might imply to break norms and create emotional strain in the relation to the academic culture. Table 2.6 highlights some of the main differences between the university setting and the industry setting.

Table 2.6: Differences between the university and the industry setting

	University setting (academic)	**Industry setting (capitalist)**
Reward structure	Priority based	Property based
Motivation	Broad range of motivational factors (i.e. curiosity, esteem, financial)	Profit
Knowledge	Sharing of knowledge (IP)	Protection of knowledge (IP)
Cooperation form	Loose relations (couplings)	Formal contracts
Time horizon	Long term	Short term
Role	Knowledge production	Knowledge exploitation
Goal	Novelty important	Market accept important
Management	Academic freedom	Hierarchy

Priority of discovery is regarded as a fundamental currency in the reward structure of academic scientists (Stephan and Levin, 1996). This is a non-market

based reward structure where recognition is awarded by the scientific community for being first. The work of scientists is motivated by the quest for knowledge, and the decisions of what to explore and evaluation of performance is mostly in the hands of fellow scientists. The motivation that drives scientists is not so much connected to financial rewards, but prestige in form of eponymy, prizes (e.g. Nobel Prize), societies, publications, etc. According to Stephan (1996) this can be compared to patent races where the winner takes it all and there is no award for being second. Hence, the scientific contest is risky in nature and the effort of scientists is difficult to monitor.

As asserted by Stephan (1996), economic models to explain the science system lack credibility. This may also apply to spin-off activity, as there are several non-pecuniary benefits for academic researchers associated with the commercialization of their research. One is certainly to validate the usefulness of new discoveries (Shane, 2004), thus increasing academic visibility and esteem. Personal pull factors (Smilor et al., 1990), like independence and fun should not be underestimated. A well known incentive in science is 'the love of the puzzle' (Kuhn, 1962; Stephan and Levin, 1996) which for some individuals may as well apply to the application of the results. Still another incentive is the possibility to attract more research funding from industry. A spin-off company may develop to be a valuable cooperation partner and future sponsor of research (Rasmussen et al., 2006c). Also, a desire to contribute to employment and national economic development is found as a motivation for academics to create new ventures (Rosenberg and Nelson, 1994).

As argued by Merton (1973a), the spirit of science is that research findings are a product of collaboration and assigned to the community. The science system is based on open sharing of ideas and technology, while an exclusive access to technology can be a valuable asset in market based systems. Thus, disclosing and sharing research results instantly may hinder further application because clear ownership and some form of protection of the intellectual property rights (IPR) is often needed to make an invention commercially interesting (Granstrand, 1999). This leads to a focus on IP issues, and patenting has become a part of the activity in many university departments (Geuna and Nesta, 2006; Packer and Webster, 1996). A patented invention is protected for commercial purposes and is through the patenting process made publicly available. Patents

are, however, not characterized to be good vehicles for dissemination of knowledge (Agrawal and Henderson, 2002; Packer and Webster, 1996; Strandburg, 2005), and there are situations where a patent holder can limit further research and the dissemination of results (Blumenthal et al., 1997; Nelson, 2004). University patenting and exclusivity in exploitation of research results are complicated and controversial issues, especially in relation to the principle of free dissemination of publicly funded research (Slaughter and Leslie, 1997).

2.2.6. Barriers to entrepreneurship within universities

The field of entrepreneurship has been characterized as one of the most complex research areas within the social sciences (Bruyat and Julien, 2001). According to Birley (2002), entrepreneurial activity is more complex in academic settings than anywhere else. The complexity of the university spin-off process is evident from the many actors at different levels involved and their often different and unclear objectives (Brennan and McGowan, 2006; Mustar et al., 2006; Siegel and Phan, 2005). These include the government policy level, the university level, the faculty and department level, the research group level, the individual academic level, and the spin-off firm level in addition to other actors such as industry partners, investors, and support agencies. Hence, multiple levels are intervened in a complex relationship during a spin-off process. Some elements adding to this complexity are described in the following paragraphs.

The university provides composite products within education and research. To achieve its objectives, the university organization is characterized by a fragmented structure with loose couplings between different parts of the organization (Weick, 1976). The participation in the decision-making process is often fluid, and the number and role of actors involved, and the amount of effort they put in, are uncertain and changing factors (Cohen et al., 1972). Diverse goals and outputs such as teaching, both basic and applied research, societal utility, and a combination of non-profit and commercial activity add to this complexity (Lee, 1996; Navarro and Gallardo, 2003). The internal complexity is due to the highly specialized competence and autonomous work practice of the employees, the creative nature of work tasks, and the norms and structure of the science system (Merton, 1973b; Stephan, 1996). The external complexity is

evident from the many stakeholders such as students, funding agencies, industry, and other adopters of research results, combined with the changing operational contexts and expectations to universities (Clark, 2004; Etzkowitz et al., 2000; Shane, 2004). The academic culture appreciates publishing and disinterested research, while entrepreneurial activity may be a sensitive issue (Ndonzuau et al., 2002). For the spin-off activity, this may create challenges related to opportunity recognition, incentives for the researcher to exploit the opportunity, and access to university resources necessary for further commercialization.

The relation with the external context is crucial for spin-off development. As noted by Rosenberg (1991), new innovations are increasingly interdisciplinary, and close cooperation between a number of specialists is required to succeed. There might be a communication gap due to differences in expertise, motives, culture, and language between academics and potential adopters of the technology (Rogers, 2002). In order to understand scientific reports and to communicate with academics there is a need for specialized competence and infrastructure, which might not be present in industrial companies or other adopters (Cohen and Levinthal, 1990). Conversely, academics may also lack awareness for business culture and the requirements of the commercialization process (Stankiewicz, 1994). Hence, spin-off firms might be described as a mediating space between academia and industry (Druilhe and Garnsey, 2001). As found by Samsom and Gurdon (1993), the clash of business and scientific cultures often leads to difficulties and sometimes to failure of the new venture.

The complexity of the university spin-off phenomenon outlined above shows some of the challenges involved in studying the phenomenon. The particular challenges associated with entrepreneurship in the university setting gives implications for the use of theories to address this issue. This section has reviewed prior studies about the role of the university setting in the entrepreneurial process. Most studies, however, look at the characteristics of university environments associated with a high spin-off rate, but provides little information about how such environments are created and how they actually influence and interact with the spin-off process.

The third research question in this thesis takes the university as the level of analysis by addressing how university capabilities may facilitate entrepreneurial

processes. Section 2.4 discusses theories that may be used to explore how universities facilitate the spin-off firm formation process. A good understanding of how the spin-off firm formation process unfolds at the micro level is, however, important in order to explore how such processes may be facilitated. This is addressed by the second research question of this thesis. Prior process studies of university spin-off firm formation and a framework for studying processes to be used in this thesis are discussed in Section 2.3 below.

2.3. University spin-off firm formation – a process view

The creation of a university spin-off is clearly a complex process, and the study of this process poses significant theoretical and methodological challenges. As shown by the prior studies reviewed above, the opportunity, the individuals, and the institutional context are all central for the creation of university spin-off firms. The characteristics of these elements are not static, and many have called for more process-driven research on entrepreneurship (Bruyat and Julien, 2001; Van de Ven and Engleman, 2004). According to Davidsson and Wiklund (2001:89): "*Relative to studies of the characteristics of individuals and firms, the characteristics of the new enterprise process have previously been vastly under-researched*". The study of processes has a longer tradition within the organization literature than within the field of entrepreneurship. Hence, this thesis will incorporate theories from the study of organizational change and innovation processes (Poole and Van de Ven, 2004b) in order to develop theoretical explanations of how the spin-off process unfolds. This section starts by reviewing existing research related to the university spin-off firm formation process before theoretical perspectives to study processes are discussed.

2.3.1. Process research on spin-off firm formation

The most prevailing way of representing the process of new venture formation has been to divide it into different stages of development (Bhave, 1994; Churchill and Lewis, 1983; Galbraith, 1982; Hansen and Bird, 1998; Kamm and Nurick, 1993; Kazanjian, 1988; Scott and Bruce, 1987). This is also the case in the spin-off literature where for instance Shane (2004) describes spin-off company creation as a multi-stage process consisting of five stages. Several studies aiming to map university spin-off processes have developed stage-

models. Based on interview data from successful university spin-off programs, Ndonzuau et al. (2002) suggest four stages in the university spin-off process. By following one university spin-off, Clarysse and Moray (2004) also suggests four phases of development, while Vohora et al. (2004) suggest five phases based on a study of nine spin-off projects. Some stage-models used in previous entrepreneurship and spin-off studies are presented in Table 2.7.

Table 2.7: Stage-models used in prior entrepreneurship and spin-off research

Reference	Number of stages	Stages
(Bhave, 1994)	3	(1) Opportunity stage, (2) Technology set-up and organization-creation stage, (3) exchange stage
(Churchill and Lewis, 1983)	5	(1) Existence stage, (2) Survival stage, (3) Success stage, (4) Take-off stage, (5) Resource maturity stage
(Clarysse and Moray, 2004)	4	(1) Idea phase, (2) Pre start-up phase, (3) Start-up phase, (4) Post start-up phase
(Galbraith, 1982)	5	(1) Proof of principle, (2) Model shop, (3) Start-up, (4) Natural growth, (5) Strategic maneuvering
(Kamm and Nurick, 1993)	2	(1) Idea stage, (2) Implementation stage
(Kazanjian, 1988)	4	(1) Conception and development, (2) Commercialization, (3) Growth, (4) Stability
(Ndonzuau et al., 2002)	4	(1) generate business idea from research (2) finalize new venture projects out of ideas (3) launch spin-off firms from projects (4) strengthen the creation of economic value by spin-off firms
(Scott and Bruce, 1987)	5	(1) Inception stage, (2) Survival stage, (3) Growth stage, (4) Expansion stage, (5) Maturity stage
(Sijde and Tilburg, 2000)	5	(1) Awareness, (2) Feasibility, (3) Start-up, (4) Growth, (5) Maturity
(Vohora et al., 2004)	5	(1) Research, (2) Opportunity framing, (3) Pre-organization, (4) Re-organization, (5) Sustainable returns

Stage-models have been criticized for being too rigid (Neergaard, 2003), and the models are often adjusted with feedback loops and overlap between stages (Fayolle, 2003). A number of recent studies have, however, nuanced the linear stage perspective by looking at different types of spin-off processes related to the opportunity, the individuals involved, and the context.

First, the opportunity or new venture idea of university spin-offs is found to develop in a process over time (Klofsten, 2005). Druilhe and Garnsey (2004) provides case evidence that business models are modified as the entrepreneurs' improve their knowledge about opportunities and resources. Further, Heirman and Clarysse (2004) argue that the heterogeneity in initial resources influences the start-up process of research-based ventures. They developed a taxonomy of four start-up configurations: venture capital backed start-ups, prospectors, product start-ups, and transitional start-ups. They found that the start-up process differed highly between the categories and that many start-ups have no clear idea about the business model or significantly change their business model during the start-up process. Overall, Mustar et al. (2006) assert that a dynamic view on how business models of university spin-offs evolve over time is largely absent from the literature.

Second, at the individual level it has been found that the entrepreneurial team of academic spin-offs evolves over time and change in composition (Clarysse and Moray, 2004; Vanaelst et al., 2006) and the resource configurations (Vohora et al., 2004) are modified as the spin-offs are developing. In their special issue introduction, Wright et al. (2004a) stress process issues such as the opportunity realization, the network development, and the learning processes of academic entrepreneurs.

Third, the role of universities is seen as important for the spin-off firm development process (Ndonzuau et al., 2002). Moray and Clarysse (2005) found that the resource endowments of spin-offs are influenced by the way technology transfer is organized at the parent organization and that the organizational policies are changing in a learning process. Furthermore, Heirman and Clarysse (2004) developed a multi-dimensional resource-based taxonomy of research-based start-ups which shed light on the differences in starting resources and the challenges of identifying and acquiring a resource base. They argue that resources and links with the external environment cannot be seen in isolation, but should be grounded in configurational thinking.

The above studies show the dynamics of spin-off processes at different levels of analysis. The stage-models elaborates on the techno-economic logic of processes (Drazin et al., 2004), but fails to account for human agency (Gaglio and Katz,

2001; Minniti and Bygrave, 2001), disequilibrium (Eckhardt and Shane, 2003) or pre-equilibirium (McKelvey, 2004), and equifinality (Eisenhardt and Martin, 2000). It seems clear that no single process model can capture or explain the entire spin-off process, but as asserted by Poole and Van de Ven (2004b), the incompleteness of one process model or "motor of change" can often be accounted for by another model or theory. There is also a need to account for the interaction between multiple levels. According to Phan (2004), entrepreneurship theorizing on the emergence process calls for more multi-level theories. Hence, the use of several process theories may be a viable strategy to explore the entrepreneurial process of university spin-off formation, including multiple levels of analysis, such as the individuals, the opportunity, and the context.

2.3.2. Process theories

Van de Ven (1992) distinguishes between three conceptions of process. The first view or logic is that a process explains the causal relationship between independent and dependent variables. There is, however, no direct observation of the process. This conception is found in studies that aim to explain the creation of university spin-offs (Di Gregorio and Shane, 2003; Markman et al., 2004; O'Shea et al., 2005) and university technology transfer (Carlsson and Fridh, 2002; Friedman and Silberman, 2003) by measuring the effect of independent variables. The second view refers to processes as a category of concepts where a series of constructs represents the actions of individuals and organizations. Here the focus is on changes in variables over time. One example is the model of university/industry technology transfer proposed by Siegel, Waldman et al. (2004). The third conception of process takes on an historical development perspective, focusing on the sequence of events that describes how things change over time. In this perspective, variables are not the main interest, but the progression of activities and events driving the process of change. With a few exceptions (Moray and Clarysse, 2005), this approach has rarely been used in spin-off research. The latter conception of a process is used in this thesis because it opens the possibility to move beyond variables and causal explanations and actually investigate how the process proceeds over time. This approach is outlined more in detail in Paper 3 which use four basic or ideal-type theories or motors to explain processes, as outlined by Van De Ven and Poole (1995).

In their classic article, Van De Ven and Poole (1995) develop a typology of four distinct process theories about the complex processes of organizational change and innovation. Each of the four types, life-cycle, teleology, dialectics, and evolution, represents archetypal explanations of development processes. First, the life-cycle theory assumes that change processes proceed through defined steps or stages of development (immanent program). Second, the teleological theory assumes that it is the purpose or final goal that guides the development process. Thus, the developing entity is purposeful and adaptive, and the process can be seen as a repetitive sequence of goal formulation, implementation, evaluation, and modification of goals (purposeful enactment). Third, dialectic theories explain development processes by conflict between entities, and refer to the balance of power between opposing entities (conflict and synthesis). The fourth type, evolutionary theory, assumes that change processes go through a continuous cycle of variation, selection, and retention (competitive selection). Hence, each theory relies on a different motor driving the change process; a life-cycle motor, a teleological motor, a dialectical motor, and an evolutionary motor.

The use of these theories have been further developed in later works (Hargrave and Van de Ven, 2006; Poole and Van de Ven, 2004a; Poole et al., 2000; Van de Ven and Hargrave, 2004; Van de Ven and Poole, 2005) and adopted by other academics (Cule and Robey, 2004; Weick and Quinn, 2004). The third paper in this thesis explores how the process of spin-off formation unfolds within a university context with reference to each of these four process theories. A better understanding of how the spin-off firm formation process unfolds at micro-level is important in order to understand how universities can facilitate this process.

2.4. University capabilities facilitating spin-off firm formation

The third research question in this thesis relates to how spin-off firm formation processes can be facilitated within the university setting. New venture creation from academic institutions involves particular challenges compared to entrepreneurship conducted by independent entrepreneurs or taking place within business organizations. The classic university is characterized by high complexity and loose couplings within the decision structure (Weick, 1976), and

there are a number of operational and cultural differences between the academic system and commercial entrepreneurial processes (Cohen et al., 1972; Stephan and Levin, 1996). Thus, the university needs organizational capabilities or routines in order to stimulate and facilitate entrepreneurial processes (Lockett and Wright, 2005). This section presents a number of theoretical perspectives that may contribute to a better understanding of how universities can facilitate spin-off processes. By considering the assumptions connected to these perspectives, the dynamic capabilities perspective is then chosen as the point of departure for exploring the third research question in this thesis.

2.4.1. Theories related to facilitating processes

One of the main quests within management research has been to understand how organizational processes can be managed. Research within the fields of strategy and organizational management is aimed to give advice to managers about how to operate in order to achieve the desired goals of the organization. Hence, strategy research is a relevant perspective for understanding how the university organization can be designed and managed in order to facilitate the spin-off firm formation process.

There are, however, different views on how organizational processes emerge and develop and to what degree they can be controlled and managed. First, there are different views on change processes. Two opposite conceptions of change processes are whether they evolve towards a predictable or pre-given state of equilibrium, or whether they are unpredictable and self reinforcing. Second, there are also differing views on how much control and influence managers or framework conditions in general can have upon processes and their outcomes (Marion, 1999). Some theories assume that managers are in a position to have a strong influence and control over change processes. Others see such processes as unstructured and emerging, leaving managers with only limited or indirect control. For universities, this may relate to how much influence policy makers, university managers, or university employees can exert on the new spin-off venture development process.

Figure 2.2 compares some theories in order to illustrate the different views on process and control. The vertical axis represents the degree of control and

structure in change processes from high degree of coordination and intention at the top, to unstructured and emergent processes at the bottom. This distinction is similar to the distinction between strategic adaptation and population ecology perspectives within entrepreneurship research (Low and MacMillan, 1988). The horizontal axis represents differences in the underlying view on change processes from a view that such processes are prescribed and their outcome is predicable on the left, to a constructivist view seeing such processes as socially constructed on the right. The theories in Figure 2.2 are examples to illustrate underlying assumptions found in organization and management research. Such assumptions do, however, affect the way phenomena, such as the university spin-off process, is approached and analyzed.

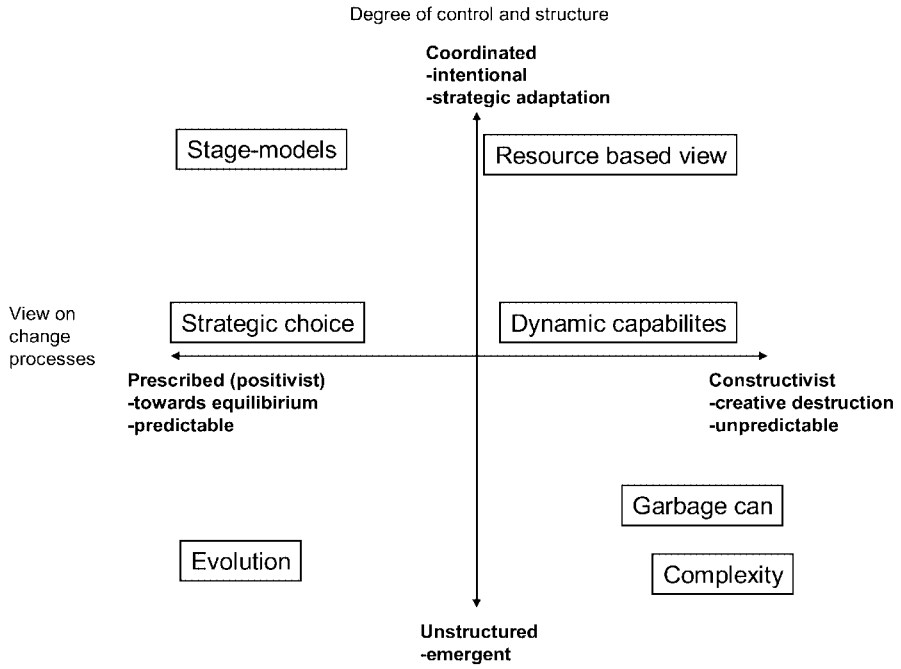


Figure 2.2: Assumptions about change processes and control in different theories

Starting with the lower left quadrant, evolutionary theories describe changes at the population level (Nelson and Winter, 1982). Thus, they are more suited for

population-level studies and the study of clusters of organizations than the development of single organizations. Entrepreneurship is about emergence and evolutionary models do not explain how variation occurs, only the selection and retention mechanisms. According to McKelvey (2004), evolutionary theory and population ecology are inappropriate for studying entrepreneurship because these theories do not focus on new order creation, but on equilibrium. Arguably, theories to explain entrepreneurial processes needs to take into account emerging processes that destroys an economic equilibrium (Eckhardt and Shane, 2003; Lichtenstein et al., 2006).

Moving to the top left quadrant, the strategic choice perspective is a well established way of viewing organizational processes (Stacey, 1995), together with the ecology or evolutionary perspective. Both perspectives assume that there is a link between specific causes and specific effects, and that negative feedback ensures movement towards predicable equilibrium states. The strategic choice theory is based on a rational analysis of the environment and choosing the right strategy for achieving the desired outcome (e.g. through a SWOT analysis). Control and structure in change processes are dependent on the qualifications of managers to choose the right strategy in the given environment (Porter, 1980; Porter, 1985). Two important assumptions taken by this approach are problematic when looking at how university spin-offs may be facilitated. First, it is assumed that managers or policy makers are able to choose the right strategy. The existing research on university spin-off seems, however, not to be able to identify any clear strategies for universities and policy makers to follow. Second, it is assumed that it is possible to implement the chosen strategies. There are, however, limits on the role and influence that managers can execute in a changing world (McGuinness and Morgan, 2000). This is especially the case in loosely coupled organizations such as universities (Weick, 1976).

A theory assuming even more coordination and structure of processes is found in the stage-based or life-cycle models. The literature on organizational change often describe change processes as typically occurring in multiple steps (Armenakis and Bedeian, 1999). As outlined in Section 2.3.1, stage-models are also the most common approach to explain the development process of university spin-off firms. These theories take a positivist or realist position assuming that the environment is pre-given. In their simplest form, stage-models

describe a predicable process moving from one given state to the next. Hence, such processes are easily managed as the next steps of the process are known and predicable. Stage-models assume a high level of prediction and seem better suited to study incremental processes, such as growth (Galbraith, 1982) and product development (Cooper, 1993), while the emergence of a spin-off firm is more unpredictable as an entirely new organization are created.

Moving to the top right quadrant, some conceptions of organizational development allow for processes to be internally constructed and not only the result of adaptation to the external environment. Still, it is assumed that processes can be intentionally coordinated. Strategy research has addressed the entrepreneurial challenge of constructing a resource base (Brush et al., 2001). The resource-based view of the firm (Barney, 1996; Wernerfelt, 1984) assumes that change is not necessarily dependent on a predicable environment, but is based in organizational and human resources being built over time and possessing the ability to adapt to a changing environment. Success is, however, seen to be the result of a clear, prior, organization-wide intention (Stacey, 2003). In recent years, several studies of the university spin-off phenomenon have used the resource-based view as theoretical framework for studying the creation of university spin-off firms (Druilhe and Garnsey, 2001; Druilhe and Garnsey, 2004; Heirman and Clarysse, 2004; Lockett and Wright, 2005; O'Shea et al., 2005; Powers and McDougall, 2005b; Vohora et al., 2004). These studies have led to a better understanding of the spin-off phenomenon by exploring factors directly related to the new venture project which may explain its outcome. This view differs from the linear stage-models by not assuming that spin-off formation can be explained by the exogenous conditions alone, but also including endogenous or internal features as being important for the outcome. Still, the resource-based view assumes that certain types of resources are more valuable than others without explaining how organizations can get hold of or develop such resources.

Another perspective that may be suitable to illuminate possible organizational tools facilitating corporate entrepreneurship within the university setting is the dynamic capability perspective (Lockett and Wright, 2005). Compared with the resource-based view, the dynamic capability approach (Eisenhardt and Martin, 2000; Teece et al., 1997; Winter, 2003; Zollo and Winter, 2002) softens the

focus on clear and fully manageable strategies and intentions, while assuming that specific organizational capabilities can help organizations to be competitive in rapidly changing and unpredictable environments. The dynamic capability framework is about knowledge-handling routines and mechanisms that facilitate entrepreneurial change (Grant, 1996; Pisano, 1994). Such mechanisms are, however, not easily tracked or managed, they are often individualized, based on tacit knowledge, and socially and emotionally embedded (McGuinness and Morgan, 2000).

Finally, as shown in the lower right quadrant, theorizing in the science of complexity (Cilliers, 1998; Fonseca, 2002; Marion, 1999; Stacey, 1995) and the garbage can model (Cohen et al., 1972) gives prediction, management, and intention a smaller role. University spin-offs may be seen as a process of organizational emergence (Chiles et al., 2004; Macintosh and Maclean, 1999) taking into account the properties of emergent processes rather than trying to identify causes and predict their outcomes. Although complexity science provides fruitful avenues for research on entrepreneurship (Chiles et al., 2004; Lichtenstein et al., 2006; McKelvey, 2004; Peterson and Meckler, 2001), the theories and methods available are still not very well developed for the purpose of this thesis. Complexity theorists rely significantly on computer simulations (Minniti, 2004), while this thesis aims to be close to practice.

In order to study how the university spin-off process can be facilitated, there is a need for theories that fit with some of the basic characteristics of the phenomenon. The perspective of this thesis is that entrepreneurial processes are emergent, rather than prescribed. Hence, the theories at the right side in Figure 2.2 might be better suited to explore the spin-off process by taking a constructivist perspective. Prior research on how universities can facilitate spin-off processes asserts that these processes are not fully predictable or controllable, but somewhat possible to influence. Thus, insights may be borrowed from the resource-based view and other perspectives that would fit on the left side in Figure 2.2. The resource-based view (Barney, 1996; Wernerfelt, 1984) is, however, based on the assumption that successful strategies are based in the present (external or internal) situation. Hence, this perspective assumes economic rationality and Newtonian conceptions of equilibrium and stability where an optimal behavior (strategy content) can be found in the current

situation. This seems not to be the case with spin-off formation, as no strong relationships between university characteristics and spin-off formation has been detected.

The facilitation of spin-off processes in a university setting is investigated in Paper 4 in this thesis by using a dynamic capability perspective (Helfat and Peteraf, 2003). This study explores the university capabilities, referring to the ability of the university organization to facilitate the spin-off firm formation process. As argued in this paper, the dynamic capability perspective is suitable for the research question because it allows a focus on processes rather than specific strategies and resources. Moreover, the dynamic capability perspective softens the focus on management control by seeing the organizational capabilities as embedded at multiple levels within and sometimes also outside the organization (Teece et al., 1997). Thus, the dynamic capabilities perspective provides an opportunity to capture the complex set of actors involved in and influencing the university spin-off process within a single framework.

2.5. Theoretical approach summarized

The university spin-off phenomenon seems to be an area where theorizing effort can be fruitful, as it is a recurrent and rather well-defined behavior receiving increasing attention and found to be important for technology transfer and economic development. The accuracy of such theories remains to be seen, as theoretically grounded research on the university spin-off process is scarce. This thesis aims to add more theoretically based approaches to the spin-off literature. Research question 1 is mainly addressing the current status of spin-off formation and support activities at universities. Such descriptive data are important for classification and broader knowledge of the phenomenon and the context. Research question 2 address the spin-off venture creation process at the micro-level, relying on prior work within entrepreneurship and innovation processes. Research question 3 investigates the organizational support at the university level, using an organizational capabilities perspective. Hence, the three research questions addressed in this project will be analyzed by using theoretical platforms from complementary fields of research; entrepreneurship, innovation processes, and strategic management.

3. Research design and methods

3.1. Introduction

This thesis advocates a process approach to increase our knowledge on the university spin-off phenomenon. A constructivist approach is taken, and together with the sparsely systematic research on the spin-off topic, the use of qualitative methods is warranted. The first research question in this thesis is of a "what" type, seeking to explore what initiatives universities use to facilitate spin-offs. To explore this mainly descriptive research question, Papers 1 and 2 in this thesis use an exploratory case study approach to map the initiatives at several universities. The second and third research questions of this thesis address "how" questions, looking at how university spin-off firm formation process unfolds and how they can be facilitated. Process theories are particularly suited to study questions of the how type (Van de Ven and Poole, 2002). A process approach is applied in Papers 3 and 4, which use a longitudinal case study approach to trace the development process of four university spin-off projects over time. Table 3.1 provides and overview of the purpose, the units of analysis, and the research strategy related to each research question.

Table 3.1: Research design related to each research question in this thesis

Research question	Purpose	Unit of analysis	Research approach	Data collection strategy
1	Descriptive: overview and characteristics of what initiatives universities use to facilitate spin-off firm formation	University/ University initiatives	Multiple cases	Cross-sectional
2	Explanatory: investigate how the spin-off firm formation process unfolds at micro level	Spin-off process (multi-level)	Multiple cases	Longitudinal/ process Narrative
3	Explanatory: investigate how the spin-off firm formation process can be facilitated within universities	University and spin-off process relation (multi-level)	Multiple cases	Longitudinal/ process Narrative

The two studies related to the first research question use a cross-sectional data collection strategy. This approach allows for efficient data collection and is well suited to get an overview of the current situation when it comes to initiatives for spin-off firm facilitation at universities. In order to explore the entrepreneurship process, however, more dynamic approaches are warranted. Theories which do not assume the operation of equilibrium forces, such as process theories and theories about emergence, imply that static cross sectional tests cannot be used to explain the phenomenon (Eckhardt and Shane, 2003). The use of static cross sectional studies would fail to account for the internal changes in the variables measured, relating to the opportunity (Eckhardt and Shane, 2003), the individuals involved, and the university context. As argued by Pettigrew (1990:271), the longitudinal comparative case study method is preferable to study broad research questions of change, taking the context into account.

A longitudinal process study of several cases is used for the second and third research question in this thesis because it gives an opportunity to examine continuous processes in context and to include multiple levels of analysis. Some of the limitations associated with case studies can be addressed by larger samples applying quantitative techniques. Such approaches, however, often have problems in caching the dynamics of development processes in general, and emerging processes in particular. The theoretical approaches chosen to investigate these issues call for in-depth studies that are able to capture the theoretical narratives (Poole et al., 2000). Several tools and methodologies are available to study processes. Three research strategies for investigating questions related to processes are compared in Table 3.2.

Table 3.2: Comparison of research designs to study processes

Design	Strengths	Weaknesses	Comments
Cross-sectional	Large sample size possible Systematic valid measurement Measurement facilitates quantitative analysis	No direct access to process Reliance on recall Weak causal inference	This thesis uses comparative cases to map the field
Panel	Large panel size Systematic valid measurement Measurement facilitates quantitative analysis Stronger causal inference	Only sporadic observation of process Reliance on recall Time interval between measures usually arbitrary	
Process	Strong causal inference Access to detail of process Ability to weight individual causal factions Possibility of unexpected discoveries	Small sample size Must transform event data into format suitable for analysis Massive data analysis task	This thesis uses longitudinal case studies to gain in-depth accounts of the process

Source: Inspired by Poole et al. (2000:15)

The explanatory part of this thesis is based on a process approach as originally outlined by Mohr (1982). The process approach is according to Mackenzie (2000) another methodological paradigm than the dominating variable or variance approach within organization sciences. Moreover, the process approach is based on a narrative explanation to show how actions and events contribute to an outcome and then configure these parts into a complete episode (Polkinghorne, 1988). Thus, this thesis will make use of narrative data in order to study processes and make explanations that become particularly close to the phenomena being studied (Pentland, 1999). Narrative data are able to capture all kinds of data that are relevant to most aspects of the spin-off process. According to Polkinghorne (1988), narrative explanations are genuinely explanatory because they can answer the question of why something has happened. Thus, a process approach and the use of narrative data are particularly relevant for the questions in this thesis. Such data are able to capture the patterns of events leading to the formation of a spin-off venture and the barriers and facilitators of this process. Also the dynamic capabilities perspective chosen for the third research question was developed to include the dynamics of organizational processes. Hence, it calls for the use of longitudinal data sources which are able to capture the variation of variables over time.

Much of the conceptual literature on entrepreneurship emphasizes new venture creation as a process over time. Longitudinal research designs are preferable when studying processes, but still most studies on entrepreneurship rely on data collected at one point in time. Actually, among 416 reviewed entrepreneurship articles, Chandler and Lyon (2001) found only eight that were using real time approaches. Little is known about how entrepreneurial processes develop and the drivers influencing their development paths, particularly within a university context. Hence, there is a need to explore the dynamics of the spin-off process and how the opportunity, the individuals, and the institutional context participate and contribute in a process over time. By using a process perspective on university spin-off firm formation, the objective of this thesis is to remedy some of the shortcomings of existing approaches used in spin-off research.

This chapter outlines the research design and methods used in this thesis, starting with a discussion of the scientific perspective underlying this research. Next, the research design and how the three studies composing this thesis are connected together are discussed. Then, some methodological reflections are provided. Finally, the four individual papers in this thesis are introduced.

3.2. Scientific perspective and the process approach

According to Mohr (1982:25-33), the most important outcome of social science research is to generate explanatory theories in order to make generalizations about human behavior, although research may have other functions such as description, forecasting, and evaluations. Further, Mohr (1982:6) claims that the term theory *"refer to relatively confined statements about what causes the recurrent behavior Y or how Z comes about"*. The concern of social scientists is then to develop theories that are *"highly accurate with respect to a large and well-defined scope of occurrences of an important behavior"* (Mohr, 1982:5). Research may be conducted for many reasons, but the prevailing goal is to build cumulative knowledge by developing and refining theories. Descriptive studies are common in areas related to university spin-offs, and this seems to be an impediment to the development of cumulative knowledge about this topic. Nevertheless, any science profits from good descriptive data (Mohr, 1982:28), and descriptive studies are a valuable source of raw material for theory development.

The goal of research is often seen as being the search for casual inference, also in qualitative textbooks (King et al., 1994). Causal relationship is about finding the correlation between one or more independent variables and a dependent variable. The process approach is more occupied with processes and not so much with causality (Abbott, 1990; Mohr, 1982; Poole et al., 2000). Mohr (1982) argues that there are two distinctive types of theories that should be aimed for in social research; variance theory and process theory. Furthermore, Mohr claims that the confusion of these types and attempts to mix them constitute significant impediments to theory development. In variance theory the independent variable is both a necessary and a sufficient condition for explaining the dependent variable. Long term efforts by social scientists show, however, that it is extremely difficult to find solid relationships of this kind. In process theory, the independent variable needs merely to be a necessary condition for the outcome. Where variance theory deals with variables and causality, process theory deals with discrete states and events where the time ordering among the events is critical for the outcome (Poole et al., 2000). As emphasized by both Langley (1999) and Pentland (1999), events and the patterns among them are the core of process theory.

To cite Abbott (1990:140): "*Those worried about causality see no point in studies that don't discover causes. Those worried about typicality see causes as so much reification*". The variance approach looking for causes explaining spin-off creation have been dominating compared to process research. The university spin-off phenomenon might be a good example where variance and process research are mutually beneficial. The creation of a university spin-off venture indeed is a complex process where many routes can lead to the same goal. Apparently, a large number of causal effects influence this process. These are, however, not only of the efficient-cause kind and operating in a linear way, as described by variance theories. Although, looking for causal relations explaining the emergence and development of university spin-offs might yield fruitful results, it seems unlikely that a university spin-off is a causal result of some necessary and sufficient conditions. Alternatively, the process leading to a new spin-off venture can reveal patterns that are necessary, although not sufficient, for spin-off creation.

The first assumption of my approach to university spin-offs is that these new ventures emerge as a result of a social process which develops over time in a particular setting. The almost indefinite number of elements and immense complexity in the relation between them make it impossible to draw accurate conclusions of the outcome of such a process. Processes that are dependent on human action will not be consistent over time (Mohr, 1982). Cultural and technological and societal changes will affect human and organizational life in a way that makes the result of any study dependent on the particular time and place of the study.

By this, I do not say that there is no hope of finding relatively confined knowledge about how recurrent social or organizational phenomena's comes about. Instead I agree with Mohr (1982) that the kind of causal relationships sought for by variance theorists, looking for causal relationships, are extremely difficult to find in the study of human and organizational behavior. The objects of social science are different from those of natural science as they are capable of independent action (Seale, 1999). On a continuum, as the one presented by Morgan and Smircich (1980), I will identify myself as having a more subjectivist approach than an objectivist approach to social science. There is no objective truth to be found, but a better understanding of social and organizational phenomena can be achieved. The social scientist's task is to make concepts and theories that make it easier to understand and to navigate in complex settings.

A considerable share of the studies related to university spin-offs has been quantitative. Hence, the strategy in this thesis is to build on the relations found in these studies in order to get a deeper understanding of the underlying relationships. The purpose of this thesis is not to find any general characteristics or patterns, or to make testable hypothesis. Rather, the aim is to develop a better understanding of the process. This synergy is described by Mintzberg (1979:587): "*For while systematic data create the foundation for our theories, it is the anecdotal data that enable us to do the building. Theory building seems to require rich description, the richness that comes from anecdote. We uncover all kinds of relationships in our hard data, but it is only through the use of this soft data we are able to explain them.*" The qualitative data is useful for getting a deeper understanding of a phenomenon and to understand underlying

relationships, which again can be supported by quantitative data (Eisenhardt, 1989).

3.3. Research design

One aim of this thesis is to address the lack of multi-level and process studies on the university spin-off phenomenon. Research design is the string of logic that ultimately links the data to be collected and the conclusions to be drawn to the initial questions of the study. King, Keohane, and Verba (1994) divides research design into four components: the research question, the theory, the data, and the use of the data. The case study research process is characterized as iterative and untidy (Pettigrew, 1990), and the components in this process are not developed separately or in an exact order. This thesis is based on three different empirical studies reported in four papers. Hence, there is an overall research design for the entire thesis, as well as one for each of the empirical studies. This section deals primarily with the overall design, while the specific research design of each study is accounted for in the methodology section in each of the papers in Chapters four to seven.

3.3.1. Research questions

A first criteria for research projects in the social sciences is that "*a research project should pose a question that is 'important' in the real world*" (King et al., 1994:15). Given the infancy of research on the university spin-off topic, the main design for this thesis may be regarded as explorative. The research in this thesis started with an empirical interest in the spin-off phenomenon. At the time when I started this research, there was a growing interest among practitioners and policy makers about how to facilitate spin-offs, but they seemed to face more questions than answers in how to handle this phenomenon. The many experimental efforts to stimulate spin-offs within universities were rarely followed by scientific studies, particularly not in the Norwegian setting. This situation gave me the possibility to be involved in the first two studies reported in this thesis. These studies are mainly explorative and provide data to illuminate the first research question in this thesis (RQ1): *What initiatives are used by universities to facilitate the formation of spin-off ventures?*

Many countries and universities had undertaken reforms and set up initiatives in order to increase the commercialization of research results and to facilitate the creation of university spin-offs. Hence, the strategy used in the first two studies was to learn from the experiences made at universities during efforts to stimulate spin-off creation. Universities are very diverse, however, each having a unique history and composition of activities, making it difficult to generalize from cross sectional studies. Furthermore, institutions having good track records in commercializing research results seem not to rely on specific initiatives, but are characterized by an environment including many actors, initiatives, and social attributes. As a result, case studies of universities may be particularly suited to gain insight and reveal the best practices taking into account the idiosyncratic characteristics in each institutional setting (Clark, 2004:6). Such studies could focus on the system as a whole, as in the first study in this thesis, or on particular initiatives, as in the second study.

Together with further reading and interaction with the field, the results from the first two studies were important in order to design the third study in this thesis. It seemed clear to me that there was a lack of understanding as to how the spin-off process actually unfolds at the micro-level. Existing studies were mainly based on quantitative and cross sectional data and presented a picture of the spin-off process that, according to my experience, appeared to be too simple. Little was done to 'open the black box' of spin-off formation, and I was also convinced that a better understanding of the spin-off process was necessary in order to generate knowledge about how this process could be facilitated. Hence, the third study aimed at exploring the following two research questions: *How does the spin-off venture formation process unfold within a university context?* (RQ2) and *How can university capabilities facilitate the spin-off firm formation process?* (RQ3). Again, the research questions called for an explorative case study approach including longitudinal data to capture the process. The connection between the research questions and the empirical studies is illustrated in Figure 3.1.

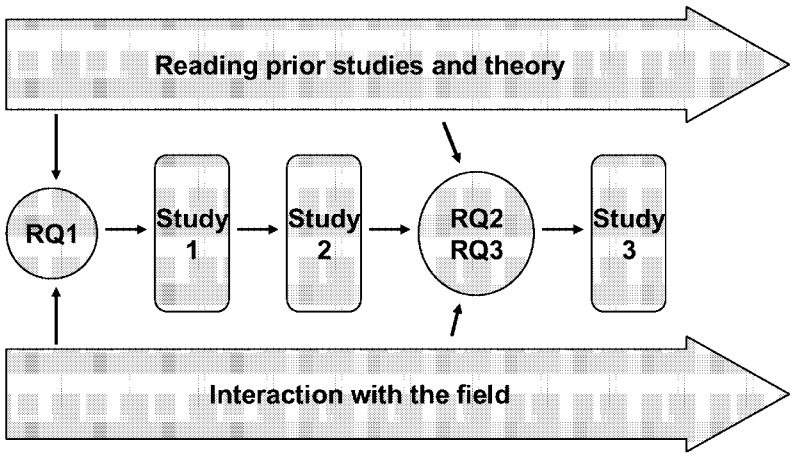


Figure 3.1: Connections between the research questions and the empirical studies

Close interaction with the empirical world have made me better able to formulate the specific research questions and to develop frameworks to study these questions. This has been a dynamic process which started before this PhD project was initiated, and is still in progress. My initial interaction with entrepreneurs, support agents, and policy makers through development projects and project reports have indeed developed my knowledge and improved my ability to identify relevant topics and approaches. The networks and practical knowledge were also crucial in order to obtain ample access to data. A more detailed description of my background and interaction with the field during the work with this thesis is provided in the Appendix.

King et al. (1994:15) also defines a second criteria stating that "*a research project should make a specific contribution to an identifiable scholarly literature by increasing our collective ability to construct verified scientific explanations of some aspect of the world*". As outlined in the theory discussion in Chapter 2, the research questions in this thesis are connected to existing streams of research within entrepreneurship, innovation processes, and strategic management. Even more important, there seems to be an emerging scholarly literature regarding the university spin-off phenomenon, where this thesis clearly aims to contribute.

3.3.2. Theory

The development of a theory or theoretical framework is often considered to be the first step (Collis and Hussey, 1997), especially in quantitative research. Other approaches, like grounded theory (Glaser and Strauss, 1967), moves from the opposite direction by seeking empirical observation without any frameworks that could interfere with data collection and analysis. Still, even in this tradition many argue for the value of being aware of existing literature and theories before entering the field. Actually, a theoretical framework cannot be developed without the knowledge of some prior work and some knowledge about the field - then even the research question would be unknown (King et al., 1994).

The researcher's motivation for a study will to a large degree decide major aspects of how to design the study. If the motivation is to learn about a particular phenomenon, the ideal is to let the phenomenon, not theories, guide the study. Still, a case study is usually designed on the basis of a theoretical model. All studies are based in some form of interpretation or model (Pettigrew, 1990), at least unconscious on the basis of social conventions (Andersen, 1997). The choice of focus will reflect the researcher's values and interpretation of the situation.

The work on this thesis started with an empirical rather than theoretical interest. Hence, my initial aim was not to develop or to test any specific theory. Rather, as my interest for theorizing developed, I started to look for theories that could inform the research on university spin-offs. Hence, the data collection and analysis was conducted in an interactive process. For instance in the third study in this thesis, the collected data provided both narrative accounts of the process (Czarniawska, 1998) and factual descriptions of context, actors, and events from a large number of sources. Based on these data, critical characteristics and events related to the spin-off process were identified through induction. Several different theoretical perspectives were used to capture different aspects of the same process (Pettigrew, 1990). Observations from the data that matched theoretical concepts were identified and helped to develop theoretical explanations for the processes observed (Borch and Arthur, 1995). Hence, the theoretical concepts were formed to match the empirical data in an interactive

process. As pointed out by King et al. (1995), appropriately marshalling a rich data material to evaluate a theory or hypothesis can be a very powerful research design.

3.3.3. Case selection

All the studies in this thesis rely on a case study approach. Case studies can be used to accomplish various aims like providing descriptions, test theory, or generate theory (Eisenhardt, 1989). The case study is a research strategy that focuses on understanding the dynamics present within single settings (Eisenhardt, 1989). A case study is not a methodological choice but a choice of what to be studied (Stake, 2000). Although a sharp definition is difficult, Yin (1989:23) provide the following: *"A case study is an empirical inquiry that: investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used."* As pointed out by Yin (1989), case studies are relevant when the research question is of a "how" or "why" form, focuses on contemporary events, and the researcher is not in control of the event. Case studies can also involve numerous levels of analysis, and within an embedded design it is possible to have multiple levels of analysis within a single study (Yin, 1989). Different subunits of analysis are then brought in as a part of the analysis to enhance the insight to the case.

A common concern when designing and conducting case studies is where to set the boundaries between what elements should be included, and what should be outside the scope of the study. Hence, the concept of a population is important when selecting cases because it defines the possible cases from where the research sample can be drawn. The defined population also helps to define the limits for generalizing from the findings and to control unwanted variation (Eisenhardt, 1989).

It is very difficult to isolate the units of analysis in an unambiguous way. Qualitative researchers are more in control of the selection of observations than most other features of their research design (King et al., 1995). To do a thorough job in selecting cases is one of the most important parts of doing a good case study. To select cases for theory building relies on theoretical sampling. "*The*

cases may be chosen to replicate previous cases or extend emergent theory, or they may be chosen to fill theoretical categories and provide examples of polar types" (Eisenhardt, 1989:537). Theoretical sampling is the process of collecting data for comparative analysis, and is especially intended to facilitate the generation of theory.

To arrive at the definition of a university spin-off presented in Chapter 1 was an important decision, both for selecting cases and for considering possible theories. The selection of cases in the third study, which is reported in Papers 3 and 4, was more theoretically motivated than in the two first studies. The aim of this study was to examine a few chosen university spin-off projects as they developed over time. One major focus of the study was the relation between the spin-off project and the organizational setting where the initiation processes took place. Research groups within the same field of science are found to be very different when it comes to the extent of spin-off and commercialization activity. Hence, the spin-off projects selected for this study represented both research groups having considerable previous history and experience with fostering spin-offs, and groups where the selected case was the first spin-off project from the group. This highlights the role of previous experience (paths) and learning for the ability and willingness to facilitate subsequent spin-off projects.

A high number of spin-off cases gives a broader specter of empirical data, while fewer cases will allow a more in-depth study of each case. Due to time and resource constraints, a minimum of cases were chosen while at the same time maintaining the desired variation. My prior experience from studies on the same topic within the university context helped in selecting more informed sites and negotiating access to potentially interesting cases (Pettigrew, 1990).

In order to give real-time data about particular characteristics throughout the spin-off process, the cases should ideally be followed throughout the entire venturing process. Projects in very early phases may, however, be difficult to identify, have a high risk of making a halt, and be most likely to undergo limited development during the period of data collection. Thus, a minimum condition when selecting a case was that the project had gone through some development and had been in operation sufficiently long to make some impact on the organizational setting. As the objective of the study was follow the cases from a

university perspective and over a period of time, the university context should still be important for the development of the spin-off project. More mature projects will have a longer history to reveal, but data from the early stages of the process is less available as the analysis has to rely on experiences seen in retrospect. Due to time limitations, the main data collection within each spin-off project took place over a one year period. Through interviews with the persons involved and collection of written material from earlier in the process, the goal was to analyze the entire history of each project.

My experience with case selection is ambiguous. On the one hand, many practical considerations affect the selection process (Pettigrew, 1990) and make it difficult to select cases exactly according to the pre-defined theoretically deduced criteria. In addition, after some data are collected, the cases often turn out to be quite different than initially thought. That is, cases that were selected to fit some specific categories, like high or low previous experience, turned out not to fit the category they originally were selected to represent. On the other hand, the diversity and idiosyncratic properties of each case revealed during the in-depth studies provided a rich dataset with extensive possibilities for comparing differences on key variables. Longitudinal case research also adds a new dimension, as the key variables could change over time, which open new possibilities for comparison. As a conclusion, I found that a carefully considered case selection process was very important. Not because of the outcome or the specific cases selected, but because the case selection process developed my awareness about the critical characteristics of each case.

3.3.4. Data collection

The following paragraphs outline the type of data collected during the three case studies in this thesis. The main characteristics of the three case studies are outlined in Table 3.3.

Table 3.3: Key characteristics of the three case studies in this thesis

	Data used in	Number of cases	Unit of analysis	Data collection strategy	Number of interviews
Study 1	Paper 1	4	University	Cross-sectional	65
Study 2	Paper 2	5	University initiative	Cross-sectional	20
Study 3	Paper 3 and 4	4	Spin-off process (multi-level)	Longitudinal	49

Data can be collected to verify a specific theory, but often the data is collected before the researchers know precisely what they are intended to find out. In their guidelines for improving data quality, King et al. (1994:23) claim that the most important thing is to "*record and report the process by which the data are generated*". For the research in this thesis, the data has been collected in several steps. In the first two studies reported in Papers 1 and 2 the cases were not primarily selected to generate theory, but to examine successful initiatives or 'best-practice' of facilitating spin-off creation under different conditions. Prospective cases were found by searching for cases generally reported as successful and through discussions with well-informed persons. In this approach, the main criterion for selecting a case is success in the behavior being studied. Hence, the sample consists of only cases perceived to be successful. Other criteria were that the selected cases should vary on central dimensions such as size, number of years in operation, local context, and relation to other actors. The aim of including cases that differed on central variables was to study a widest possible variety of best practices under different conditions using a so-called maximum variation sampling (Miles and Huberman, 1994).

A key strength of the case study method involves using multiple sources and techniques in the data gathering process. Case studies can combine different types of data collection methods like archives, interviews, questionnaires, and observations (Eisenhardt, 1989). In the third study, reported in Papers 3 and 4, data triangulation including several sources of data was used to map out the situation and critical events prior to and during the development of the spin-off projects (Van de Ven and Poole, 2002). For each spin-off, archival data such as memos, financial reports, business plans, and market analyses were achieved. Primary data was collected by 7 to 17 personal interviews at each case conducted throughout a 12-15 month period.

As this project was taking a multi-level approach, data had to be obtained from people in several positions. Central in the creation of university spin-offs are the person(s) that initially perceived the opportunity, those who have pursued this opportunity, and those who manage the spin-off development. These person(s) could be labeled the entrepreneur(s) or entrepreneurial team. Another central source of information was the organizational environment where the spin-off process was taking place, represented by colleagues and department managers. Finally, information had to be obtained from stakeholders and representatives from the support structure, which for shorter or longer time have been involved in the project. Examples are: university managers, technology transfer officers, business consultants, investors, incubators, board members, industrial partners, customers, and public agencies. Throughout the data collection for this thesis, I have increasingly adopted the use of what Czarniawska (1998:29) would call narrative interviewing.

3.3.5. Narrative interviewing

The narrative approach encourages the interviewees to tell as much as possible about the history and events that have been taking place during the process being investigated (Polkinghorne, 1988). In this way the interviewee decides both the plot or structure, and the main concepts or metaphors to be used. Also, the use of actual events in the interviewees' stories is vastly more informative than talking about hypothetical events, and makes narrative interviews come near to direct observation (Czarniawska, 1998). Narratives are particularly sensitive to the temporal dimension of human existence because it pays special attention to the sequence in which actions and events occur (Polkinghorne, 1988:36). For instance in the third study in this thesis, the interviews focused on letting the interviewee describe his or her involvement in and knowledge of the spin-off project from its inception up to date, with a minimum of interruption by the interviewer. This type of narrative interviewing was done in order to get closer to the actual events and to avoid that the researchers' personal views and theoretical perspectives influenced the data collection.

The narratives given by the interviewees are reconstructions of past events. Events retained in memory are, however, often reshaped by later happenings and

by the plot line of the narrative (Polkinghorne, 1988). Hence, making repeated interviews relatively close in time to the events were important in order to avoid that later happenings influenced the stories. Further, the collection of several narrative accounts about the same process together with collection of written records was made in order to be able to reconstruct the past events.

Although commonly used in genres such as ethnography, the expression fieldwork is not very common in organizational and management studies. According to Czarniawska (1998), the field is where "*the Other*" lives. As discussed by Czarniawska (1998), the interviewer is even more an interview victim than the interviewees. As an interviewer you need to argue for the logic of what you are doing and to get used to have a rather low priority among the people you interview. Their time is more valuable than yours, and you depend on goodwill to get your job done. Especially in a longitudinal study, the researcher is locked in a dependent relationship towards the informants where any disagreements may have severe consequences for the study, but usually no consequences for the interviewee.

The experience from all three studies providing data for this thesis is that getting people to talk is much easier than I originally anticipated. In the first two studies, the effort required by each informant was limited to around one hour, but still the interviewees' prospects of gaining anything at all from sharing their thoughts was low. Also, there would be no negative consequences for refusing or finding an excuse to not participate. My impression is that people are generally eager to talk about themselves and their experiences. In some of the cases where I have used confidentiality agreements, it sometimes seems to be a relief for the interviewees to be able to talk freely to a neutral party who is listening. Several times I have been able to get an appointment for a short interview, but when the time was up, the interviewee has delayed other appointments in order to finish the story. I believe an advantage of using the narrative approach is that the interviewees get more engaged and report their stories in a way that appears natural to them, thus increasing the richness and the consistency of the data. After all, human memory seems to consist of stories rather than separate pieces of information (Polkinghorne, 1988; Simon, 1996).

3.3.6. Data exploration

Because case study research generates a large amount of data from multiple sources, systematic organization of the data is important to prevent the researcher from becoming overwhelmed by the amount of data and to prevent the researcher from losing sight of the original research purpose and questions, i.e. what Pettigrew (1990) refers to as "death by data asphyxiation". This is particularly the case with process data covering multiple levels of analysis (Langley, 1999).

In my experience, data collection and analysis have been an ongoing process that have been embedded in all my work during the time I have been working with this thesis, and even before that. My work experience prior to and during the work with this thesis has been an important part of the research process. During the work with this thesis, I have participated in a number of settings, attended numerous seminars and conferences, discussed with a great number of people, read everything from scientific reports to media coverage, and shared my thoughts with people in many positions (see Appendix). Undoubtedly, this activity have played a major part in forming my knowledge and views about the topic I have studied, and have certainly affected the result of my work as reported in this thesis. This experience has provided me with both networks and practical knowledge making it possible for me to learn more and to have a deeper view into the data than if the three studies in this thesis were my only interaction with the field. I believe in a broad approach where a multitude of different experiences add to the total knowledge and understanding of the phenomenon.

Writing also has an important function throughout the entire research process as a medium for communication, documenting, analyzing, and finally presenting the results. To share the research results through writing is one of the most important parts of the research craft. As argued by Czarniawska (1998), organization and management science is a field eager to be in close contact with practice, and the art of writing becomes extremely important. Although tables and lists can fulfill certain functions that narratives cannot, the reverse applies even more (Czarniawska, 1998:8). As mentioned earlier, the data collection and data analysis was conducted in an interactive process. In the two first studies, the data was used to make an extensive case description about each university

case. This work involved several researchers. Then, the case descriptions were commented on by well-informed persons at each university. These descriptions then formed the basis for a so-called multiple-case report (Yin, 1989), containing both the case descriptions and cross-case analysis. The papers presented in this thesis provide a condensed version of these reports. The papers had also been commented on by several other academics who did not participate in the data analysis. Choosing a paper-based format for the thesis, however, put space limitations on the extent of original data that can be reported in each paper.

Due to the longitudinal research design, the third study in this thesis gave room for a more interactive data collection and analysis process. Most interviews were recorded and transcriptions were done as a part of the data analysis process. In addition, relevant written documentation was collected both from the informants and other sources like press articles and the internet. An in-depth description of the research and commercialization process was obtained by combining the different sources of information and by collecting information over a period of time, doing repetitive interviews with central informants. Data collection and analysis was conducted in an interactive process as summarized in Table 3.4.

Although the spin-off cases were still interacting with their universities of origin, they had become established projects having a separate organization and funding when the data collection ended. The cases are based on anonymity, and some of the factual information has been slightly adjusted. Confidentiality has resulted in a richer set of data including better access to documentation and more honest statements from the informants.

The collected data provided both narrative accounts of the process (Pentland, 1999) and factual descriptions of context, actors, and events from a large number of sources. All sources related to each case were reviewed and the main events and focal actors were chronologically listed in tables in order to get an overview of the process. I also experimented with software tools in order to structure the data and assist in the analysis process, but I was not able to find any tools that could capture both the detailed insights about the cases in their context and deal with the time dimension at the same time. Hence, the data

analysis was conducted by working with theory and empirical data in an interactive process, also involving colleague researchers.

Table 3.4: Summary of main steps in the data collection and analysis process

Step in data collection and analysis process	Data sources, collection, and analysis
Mapping the national context and the universities	National level: attending policy/practitioner conferences, conversations, and documents. University level: visits, conversations, and personal interviews
Case selection	Identified commercialization projects based on prior work experience, network, and general information search
	Identified case informants through key informants and network
Initial case investigation	Internet search and informal conversations
Interviews	Interviewed central informants over a 12 to 15-month period (49 interviews)
Document collection	Obtained plans, presentations etc. from interviewees
	Searched the Internet for web pages, press articles, etc.
	Obtained student thesis, including source material (2 of the cases)
Data transcription	Transcribed the interviews (most from tape), focus on revealing the process
Mapping central events over time	Writing narratives about the spin-off process and making tables describing time, actors, and critical events
Matching theoretical concepts	Working with theory and empirical data in an interactive process, including discussions with colleague researchers

Critical characteristics and events related to the spin-off process were identified through induction. In order to arrive at theoretical explanations for the processes observed, observations from the data that matched theoretical concepts were identified (Borch and Arthur, 1995). Several different theoretical perspectives were used to capture different aspects of the same process (Pettigrew, 1990). This type of alternate templates strategy (Langley, 1999) provided theoretical explanations covering different aspects of the phenomenon. The theoretical concepts were formed to match the empirical data in an interactive process. As the analysis proceeded, the overarching logical frame shifted from exploring data using retroduction to verifying theory through deduction (Van de Ven and Poole, 2002). For further validation of the results, the findings from the cases have been aligned with existing empirical research on the university spin-off

phenomenon, and presented to other academics at conferences and through blind review processes.

3.4. Research quality issues

This section provides some reflections about the methodology used in this thesis. First, issues related to the research credibility and dependability of the studies in this thesis are discussed. Then, ethical issues are considered.

3.4.1. Research credibility and dependability

An important part of the research methodology is to establish criteria to assess the quality of the work. In a positivist sense and using quantitative methods, a number of such criteria are often clearly stated. In the other extreme, in a constructivist view working with narrative texts, such criteria for evaluation of the quality of a research text would be impossible to establish *a priori*. Still, many refer to reliability and validity as two chief criteria for soundness in qualitative research just as for quantitative research (Dougherty, 2002; King et al., 1994; Peräkylä, 2004). Using criteria such as the reliability and validity is a helpful starting point in developing methodological awareness for qualitative researchers (Seale, 1999).

Validity refers to the correctness or precision of the research (Lewis and Ritchie, 2003). Lincoln and Guba (1985) use the term credibility as an alternative term to discuss the truth value of a qualitative study, or what is referred to as internal validity by quantitative studies (Seale, 1999). As this thesis takes a constructivist perspective, it would be artificial to discuss validity as if the goal is to get close to one objective truth. The aim of this thesis is to provide a deeper understanding of the diversity and complexity related to the spin-off firm formation process by developing analytical generalizations rather than statistical generalizations (Yin, 1989). After all, the conclusions of narrative research does not produce certainty, they produce likelihood (Polkinghorne, 1988).

There can be many reasons that cause different outcomes depending on the researcher and on when a phenomenon is studied (Agar, 1985). One reason for such instability in reliability is different cultural background and initial

knowledge of the researcher. This is wisely stated by Bozeman (2000) in his review of technology transfer. "*In the study of technology transfer, the neophyte and the veteran are easily distinguished. The neophyte is the one who is not confused*". To have a profound practical knowledge about a phenomenon, I think, will make a researcher able to ask better questions, to make better interpretations of the data collected, to better understand why things happen, while being able to sort out the important from the unimportant. In order to improve the quality of my research, I have seen it as important to maintain broad and extensive contact with practitioners in the field (see Appendix).

The issue of credibility has been addressed by collecting a rich data set involving many data sources. According to Lincoln and Guba (1985), one activity to increase the probability of making credible findings is prolonged engagement with the field. Hence, both the longitudinal design of the third study in this thesis and my active interaction with the field are important for the credibility of this thesis. In order to display the data, all studies in this thesis make use of tables to present the key characteristics of each case. In addition, I have used case descriptions (Paper 1, 2, and 3) and frequent citations from the interviews (Paper 4) to show a link between the data and the findings. Table 3.5 summarizes some steps to increase the validity or credibility in each of the three studies.

Table 3.5: Summary of strategies to increase the credibility of each study

Study	Cases	Fieldwork	Validation	Documentation
1	4	Case reports	Triangulation of sources	Case descriptions
2	5	Case reports	Triangulation of sources	Case descriptions
3	4	Longitudinal data collection	Triangulation of sources and theories Linkage to prior studies	Case descriptions (Paper 3) In-text citations (Paper 4)

Furthermore, Lincoln and Guba (1985) translate consistency or reliability into the term dependability for use in qualitative research. Reliability is concerning whether the research findings would be repeated if another study using the same methods was undertaken (Lewis and Ritchie, 2003). In order to increase the reliability or dependability of the research in this thesis, almost all interviews in

study one and three were recorded (Peräkylä, 2004). For the interviews where only written notes were taken, these notes were used to write a detailed interview report as soon as possible after the interview. Another way to increase the reliability of study one and two was that almost every interview was conducted with at least two researchers present. Due to resource constraints, this strategy was not possible to pursue in the third study. For three of the papers in this thesis (1, 2, and 4), I have also involved co-authors in the writing process in order to validate my thoughts and to bring in complementary views. Table 3.6 summarizes the main strategies to increase the reliability or dependability in each of the three studies.

Table 3.6: Summary of strategies to increase the dependability of each study

Study	Interviewers	Data	Data verification	Analysis
1	Two researchers	Recorded interviews	Multiple data sources Feedback on case descriptions Concluding project conference	Interview transcription Discussion with peers and co-authors
2	Two researchers	Written notes	Multiple data sources Feedback on case descriptions	Discussion with peers and co-authors
3	One researcher	Recorded interviews	Multiple data sources Repeated interviews over time	Interview transcription, retroduction and deduction, discussion with peers and co-authors

Another reason for instability in findings is that the phenomenon being studied is changing over time (Agar, 1985). This is indeed the case with the university spin-off phenomenon that have experienced an almost exponential growth in volume, differing legislative and funding regimes, and changes in culture and attitudes, to mention a few. Such changes pose good opportunities for research, especially process research, but at the same time make reliability problematic.

3.4.2. Ethical considerations

Ethical issues have to be considered in relation to the persons and the organizations involved in the research and those who may be affected by the results of the research. The following guidelines have been used to keep a sound

relation to the information sources and to avoid negative consequences (Lewis, 2003). Firstly, I have gained acceptance from the persons involved before the information is gathered. Secondly, I have clearly stated the aim of the research and how the information will be used. Thirdly, I have been reluctant to reveal or quote specific information outside the public domain without knowledge and acceptance from the sources. This includes secure handling and storage of such information. Due to my access to company sensitive information, confidentiality agreements have been signed with some of my cases.

The research in this thesis is not directly related to private matters of the persons included in the data collected, but related to professional issues. The respondents are considered to be highly aware of their situation and responsible of their actions. Still, my research includes personal characteristics, making it necessary to act with care in order to avoid that the persons involved suffer from negative consequences as a result of my research. Research results can have a significant impact on opinion, practice, and policy. Revealing information can have extensive consequences for those involved. The aim of the research in this thesis is to generate more general knowledge and policy implications at the macro-level. Thus, direct consequences for the data sources (micro-level) will be limited. The chance of a more general impact on opinion, practice, and policy, however, brings a responsibility to the researcher to present the research results as correct as possible without drawing speculative conclusions.

The values, interests, and the position of the contractor, researcher, and study object will often influence the positioning of the final story. The audience may have a different focus and approach to the issue than the author. If the position and premises for the study are not made explicit, it is difficult for the reader to assess the content of the study. As such, to be conscious of one's theoretical basis and strategic position helps in defining more precise conditions for the study, even when the study is not motivated by theoretical issues. In the words of King et al. (1995:476): *"..uncertain inferences are every bit as scientific as more certain ones so long as they are accompanied by honest statements of the degree of uncertainty accompanying each conclusion."* Within applied research the choice of position and assumptions is usually passed on pragmatic choices about what is of interest to the opinion or contractor. The practical utility of a study will usually increase as more of the values and assumptions of the user are

taken for granted. Also the intended audience of the research report affects in what form the results are presented (Agar, 1985). For instance, Papers 1 and 2 in this thesis is aimed more towards practitioners having less emphasis on theoretical implications than Papers 3 and 4 that are aimed more towards academics in the field.

Although it does not appear to be widespread, the issue of fraud and plagiarism is not unknown among scientists. This problem might not be as urgent in social sciences as in fields like medicine and engineering where one specific finding might have a great impact and commercial value. In our daily work, the practice of citing might lead a social scientist into ethical dishonesty. In this thesis I have adopted a practice of using relatively many citations, hoping that this would both acknowledge the original work and at the same time be an advice for further reading.

Finally, as a researcher I occupy considerable resources, often funded by public sources. This investment is expected to give a return back to society. Hence, all researchers have a responsibility to make an effort in delivering valuable results from their work, although an important part of the PhD research project is to be a learning experience for the candidate.

3.5. Introduction to the individual papers

This thesis comprises four papers. The first two papers are mainly explorative, addressing the first research question of this thesis by examining a variety of university level initiatives to promote university spin-off firms. The last two papers are more theoretical. Paper 3 is addressing the second research question, aiming to contribute to the understanding of how the process of creating a university spin-off firm unfolds. Paper 4 address the third research question by investigating how such processes can be facilitated within universities. All four papers are based on case studies. Key properties of the four papers are summarized in Table 3.7.

Table 3.7: Summary of the four papers' key properties

	Paper 1	Paper 2	Paper 3	Paper 4
Title	Initiatives to promote commercialization of university knowledge	Action-based entrepreneurship education	Spin-off venture creation in the university context – a process view	University capabilities facilitating spin-off venture formation
Author(s)/ Reference	Rasmussen, Moen, and Gulbrandsen (2006c)	Rasmussen and Sørheim (2006)	Rasmussen (2006c)	Rasmussen and Borch (2006)
Status	Published in Technovation, Issue 4, 2006	Published in Technovation, Issue 2, 2006	Earlier version presented at the 2006 NCSB Conference, Stockholm*	Earlier version presented at the 2006 Academy of Management Conference, Atlanta**
Related to research question in this thesis	1) What initiatives are used by universities to facilitate the formation of spin-off ventures?	1) What initiatives are used by universities to facilitate the formation of spin-off ventures?	2) How does the spin-off venture formation process unfold within a university context?	3) How can university capabilities facilitate the spin-off firm formation process?
Level of analysis	University	University	Multi-level (process)	Multi-level (process)
Empirical data	Four university cases	Five study program cases	Four spin-off cases	Four spin-off cases
Main theoretical perspectives	Descriptive	Descriptive + entrepreneurship	Process theories + entrepreneurship	Dynamic capability
Dependent variable	University initiatives	University initiatives	Spin-off process	University initiatives

* Some of the conceptual ideas in this paper have previously been published in Rasmussen (2006b). The paper is submitted to Journal of Business Venturing.

** An earlier version was presented at the RENT conference (Rasmussen and Borch, 2005), selected for the Inter-RENT 2006 where it became one of three best papers selected. The paper is submitted to Research Policy.

The first paper analyzes four European universities and their initiatives to commercialize university-based knowledge, showing that spin-offs are an important tool which is supported by several measures. The second paper looks at one specific initiative –entrepreneurship education. By studying

entrepreneurship education initiatives at five Swedish universities, this paper shows that under certain conditions students can actually play an important role in establishing research-based spin-offs. The third paper uses in-depth longitudinal data to analyze four spin-off projects, and uses an entrepreneurship perspective combined with process theories to suggest an explanation of the spin-off development process. The fourth paper aims, by investigating the same four spin-off cases, to explore what capabilities within a university context that may facilitate the university spin-off process.

In the following paragraphs, the content of each paper is briefly summarized and the relation between the four papers is outlined.

3.5.1. Paper 1

The first study presented in this thesis explores different initiatives to promote the commercialization of knowledge. The creation of spin-off firms is one among several routes to commercializing research from universities. To get an overview of the spin-off phenomenon and its role in the commercialization of university research, this thesis explores practice among universities on how to facilitate commercialization of research in general. Prior studies have investigated specific initiatives for the commercialization of research, but few have examined the total range of initiatives and the interplay between them at university level.

Through case studies of four European universities of science and technology in Finland, Ireland, Norway, and Sweden, this paper analyses several commercialization initiatives. The study shows that the creation of spin-off companies is seen as important by the universities and many initiatives have been set up to facilitate the creation of such companies. All four universities have increased their commercialization activities and focus the last two decades, and have a more or less broad range of support mechanisms for entrepreneurship. These initiatives are initiated and based at multiple levels within and outside the university. The challenge seems to be how to coordinate them with each other and with the traditional university activities.

The diversity of initiatives and the need for local adaptation showed that there were no general receipts for how to stimulate spin-offs within universities. It seemed like there were a lack of knowledge about how the university mechanisms to facilitate spin-off creation should be designed. This lack of knowledge inspired the later study of spin-off processes and university capabilities in Paper 3 and 4 in this thesis. Furthermore, an interesting initiative identified in this study was the role that students may play in the commercialization of research. This role had hardly been investigated by the spin-off literature, and provided inspiration for the next study included as Paper 2 in this thesis.

3.5.2. Paper 2

The second study presented in this thesis focuses on a specific type of initiatives to facilitate university spin-offs by exploring how teaching of students can be combined with research-based new venture formation within universities. Commercialization of knowledge is seen as a third mission of universities, in addition to teaching and research. Many studies have investigated the link between university research and new firm formation, but few have looked at the link between teaching and spin-off-based commercialization of research. This study examines cases of action-based entrepreneurship education at five Swedish universities. The cases show that the entrepreneurship education initiatives focus less on teaching individuals in a classroom setting and more on learning-by-doing activities in a group setting and a network context. Several initiatives have multiple goals, such as educating entrepreneurs, establishing new ventures, and commercializing university research. The study shows that entrepreneurship education can successfully be combined with commercialization of research-based ideas. In this way the traditional university task of education is combined with the newer university mission of contributing to the application of knowledge.

The first two studies have investigated the first research question of this thesis: *"What initiatives are used by universities to facilitate the formation of spin-off ventures?"*. These studies have provided an overview and analysis of initiatives at the university level, but they have not investigated the spin-off process at the micro-level. Another approach to learn about spin-off formation would be to

analyze the actual process of creating a spin-off venture within a university setting at the project level. To examine specific cases as they develop may lead to a more thorough understanding of the process of spin-off firm formation. A good understanding of how the spin-off process evolves through specific events, including specific actors in a specific context of operation, may be the basis for understanding how such processes unfold and how they can be facilitated. When studying complex issues, the understanding of processes at the micro-level is a powerful, and maybe necessary, tool to understand the impact of initiatives and policies at the macro-level. Hence, the third study presented in this thesis explores how four university spin-off projects emerge at the micro level. This study has two research objectives which are addressed by Paper 3 and Paper 4, respectively.

3.5.3. Paper 3

The third paper key into the second research question of this thesis: *"How does the spin-off venture formation process unfold within a university context?"*. By using the four basic theories or 'motors' to explain processes outlined by Van De Ven and Poole (1995), the aim of this paper is to provide a theoretical explanation of how new research-based spin-off ventures develop within a university context. The paper argues that the four process theories, life-cycle, teleology, dialectic, and evolution, can be used to explain different aspects of the spin-off venturing process. First, the research-based invention is refined to become a business idea and finally a business operation through a life-cycle process. Second, the individuals or entrepreneurs creating the new spin-off venture are involved in a process of purposeful enactment where their behavior and goals are modified in a learning process. Third, the relation between the academic world and the business world is not easily aligned. As the development of a commercialization project emerges within the university context, dialectics between the open academic science and the business activity of the new spin-off venture have to be resolved. Fourth, the spin-off process is part of a macro environment where evolutionary processes, such as industry cycles, affect both timing and viability of the spin-off project. This view is developed through a review of prior spin-off research and further articulated by deriving four propositions, one related to how each process theory may explain one specific aspect of the spin-off process:

Proposition 1: Life-cycle theories are more salient than other theories in explaining how the opportunity or business idea develops during the formation of a university spin-off venture

Proposition 2: Teleological theories are more salient than other theories in explaining the role of the entrepreneur or entrepreneurial team during the formation of a university spin-off venture

Proposition 3: Dialectical theories are more salient than other theories in explaining the role of the university context during the formation of a university spin-off venture

Proposition 4: Evolutionary theories are more salient than other theories in explaining the role of environment adaptation during the formation of a university spin-off venture

Empirical data to explore this process perspective is provided through in-depth studies of four spin-off projects at two Norwegian universities. The cases were followed for more than one year by documentary collection and repetitive interviews. A narrative approach was used in order to get close to the actual events. The longitudinal case studies revealed that the spin-off process is much more unstructured and messy than assumed by many prior studies. Hence, the use of single theories provides only partial explanations of the spin-off process. While prior studies have often relied on a single theory to analyze the spin-off process, notably life-cycle or stage-based theories, this study contributes by using four process theories to explain different aspects of the spin-off process. By adding on teleological, dialectical, and evolutionary theories, this study provides a broader explanation of why spin-off processes moves from one stage of development to the next. Moreover, the findings suggest that the different theories may be more or less prominent to explain the development at different times throughout the spin-off process.

3.5.4. Paper 4

The fourth paper keys into the third research question of this thesis: "*How can university capabilities facilitate the spin-off firm formation process?*". This paper focuses on organizational mechanisms in a university facilitating the creation of new ventures based on academic research. The organizational characteristics of a university includes complex tasks, multiple and ambiguous goals, a high degree of autonomy on the part of employees, and possible conflicts of interest. A number of mechanisms within the university organization that may support the process of new firm creation have been described. In particular, the paper looks at the challenges related to the exploration and exploitation of entrepreneurial opportunities within the university setting and introduce both de-coupling and integration mechanisms to configure resource for spin-off development.

Furthermore, the paper discusses the university capabilities that may improve the university's ability to support new firm development and transform research findings into commercial business concepts. The paper introduces a set of four dynamic capabilities facilitating entrepreneurial processes within the university, emphasizing the creation of new paths of action; the creation of new knowledge resources; balancing past, present, and future positions; and the reconfiguration and integration of resources. These capabilities are developed through a discussion of findings from prior spin-off research and further articulated by deriving four propositions, one related to each of the university capabilities:

> *Proposition 1: There is a positive relation between new action path mechanisms and spin-off based entrepreneurship within universities*
>
> *Proposition 2: There is a positive relation between new knowledge creation mechanisms and spin-off based entrepreneurship within universities*
>
> *Proposition 3: There is a positive relation between university mechanisms that balance past, present, and future positions, and spin-off based entrepreneurship within universities*

Proposition 4: There is a positive relation between reconfiguration and integrating mechanisms and spin-off based entrepreneurship within universities

The empirical analysis is based on the same longitudinal study of four entrepreneurial processes as was used in Paper 3. In this paper, the data was analyzed to identify critical characteristics and events influencing how the spin-off process emerged and developed within the university context. The findings describe the role and specific content of the university capabilities related to each proposition. It is also suggested how each of the four university capabilities plays a more important role at different times throughout the spin-off process.

The four papers are presented in the following Chapters four to seven.

4. Paper 1 - Initiatives to promote commercialization of university knowledge

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4.1. Abstract

In addition to teaching and research, universities are increasingly expected to take on technology transfer and commercialization as a part of their mission. This development gives new challenges to the institutions in making initiatives to promote commercialization of university knowledge. Through case studies of four European universities of science and technology in Finland, Ireland, Norway and Sweden, this article analyses several commercialization initiatives. All four universities have increased their commercialization activities and focus the last two decades, and have a more or less full range of support mechanisms for entrepreneurship. The challenge seems to be how to coordinate them with each other and with the traditional university activities.

Keywords: Commercialization, University

4.2. Introduction

Many authors claim that there is a new role for universities in society with respect to commercialization of research results, or 'entrepreneurial science' (see: Etzkowitz, 1998; Martin, 2003). As scientific knowledge becomes increasingly important for innovation and new business development (Mansfield and Lee, 1996), and as an increasing share of the population enters higher education, universities can play an enhanced role in innovation (Laredo and Mustar, 2001; Leydesdorff and Etzkowitz, 1996).

Few studies have investigated how the universities adjust to these new expectations from policy-makers, in order to take a more direct role as actors in regional and national economic development (Martin and Etzkowitz, 2001). From the university perspective the challenge becomes threefold: to increase the extent of commercialization, to visualize the contribution to economic development, and to manage the relationship between commercialization and other core activities. As commercialization activities may affect both teaching and research, there is a potential for conflict and resistance, as well as mutual benefits among the activities.

This paper sheds light on how universities may respond to this new role by examining specific initiatives and policies aiming to increase commercialization of university research. Further, we analyze how different university and other public and private initiatives relate to each other and constitute a system for promoting commercialization of research at a university. Finally we reflect upon the outcomes of increased focus on commercialization activities at universities. For this purpose, four European universities with traditionally strong links to industry are analyzed.

Our focus is on commercialization of knowledge where the intellectual property rights (IPR) belong to the university or the university employees. Hence, the focus is on entrepreneurial activity, creating spin-off ventures, and licensing, rather than on more general cooperation with industry. Further, we do not question the decision to develop universities in the direction of commercialization. Our point of departure is where a university has formally adapted a goal or ambition of increased commercialization.

In the following section, we take a closer look at the changing role of universities. Then, central initiatives and policies for commercialization in a university setting are discussed before the complete system of initiatives to promote commercialization of university knowledge is examined. Finally, the outputs of commercialization activity seen from a university perspective are discussed.

The subsequent empirical part is based on extensive case studies of four European universities of science and technology: Chalmers University of Technology in Sweden, the Norwegian University of Science and Technology, the University of Oulu in Finland, and Trinity College Dublin in Ireland. In the last part of this paper, our main topics are analyzed on the basis of the empirical evidence, and implications for university policies and further research are provided.

4.2.1. The changing role of the university

Traditionally, teaching and research have been the university's main missions. This has gradually changed with the emergence of disciplines like

biotechnology, increased globalization, reduced basic funding, and new perspectives on the role of the university in the system of knowledge production. Innovation is increasingly seen as an evolutionary process that involves different institutional spheres, or sectors, in society. Gibbons, Limoges et al. (1994) argue that we now see a fundamental change in the system of knowledge production with new organizations and relations identified with key words like reflexivity, transdisciplinarity and heterogeneity. The "Triple Helix" literature (e.g. Etzkowitz and Leydesdorff, 1997) also argues that the acceptance of commercialization as a central university task constitutes an "academic revolution". The relation between university, industry, and government is in this model symbolized by a triple helix of evolving networks, in which the university can play an enhanced role in innovation. Florida and Cohen (1999) argue that a key role for the university in the knowledge economy is as a collector of talent, thus acting as an important infrastructure for nations and regions in building capability to survive and prosper in the knowledge economy. In a knowledge-based economy, the university then becomes a key element of the innovation system both as a human capital provider and a seed-bed of new firms (Etzkowitz et al., 2000; Laredo and Mustar, 2001).

Following changes in government control (e.g. OECD, 2000a), universities to an increasing extent have to argue for their economic role and demonstrate their societal impact in order to obtain public funding. OECD (2000b) reports that many countries are undertaking university reforms with a view to greater autonomy, more competitive and performance-based funding, and increased commercialization of the results of public research. There is also a substantial increase in university support of commercialization and technology transfer in general. Etzkowitz et al. (2000) suggest that a pattern of transformation towards an entrepreneurial university is emerging from different geographical bases. This shift is arguably arising from both the internal development of the university and external influences on academic structures, and perhaps the increasing prevalence of innovative clustering at the regional level.

More generally, universities can contribute to economic development both by interaction with existing industry and by other types of commercialization of knowledge, like the establishment of new firms. Many universities take this opportunity to secure and expand their activity by demonstrating their utility in

society (Gulbrandsen, 1997). According to Fairweather (1990), academic institutions can by appearing to respond to social needs and 'economic development' enhance their public image, which in turn can lead to accountability for funding. In addition, the change in the university's mission opens the possibility for many universities to get a broader funding base through non-governmental sources.

In sum, universities experience a changed funding structure and new expectations, and may also have self-interests in an increasing focus on starting new firms and other types of commercialization of knowledge. Still, commercial activities have met some concern and criticism among academics. Some argue that commercial activities may be a threat to traditional academic freedom and basic research (e.g. Nelson, 2004). More frequent are worries about shorter time horizon in research and tensions related to impartiality and conflicts of interest (Etzkowitz, 1998). Still, just as most institutions experienced that research and teaching can be mutually beneficial around a century ago, this may happen with the new commercialization activities as well (Etzkowitz and Webster, 1998). There is, however, still a need for evidence on how commercialization activities and support structures are integrated into the universities and the existing activities and structures related to teaching and research.

4.2.2. Initiatives and policies for commercialization of university knowledge

The increased focus on commercialization of university research has led to the development of university policies and initiatives to promote such activity. Some initiatives may be induced "top-down" from the government and its agencies, while other initiatives are emerging "bottom-up" from individuals and entities inside the university (Goldfarb and Henrekson, 2002). Some initiatives are formal, while informal mechanisms are in many cases found to play an even more significant role (Franklin et al., 2001).

Investigations of commercialization activities at universities have tended to concentrate on describing infrastructural reforms and institutional innovations that promote a culture of entrepreneurship within the institution (Klofsten and Jones-Evans, 2000). In order to stimulate commercialization of university

knowledge, entrepreneurial behavior should be promoted not only by practical and organizational arrangements but also by motivating staff and students (Henrekson and Rosenberg, 2001). Jensen and Thursby (2001:241) found that most licenses from US universities comprise technologies that "...are so embryonic that additional effort in development by the inventor is required for a reasonable chance of commercial success". Hence, commercialization of university research is predominantly dependent on individuals and cannot be made a routine task. Reitan (1997) concluded that researchers involved in commercialization need to perceive it both as a desirable and a manageable activity. This perception is influenced by factors such as work experience from industry and training in business administration and entrepreneurship.

Entrepreneurship seems in many cases to be a driving force in the process of commercializing university knowledge. Klofsten and Jones-Evans (2000) suggest that three basic activities for stimulating entrepreneurship should be found at a university: 1) the creation and maintenance of an enterprising culture on the whole at the university, 2) separate courses in entrepreneurship and, 3) specific training programs for individuals who wish to start their own enterprise.

A range of initiatives have been set up to commercialize university knowledge. Many universities, especially in the US, have established offices for patenting and licensing, but very few of these have succeeded in creating a significant income. Only the universities with the highest academic prestige have managed to get multi-million dollars of income from patenting. In fact, a clear policy recommendation from recent studies is that countries should support 'excellent' science, because 'mediocre' or 'poor' science leads neither to new academic knowledge nor to industrial innovation (Fairweather, 1990; Hicks et al., 2000; Salter and Martin, 2001).

A common measure to support new ventures through their first critical years is an incubator facility, where office space and forms of other physical and immaterial support are provided. Mian (1996) found that university technology business incubators added value to their tenant firms, specifically through university related inputs such as university image, laboratories and equipment, and student employees.

Access to seed- or venture capital is important when endeavoring to foster successful spin-off companies. Seed capital is provided at a very early stage, often in order to fund the development of the idea in the period before sales are established. Venture capital is usually provided during the first years of development and growth of a new start-up company, before capital can be provided through the stock market. The involvement of venture capital provides money as well as management support based on marketing, business and financing know-how (OECD, 2000b).

Commercialization of university knowledge involves economic utilization of intellectual property. Thus, IP ownership is essential and a widely discussed political issue. The U.S. example has been particularly influential. Concern with unclear rules and low commercialization rate led to the passage of the Bayh-Dole Act in 1980. This legislation passed the IPR from federal government to the universities, giving them a formal responsibility for turning fundamental research into practical use when possible, and at the same time an opportunity for extra income. The established practice has become to share the income between the researcher(s), the academic department, and the institution. The results of the Bayh-Dole Act are much debated. Empirical investigations conclude that the impact of the Act is probably not very large – neither on the number, nor quality of academic patenting (Mowery et al., 1999; Mowery et al., 2001; Mowery and Ziedonis, 2002; Sampat et al., 2003). The authors still question whether patents and exclusive licensure is the best way to maximize social returns of public R&D investments.

Ownership of intellectual property rights varies between countries. In the Nordic countries the scientific employees at universities (but not hospitals, research institutes etc.) have traditionally owned the property rights to their work. Denmark and Norway have recently changed legislation, granting the universities the intellectual ownership and giving them a formal responsibility for commercialization. Italy has recently made a legislative change in the opposite direction. All these changes are made as part of efforts to increase direct commercialization from university research. Thus, important framework conditions still remain highly national, which is also the case with, for example, seed funding.

There are few clear recipes on how to facilitate commercialization, but success does not seem to be accomplished through infrastructure and legislation alone. Chrisman et al. (1995:277) concluded that "supporting research and sending a message that faculty entrepreneurship will be valued is perhaps more important than the specific programs designed to foster economic development". The focus in this study, however, is on initiatives and policies to facilitate commercialization. Nevertheless, to be aware of the crucial role of entrepreneurial culture and dedicated persons is necessary when developing policies and initiatives. To make the commercialization process work effectively, many single mechanisms could be important, but there is a need for a complete system and a good interplay between the different initiatives to succeed.

4.2.3. Establishing an integrated commercialization system

Based on the increasing number of support mechanisms for commercialization at universities, it seems reasonable to view each of them as parts of a complete system. As emphasized by Clark (1998), from his investigation of entrepreneurial universities, organizational values and the structures and procedures ought not be treated independently.

A commercialization system may include elements ranging from motivation and education to initiatives to support specific commercialization projects such as innovation centers, incubators, patenting offices, and seed capital funds. In many cases, different actors are involved alone or in collaboration: the university itself, public agencies, non-governmental organizations, and private companies. Research institutes adjacent to the universities are often facing the same challenges, making room for cooperative efforts to support the commercialization process. A complex and challenging task is to create a situation where the different parts and actors involved cooperate and contribute towards the overall ambitions of successful commercialization.

Flexible policies are found to be important when universities aim to generate spin-off companies (Franklin et al., 2001). Also the level of actual support is found to be a key distinction, where research institutes with little support are associated with few spin-offs (Kassicieh et al., 1996). Smilor et al. (1990) found

in their survey that the university played an important or very important role in 56% of the spin-off company formations, a highly more significant role than any other organization. The most important role of the university was as a source of personnel.

The crucial role of public funding during a university spin-off firm's start-up and initial development stage is emphasized by Mustar (1997). University ownership makes the issue of commercialization of research a formal university task. Few studies have investigated the totality of commercialization support at universities.

4.2.4. Output from university commercialization

The contribution that universities make to economic development through commercialization of research rarely becomes visible in the form of direct revenues from these activities. Thus, as commercialization becomes a task, a challenge for the university is to measure and make visible the extent and results of this activity. Common output indicators are the number of licenses and spin-off companies. Still, it should be noted that in many departments, particularly in the technological disciplines, a large share of university R&D is carried out in close co-operation with industrial partners. The results are applied or commercialized by the firms involved. As such, licenses and spin-offs constitute only a part of the industrial application of university research and knowledge. Although these activities are of a smaller size or impact than traditional contract research, they are on the rise (Nowotny et al., 2004).

Several studies indicate that formation of university spin-off companies is likely to generate more revenue than licensing (Bray and Lee, 2000; Gregory and Sheahen, 1991; Rogers et al., 2001). There are many examples of highly successful companies that started as spin-offs from universities. These organizations not only imply a transfer of research results, but also more permanent links between publicly funded research organizations and the market, particularly at the regional level. Spin-offs are diverse: 'some are created by students, and others by university professors. Some are set up on basis of a university patent, while others are only based on the transfer of tacit knowledge.

Some spin-offs are high-growth projects and require large amounts of seed financing, whereas others are and will remain small' (OECD, 2000a:14).

There are three main reasons for a university to focus on creating new firms rather than collaborating with existing ones. First, companies that are created out of activities at the university will most often start out as partners who acknowledge the university's competence, financial situation, and special long-term mission. The companies may thus become important future contractors. Second, collaboration with existing industry can be highly influenced by the general economic cycle. In economically rough periods, attempts at creating new firms could be made relatively easier and receive public attention and support. Most countries would also be highly interested in universities contributing to new economic activity and jobs, particularly if the alternative is to enter a negative 'lock-in' relationship with existing industry, where the universities cease to be a source of more radically new knowledge and innovations. The third reason is the visibility of spin-off firms. The impact of collaborative interaction with existing industry in terms of job creation or innovative new products is difficult to measure. The establishment of new firms is a more visible output of university activity and may be used in the university struggle for public funding.

Optimistically, Roberts and Malone (1996:18) state that 'R&D organizations involved in generating new ventures can expect the spin-offs to generate the following advantages: positive influences on research and teaching, a more exciting atmosphere in the organization due to new career opportunities that are evident, and an enhanced reputation and role in the region'. Limited empirical evidence exists regarding the experiences made in such transformation processes – what are the key problems and how may they be handled by the university? In the empirical part of the study, the experiences made at four European universities are described and analyzed. All these universities are characterized with profiled ambitions and university management commitment to commercialize knowledge.

4.3. Methodology

This study is based on data collected at the following four universities, where engineering education, science, and technology programs are substantial.

Chalmers University of Technology (Chalmers)	Gothenburg, Sweden
Norwegian University of Science and Technology (NTNU)	Trondheim, Norway
University of Oulu	Oulu, Finland
Trinity College Dublin (TCD)	Dublin, Ireland

Focusing on four cases was appropriate for the goal of this study, which was to seek out best practices, personal experiences, good ideas, problems and possible solutions.

These universities were selected based on information about interesting commercialization and university-industry initiatives. The universities are located in small countries in the periphery of Europe and all four have some characteristics of interest to the present study: Chalmers is known to be the origin for many spin-off companies (Dahlstrand, 1999), TCD for their campus companies (Jones-Evans and Klofsten, 1998), Oulu University as being a part of the 'Oulu phenomenon' of successful industrial development in the region (Ahokangas and Räsänen, 1998), and NTNU that together with the adjacent research institute SINTEF have a dominant position in technological education and research in Norway. The national status is different, with NTNU and TCD as the number one technological university in their respective nations while Chalmers and the University of Oulu have a more regional mission.

The study was conducted in a manner similar to the process suggested by Eisenhardt (1989). The primary source of information for this paper was 65 personal semi-structured interviews conducted at the four universities by two or three interviewers between June and October 2000. People in various positions were interviewed, including: university managers, faculty and department leaders, researchers with successful relationships with industry, leaders and other individuals in those units which engage in activities such as contract research, continuing education, and commercialization. Also managers of nearby research institutes and commercialization units were interviewed.

Interviewees were selected on the basis of an overview of the formal organization and in co-operation with well informed persons at each university.

Table 4.1: Number of personal interviews

	Chalmers	NTNU	Oulu U	TCD
Scientific employees	5	6	5	4
Administration, management	6	6	3	4
Internal organizations	5	3	3	3
External organizations	2	4	5	2
Total (65)	18	19	16	12

Those interviewed contributed with large numbers of brochures and other written material. In addition, some information was gathered through other secondary sources like books, articles, and websites relating to national, regional and university specific issues. For each university, a case report was written on the basis of collected data and other secondary sources. These reports were checked for errors and revised by a contact person at each university.

4.4. Empirical setting – the four universities and commercialization

4.4.1. Chalmers University of Technology

Chalmers University of Technology is located in Gothenburg, the second largest city in Sweden with around half a million inhabitants. Gothenburg is the capital of a region with a strong industrial base. Established in 1829, Chalmers is the second largest of the six technical universities in Sweden, comprising 8000 students and 2500 staff. Chalmers' turnover is approximately EUR 220 million per year, more than two-thirds of which is related to research. Almost half of the funding comes from the Ministry of Education, while other public and foundation money constitutes about one-third. Direct income from industry is reportedly nine percent of the total budget.

The strategic vision of Chalmers is to be regarded one of the ten best technical universities in Europe, and the best in industry co-operation. A vice-rector for

external activity has recently been appointed. Chalmers has several units designed to reinforce industrial collaboration and commercialization. The structure of these organizations has to a large extent grown out of individual initiatives as opposed to having been set up as part of a planned strategy.

Located on campus is Chalmers Science Park, comprising a number of company R&D labs and various university bodies involved in the interaction with industry. According to information material, several hundred spin-off companies have emanated from Chalmers and employ more than 4000 people. Sources at Chalmers estimate that 15 knowledge-based companies are established every year as a result of some type of university activity, student companies included, however, the spin-off companies with the greatest potential emanate from long-term research projects. The Gothenburg region has many large technology companies, that creates a market for new technology and spin-off companies from Chalmers.

4.4.2. Norwegian University of Science and Technology (NTNU)

As its name indicates, NTNU is the national centre for education and research within the natural sciences and technology fields. NTNU has traditions back from the Norwegian Institute of Technology (NTH) established in 1910. Trondheim is the third largest town in Norway with approximately 150 000 inhabitants. Comprising 19 000 students and 3000 employees, NTNU is the second largest university in Norway and the only one with a major technological focus. The total income is EUR 281 million, of which 83 percent is public funding. In addition to NTNU, the technological research institute SINTEF, with 1 800 employees, is located in Trondheim.

The activity at NTNU and SINTEF has resulted in the creation of about 120 spin-off companies over the last 20 years, most of them established either in the mid-eighties or in recent years. The focus on commercialization activities has increased, and twenty new companies were formed in 1999 and thirteen in 2000. NTNU and SINTEF are the major shareholders in a commercialization unit which provides business advisory services, incubation space, and capital. A research group at NTNU conducts research and provides courses in entrepreneurship, and is also involved in business development projects.

Recently, NTNU has taken a more proactive role in commercialization and new venture creation. NTNU's management has adopted an aspiring strategic plan regarding entrepreneurship and innovation. This plan includes new initiatives for teaching, research, incentives, and infrastructure, as well as changes in rules and regulations aimed at stimulating the commercialization of research.

4.4.3. University of Oulu

The University of Oulu was established in 1958, primarily with regional intentions. The university is considered a success in terms of student recruitment and participation in regional development. It educates roughly ten percent of the Finnish student population, and about three-quarters of them come from within the region. The University of Oulu has about 13 000 students and 3 200 employees mainly within technology, medicine, and the social sciences. Basic state funding of the University of Oulu amounted to EUR 104 million in 1999. External funding totaled EUR 48 million, originating from the following main sources: Finnish research councils (14.9), Finnish industry (7.2), and the EU (4.5).

The university has strong regional ties due to close co-operation with local authorities, research institutes and industry. During the last decades, when the 'old industry' faded, new businesses within the information and telecom industry, with Nokia in front, were established. There are now about 12 000 employees in these industries locally, and the number is increasing. In 1982, the first science park in the Nordic countries, Technopolis, was established close to the university campus. Today there are more than 150 companies employing approximately 3500 persons on the 107 000 m^2 premises. Most of the companies operate within telecommunications, information technology, and electronics. Due to Technopolis' success, a new science park in the area of medicine and biotechnology, Medipolis, was formed on the Faculty of Medicine campus in 1992. Medipolis has about 60 companies and 500 employees, but is considered to be in an early phase of development.

The development in the Oulu region has become recognized world-wide and is promoted as the 'Oulu-phenomenon'. The University of Oulu has played an

active part in this development and has been an important actor in forming local industry that later would become important collaborative partners for the university. Interviewed personnel at the University of Oulu, estimate that 10-20 knowledge-based companies are established from the university each year. Many of these companies are small software companies, often established by students, which then subcontract with Nokia.

4.4.4. Trinity College Dublin (TCD)

TCD is one of three universities in Ireland's capital, and was established in 1592. TCD is the most prestigious educational institution in Ireland with more than five times as many applicants as available positions for students. Traditionally, the College has been a preferred employer among skilled Irish scientists. The total budget is EUR 112 million where national public funding accounts for 77 percent, and EU funded projects constitute about five percent.

TCD has in recent years become more focused on external relations and research. A Business and Industry Committee has been set up and a Dean of Research is appointed. The university has also directed some internal resources to research and innovation; a difficult feat because the Irish government did not contribute significantly with research funding until the late 1990s. TCD has expanded its facilities considerably in recent years, largely depending on private donations. In 1999, the College purchased 20 000m^2 premises nearby campus. The vision is to develop an Enterprise Centre with both spin-off companies and other companies of relevance to the research activities at TCD.

TCD has actively supported the creation of spin-off companies through the campus company initiative, but is very selective about what companies they support. On average, three spin-off companies from TCD become campus companies each year. So far, the survival rate has been remarkably high, with a reported failure rate of one in ten. . The Innovation Centre at TCD is regularly visited from all around the world and claimed to be seen internationally as a model of its kind. A total of 43 campus companies have been incubated from 1985 to 2001, contributing to the development of an indigenous knowledge-based industrial sector.

4.4.5. Data comparison

Direct comparison of the examined universities is difficult, because both internal features and contextual environment varies a lot. Chalmers is exclusively an engineering school, while the other three offer a wider range of courses and degrees. There are also significant differences in the funding structure, especially pertaining to the financing of research. At all four universities, public money in the form of block grant and some research funds on competitive basis constitute the bulk of their budget. Funds from industry are likely affected by the particular regional and national industrial structures. In addition, the "competition" from other universities and research institutes seems to differ between the universities in this study. Unfortunately, few statistical figures were available and the background material for the available statistics was highly varying. Thus, any attempt to compare economic variables between the institutions is dubious, and outside the scope of this study.

The two main tangible outputs from commercialization of university knowledge are spin-off companies and licenses. It is difficult to draw comparisons between different nations and universities as to the extent of spin-offs, because no common definition of a spin-off exists. This was also the case for the universities in our study, were e.g. TCD had a very strict definition of their campus companies compared to the spin-offs from Chalmers or NTNU. Another problem is that many of the universities do not record the number of spin-off companies formed as a direct or indirect result of university activity. University of Oulu has no official statistics, and the numbers from NTNU are partial, but still used to promote the university's active role.

Despite different internal and external conditions, the challenges related to commercialization and the new venture generation remain much the same at the four universities. There are strong links to industry, with a number of research centers and science parks related to all four universities. The focus on and support for commercialization have increased in recent years, and all four can show to some success cases in this respect. All seem to have increased their internal commercialization efforts ahead of national policy initiatives like funding mechanisms and legislative changes.

4.5. Case presentation and discussion

In the next sections, case evidence is presented structurally in terms of our key research topics; the changing role of the universities, the initiatives and policies, the overall system, and the output from commercialization activities.

4.5.1. Increased commercialization, but "soft" focus

The four universities in this study undoubtedly have long traditions with commercialization of research through close ties with industry. The establishment of new businesses based on university research is not a new phenomenon, although limited in numbers. The support structure aiming to promote commercialization is relatively young, however, with many initiatives established less than a decade ago. The increase of support initiatives probably reflects a change in both public and university policies, recognizing commercialization as a valuable activity. Still, the initiatives are mainly set up to support individuals and projects already in process, while few measures are taken to motivate and stimulate the creation of new projects within the universities. A somewhat distant relation to commercialization activities was especially evident at NTNU and University of Oulu, where the first initiatives to support commercialization projects from the university were established outside campus in collaboration with public agencies. Commercialization seems, however, to be increasingly integrated as a university task, as more initiatives are set up, and the universities take a more active role also in Oulu and at NTNU.

We heard few complaints about problems between commercialization activities and more traditional university activities. Informants at all universities said that the issue of academic freedom and conflicts between commercialization and other activities should be small if some rules of thumb were applied – indicating a "soft" emphasis on commercialization. First, commercialization should be a voluntary activity for faculty; it should be stimulated, not obligatory. Second, the individual researcher should be free to publish and use results for further research. Third, commercialization should not displace the traditional university activities. This will create negative attitudes and a risk of undermining the basic requirements for successful commercialization, like high quality research.

Many argued that high quality research is a prerequisite for successful commercialization. By increasing commercial activity, the university rather expands than changes its activity. Even if there was some concern, especially about long-term perspectives and academic freedom, it seems clear that universities see advantages and are willing to respond to requests for a more direct contribution to the economy. The main concern was how to organize this activity in a manner that has a positive rather than a negative effect on teaching and research while at the same time being successful from a business perspective.

4.5.2. Initiatives and policies

To facilitate commercialization of university knowledge, initiatives to motivate people to engage in such activity, and initiatives to support actual projects such as new spin-off ventures have been created. In addition, university policies affecting the commercialization process are important, and intellectual property (IP) issues are frequently debated.

The most comprehensive initiatives to motivate individuals to start new ventures found in this study were entrepreneurship education programs, mainly aimed at students. One of these is Chalmers School of Entrepreneurship (CE), a one and a half year program which brings together students, real-life innovation projects, and teachers. CE focuses on educating entrepreneurs, a task described as 'both artistic and academic in nature'. The idea is to educate persons to fill the gap between inventors and traditional managers. Evaluations indicate that 131 new positions have been created in 12 companies started by the students since 1997.

At NTNU, the Entrepreneurship and Innovation Group (GREI), is conducting teaching and research. GREI arranges the New Venture Acceleration Program where groups of four students, together with an entrepreneur, make a business plan under the guidance of an experienced supervisor. In the period 1993 – 2000, 170 business plans have been developed, and evaluations estimate that more than half the projects become actual businesses. The University of Oulu offers a half-year study program in entrepreneurship averaging 30 participants. The estimate is that 10-20% of the students start their own company. Advice is also available to other students with business ideas.

In addition to having entrepreneurship as a part of their study, we also found an initiative set up by the students themselves. Start NTNU is a student organization at NTNU aiming at motivating, advising, and supporting fellow students who are interested in entrepreneurship and innovation. Start NTNU was established in March 1999, and has developed several activities including business-plan competitions and networking arenas. Several students have started their own company, and the student organization is also pushing the university and faculty to become more engaged in commercialization activities.

The business plan competition Venture Cup in 1999 received about 200 contributions in Western Sweden, leading to about 15 new businesses. Venture Cup is also arranged in Norway with a similar success. A large share of the participants is university students, and some are researchers. According to several informants, the number of students involved in entrepreneurial activity is increasing and constitutes a noteworthy part of university spin-offs. Still, the most successful commercializations are reportedly based on long-term research. Also, some of the projects in the above described programs at Chalmers and NTNU are research based ideas, where the students constitute a valuable resource in commercializing the ideas as a part of their training. However, there seem to be few direct initiatives to motivate the academic staff.

We found a number of initiatives both in and around the university aimed to support specific commercialization projects based on university knowledge. These range from advisory service and practical support to seed and venture capital.

Chalmers Innovation is a university owned foundation with four employees that aims to help technology-based spin-offs in their first critical years. This is accomplished by providing expertise, establishing contact with risk capital, and by offering office space. Chalmers Innovation also operates a public seed-capital arrangement in Western Sweden that provides funding for business development from idea to prototype. Further, Chalmers Innovation owns and runs the Stena Center, an incubator of 4000 m^2 on campus. Twenty companies are located in the centre, where they are offered services and infrastructure in addition to

consulting and a network of expertise. The tenants in the incubator have to pay rent and give up a five percent equity share to Chalmers Innovation.

The commercialization company OuluTech was established in 1994 to support new knowledge-based companies in the region with patenting, marketing, technical advice, negotiations, financing etc. OuluTech is owned by the University of Oulu, Technopolis and the Finnish National Fund for Research and Development. OuluTech administrates considerable public funds on project basis, but needs to generate income from the services it offers the entrepreneurs. Occasionally, equity is taken in the supported companies. OuluTech has been involved in 120 projects and 19 start-ups from 1994 to 1999. There is no incubator on the university campus, but in some cases start-up companies get premises at the relevant department. For the next stage, the companies often move to the science parks (Technopolis or Medipolis) where premises for new ventures are available.

The University of Oulu has increased the internal focus on generating spin-off companies. An innovation strategy was outlined in 1999, which the internal unit Learning and Research Service is responsible for carrying out. The goals are to motivate the researchers to commercialize and simultaneously to support the basic research of the university. By strengthening the internal competence, the University aims to give impartial advice and support to students and staff in commercialization issues.

SINTEF, the research institute nearby NTNU, has its own office, SINVENT, for handling commercialization of research. Prior to 1994, the scientific staff at NTNU frequently navigated the licensing process with assistance from SINVENT, who then took possession of the IPR. In 1994 the limited company LEN was established with NTNU and SINTEF as main shareholders. LEN offers seed capital, consulting and physical infrastructure, evaluates 120 – 150 new business ideas annually, and filed 26 patent applications in 1999. LEN has been involved in establishing 30 companies in the period 1995 – 2000 and the inventor must give up some ownership to LEN, based on negotiations in each case. A large part of LEN's activity is financed through the Research Council of Norway. This covers free advisory services and a share of the entrepreneur's office space costs. In addition LEN gets a bonus for each established company,

which ranges from EUR 6000 to 50 000 depending on the size and potential of the new company. As with OuluTech, there have been some questions about LEN's mixed role providing free public services to entrepreneurs while assuming a fiscal interest in many of the same companies.

At NTNU, an incubator was set up on campus in 2001, where 1000 m^2 premises including office infrastructure are available for entrepreneurs and early-stage start-up companies. In addition, a handful of other incubators in Trondheim offer space and a varying range of infrastructure to start-up companies. Most of the incubators have been set up recently.

At TCD an innovation centre was started in 1986, currently housing nine companies with an average of five employees. In addition, a couple of start-up desks are available for people writing business plans. To be accepted as a tenant, entrepreneurs present a business plan to the Business and Industry Committee at TCD for approval. Around half of the plans are rejected or usually returned with some encouragement for further work. 43 plans have been accepted since 1986. In addition to having a viable business concept, an absolute condition is that the company operates within a field relevant to the university research. Usually, the companies move off campus after about three years. A campus company has to give 15% of its shares to the university. If there are specific intellectual property rights belonging to the university a royalty of 2% of net sales is charged. The rent at the Innovation Centre is above market rate, and the concept is described by the director as a 'hard wall' innovation centre. Still, it is very attractive to the tenants; companies that have been asked to leave the Centre have all resisted. According to the staff, the centre 'provides a link to the kind of people the companies need contact with'. It is seen as important for the university to be somewhat involved in the operation of the campus companies, because the companies benefit from knowing that the university is behind their decisions.

The Innovation Centre operates in close co-operation with the Dublin Business Innovation Centre (Dublin BIC) which was established in 1987 with support from public and private sources. Since 1988, Dublin BIC has assisted 240 start-up companies through their first critical years. A campus company program at the three Dublin universities develops about 15 ideas annually, resulting in about 5 new companies each year. According to the Dublin BIC management, the time

it takes for many of the ideas from the universities to become a company can be long, too long to be of interest for most private investors. The co-operation between Dublin BIC and TCD is judged to have filled this gap quite successfully.

It is clear that a considerable effort is made to build a commercialization system to support the formation of spin-off companies in or around all four universities. Another common feature is the close cooperation with other organizations, especially with public agencies for funding of the initiatives. Differences are seen in how TCD and Chalmers integrates the commercialization activity into their regular operations and appear to have more initiative in this respect than University of Oulu and NTNU who rely more on services which to a large extent are provided off-campus and initiated/funded externally.

We found considerably more support aimed at creating spin-off companies than at supporting the process of licensing, reflecting perhaps a particular European (or non-U.S.) focus. Although all universities had experiences with licensing, only one initiative was dedicated to this task. Situated at Chalmers is the limited company Forskarpatent (Technology Marketing and Licensing Partner of Western Sweden). The company was formed in 1996 with the mission to contribute to the increased commercial utilization of new technology from the universities in Western Sweden. This is accomplished through a model of operation wherein Forskarpatent creates new companies based on university patents. It is said to be much easier to sell a fully operating company than selling a patent. Forskarpatent approaches researchers who have patented a technology, but do not themselves have an interest in starting a company. Forskarpatent can in some cases take on the role as entrepreneur. Then the IPR is bought from the researcher for EUR 3000, and if the commercialization succeeds, any profit is split 50/50 between the inventor and Forskarpatent. Interestingly, the only licensing partner found in this study thus had adopted a strategy for creating spin-off companies rather than selling licenses.

The availability of seed and venture capital was frequently mentioned as a major obstacle in the development of new companies, and measures have been taken by both universities and public agencies. Chalmersinvest is a university-owned seed capital fund investing in technology-based companies in Gothenburg,

mainly spin-off companies from Chalmers. Chalmersinvest offers capital, knowledge, contacts, board experience, connections to venture capitalists and legitimacy. Its two employees try to identify high potential companies at an early stage. Good access to networks within the university departments is described as a main asset of the fund. Such networks are important both to gain access to ideas, and for using competence at the university to evaluate ideas. In addition, Chalmers is part owner in a venture-capital company that invests in the subsequent growth phase. This fund has a capital base of EUR 69 million.

At TCD there is also a campus company venture fund of EUR 7.5 million set up by the university and the government. This fund has, according to interviewed personnel at TCD, not yet been successful when it comes to supporting campus-generated ventures. However, the cooperation partner Dublin BIC started the first seed capital fund in Ireland in 1991 with EUR 1 million. The value of this fund is bigger today. Now there are about 15 seed capital funds available in Ireland, half of which being financed by government. Dublin BIC manages about 10% of this money through a separate company. It is considered important to separate the consulting and funding functions so that people know whom they are dealing with.

LEN, the commercialization company at NTNU, operates a seed-capital fund of more than EUR 13 million. The commercialization company OuluTech also makes minor investments in start-up companies. In addition, other venture-capital funds operate in the region of all universities. We see the same pattern when it comes to seed and venture capital as with other support initiatives. Chalmers and TCD are more initiators, setting up their own funds, while NTNU and University of Oulu are associated with many of the same initiatives, but with a more 'arms-length' relation.

In addition to specific initiatives to commercialize university research, university policies may influence the commercialization process. As mentioned, the national intellectual property rights (IPR) legislation differs. Employees at universities and colleges in Norway, Finland, and Sweden own the IPR of their work, while in Ireland the university owns the IPR generated by its employees. Subsequent to this study, however, the legislation in Norway changed, giving IPR ownership to the universities from 2003.

TCD seeks a share of any IP created at the university by claiming ownership of their employees' work, with the exception of authors' copyright on books. The policy is to give the researcher a high share if the commercialization effort yields modest revenue; while the university keeps a higher share if the revenue is high. A fixed scale determines how revenue is split, where one inventor gets 33%, 2-3 inventors get 40%, and four or more inventors will get 45%. Software is treated differently because it is very difficult to trace; the inventor gets about 2/3 and the university 1/3. TCD does not decide whether an invention should be patented, however, and the researcher is free to publish any work. According to staff, this generates more respect for the endeavors to protect IPR at the university. The trend is that the revenue from sale of IPR increases at TCD, but this varies from year to year. Approximately half of the income from the sale of IPR comes from abroad, and a significant share of the other half is from spin-off companies. The experience from commercializing inventions is that the ownership must be clear and unambiguous. Industry has become aware of TCD's policy and will not use university work without clarifying the IPR issue with TCD.

The University of Oulu has increased its focus on patenting and licensing in recent years, which is linked to its increasing internationalization. Foreign companies are said to be very eager to protect their IPR, which in turn forces Finnish companies and universities to do the same. The University of Oulu maintains internal guidelines for handling IPR. If the IPR from a university research project is transferred to a company, the expenditure for the research that led to the creation of this IPR has to be reimbursed by the company. The university policies for IPR differ depending on the project's source of funding. Research supported by foundations, university basic funds, or the Academy of Finland is owned by the researcher. IPR from projects funded by EU or a TEKES technology program is owned by the university. The freedom to publish and to make use of the results in further research is indisputable.

Sources from Chalmers state that patents and licenses are not a stable source of income. Chalmers still wants to be involved in this activity because it is said to be good 'political marketing'. The total revenues from patents are perceived as uncertain because of the high costs of applying for and maintaining a patent.

Patents and licenses have not received much attention from NTNU centrally, but individual inventors, often in cooperation with a commercialization unit, deal with the issue.

Many people, and especially respondents from the University of Oulu and TCD, emphasized that it is critical to have clear internal directions and external contracts in order to avoid conflicts of interest between researchers, the university, and external companies. This seemed less of a theme at the two other universities. To let the researcher receive a significant share of revenue emanating from their work is also considered to be important. This makes commercialization attractive and encourages personal involvement in the process.

It was pointed out that IPR and patenting involve difficult issues because they represent a potentially substantial source of income, while at the same time being liable to constitute a waste of time and money. Value is only created when a product starts to earn revenue or the IPR can be sold. As one interviewee stated, 'It is not wise to file a patent just to get your name on it. The main issues are the ownership of IPR, how to protect it, how to defend it and how to deal with conflicts'. The university personnel we interviewed all seem to agree that it is difficult to generate substantial income from patents, and that it is expensive to hold patents. Still, patents occasionally provide substantial income to the university.

At all universities it was reported that the opportunity for additional income for faculty is important in order to keep skilled people, especially those with a business orientation. University salaries cannot compete with those of other sectors, but freedom and some extra income makes the university an attractive employer. The 'one-day-a-week' rule where faculty members can do consulting and other personal business seems to be at least informally accepted at all institutions. This is provided that the academic duties are sufficiently carried out and that ownership regulations are followed.

4.5.3. The university commercialization system

As reported in the previous section, we found a range of initiatives to motivate, educate, and to support commercialization projects. These initiatives do not operate in isolation, but are parts of a totality which in interaction determines how the total system for commercialization of university research works.

All the universities except TCD had courses and initiatives aiming to increase student motivation and competence to establish new firms. TCD had a more targeted approach in supporting campus companies. Support for persons in the process of licensing and starting a new venture was in place at all four universities, but we found no initiatives to increase competence and motivation in general among its faculty.

The national IPR legislation affects how the universities' organize their activities. TCD has a clear policy, protecting its IP and thereby establishing acceptance for the university as an IPR owner. We found that both Chalmers and the University of Oulu attempt to support the individual inventor without claiming ownership of the IPR. The University of Oulu has settled on an aspiring innovation strategy and is building internal competence to support staff in IPR issues. Clarified IPR is important, but university ownership or not seems to be of less relevance. The main issue is to give the inventor incentives to develop it commercially and to have competence and awareness of the importance of IPR protection present early in the process. One interviewee claimed, 'Without the necessary competence or capacity to support commercialization, university ownership of IPR will make it harder for the scientific staff interested in spin-offs or licensing'.

An opinion poll at TCD in 1992 showed that more than half of the academic staff wanted to be associated with the campus companies, even though the Innovation Centre works with only a small percentage of the employees. One reason for the pervasive approval amongst university personnel might be that a share of the earned royalties goes to research areas in the university with limited possibilities to commercialize their work. Also the peer system that approves or rejects new campus companies assures a certain commitment from the university to each new company. Behind the peer review is an extensive process of

informal interaction and information gathering about people, research groups, and professional activities.

At Chalmers there are a number of entities to support external relations and commercialization activities. At first sight this seems chaotic, but we were told that the initiatives have emerged out of personal initiatives, now constituting a flexible system covering the different phases of the commercialization process. At NTNU, many commercialization activities seem to have emerged from individuals and research groups at the university. The research group within the field of entrepreneurship has also been active in practical work, thus constituting a resource center and initiator of many initiatives. Formally, NTNU has relied on external units to take the responsibility for the commercialization process.

The IPR issue has much attention in two of the universities – the basic requirement leading to success seems to be awareness of the importance of individual employee motivation. Without such motivation among faculty and "would be" entrepreneurs, successful university commercialization in terms of spin-offs or licences/patents might be almost impossible.

There were many different initiatives to promote commercialization at the universities in the study. A majority of these have grown out of personal initiatives and their success depending on the work of highly committed persons. Thus, it appears difficult to launch initiatives without connection to dedicated individuals (often representing different departments, units etc.). In Table 4.2 we have presented an overview of the commercialization activities observed at the six universities in this study.

Table 4.2: Overview of commercialization initiatives and policies

Initiative:	Chalmers	NTNU	Oulu U	TCD
IPR ownership	Scientific employee	Scientific employee	Scientific employee	University
Entrepreneurship education	Chalmers School of entrepreneursh.	Undergrad. to PhD courses	Half year study program	No
Business plan development program and advisory service	Chalmers Innovation	Entrepreneursh. and Innovation Group	Learning and Research Services	Some service in on-campus incubator
Student organization		Start NTNU		
Commercialization services on campus	Chalmers Innovation/ Forskarpatent	No	Learning & Research Service	Innovation Services
External service provider for commercialization		Leiv Eiriksson Nyfotek (LEN)	OuluTech	Dublin BIC
University on campus incubator	Stena Senter	Gløshaugen Innovation Centre	Could be space at departments	Innovation Centre
Outside incubators situated in town	Yes	Yes	Yes	Yes
University controlled seed-capital fund	Chalmersinvest	No	No	Yes
Outside seed-capital	Yes	Yes	Yes	Yes
University legal shares in spin-offs/licenses	No	No (changed in 2002)	No, some exceptions	Yes, substantial income
Official Incentives for commercialization				Individual and dept. get income

Looking at the commercialization systems, we make two striking observations: First, the numbers of actors involved is large, partly with interfering and unclear roles. Second, some of these elements are owned fully by the university, some being partly owned, some entirely private and some being owned (partly of fully) by other public actors. In addition, there are some located on campus, while others are located near the campus. Making the situation even more complex, these actors partly need to generate income – for example giving advice of commercialization strategy while aiming at equity share – and might be controlling resources needed by the entrepreneur. Others are more "administrators" of public funds. For the individual entrepreneur, this might lead to uncertainty regarding motivation, the economic situation and advice imparity

during his contact with 'the commercialization system' in or next to the university.

None of the universities have any complete official statistics of the entire commercialization activities at the institution, even though each single unit does record its activity. As three of the universities in our study did not own the IP, inventors may choose other ways to commercialize than through the support initiatives provided, making the real activity larger than found in statistical material. Commercialization activities do, however, lead to a number of different outputs at the four universities.

In total, support and funding from national governments is obviously very important. The exception is perhaps TCD, which has been ahead of national agencies and been particularly eager to attain EU funds. The total commercialization system represents numerous boundary activities and linkages with public, private and corporate agents. Cooperation and common utilization and sharing of external resources were seen as important. Still, as commercialization is seen as closely related to core activities of teaching and basic research, the universities need to be in control of commercialization, especially as the activities move ever closer organizationally and physically.

4.5.4. Outputs and visibility

We found clear evidence that spin-off formation is a highly prioritized area for authorities at the national level. In turn, this leads to an increased effort amongst universities to promote spin-off formation and to make their innovations more visible. At Chalmers and at TCD, commercialization of knowledge has for many years received attention. Initiatives have been supported and control has been maintained by keeping commercialization activities inside the university organization. The University of Oulu has, through close co-operation with regional authorities and industry, played an important role in regional development. Still, the university has not until recently put any effort in promoting commercialization internally in the organization. The same is the case at NTNU, although single departments and individuals have been active.

Even if the focus on, and extent of commercialization have grown significantly in recent years, this is not a new activity at any of the case universities. Since 1960, over 250 direct spin-off companies have been generated from Chalmers (Dahlstrand, 1999). New companies have originated from NTNU departments for several decades. The University of Oulu is known to be a central contributor to the 'Oulu phenomenon' of new industrial development starting in the late 1960s. TCD has actively stimulated spin-off creation long before this became a 'hot' political issue in Ireland.

However, the trend is clear at all four universities; the commercialization activities and awareness are increasing at all levels in the organizations. Even if the degree of involvement, extent, and types of initiatives differ between the institutions, many general observations can be drawn. The universities seem to be quite eager to satisfy public expectation, which in turn generates goodwill from research councils and ministries of education and research (although commercialization is not formally a part of budget criteria). As a result, it seems ever more important to be able to show results from the university's activities, not only in number of students and scientific publications, but also via direct contributions to the national economy.

Thus, the challenge for the universities in responding to the increasing focus on new venture creation becomes twofold. Obviously, they respond by increasing such activity. In addition, there seems indeed to be a challenge in visualizing the ongoing activity. Despite the strong public focus on commercialization of university knowledge, the data found in this study are still the 'estimates' type rather than 'hard facts'. Even though many of the respondents are proud of the results they have achieved, and emphasize that larger economic benefits may only appear in the long run, there are few statistics and evaluations of the impact of commercialization activities (which was pointed out almost ten years ago, cf. Gulbrandsen, 1997). A major obstacle for assessing the impact of university initiatives to commercialize knowledge is that the outcomes occur at many levels, often in less quantifiable terms, and as good as always with a substantial time lag.

It must be emphasized that the commercialization effort at universities is more than a response to government expectations. In many cases, income from

commercialization constitutes important funding for research. Some of this is from licensing, but perhaps the largest share comes from spin-off companies. Spin-off companies constitute an important partner for research co-operation and funding. In addition, some of them contribute with significant donations to their university of origin. For example, in Ireland there are few industrial companies conducting advanced research. Until recently, the public funding for research in Ireland has been low. A motive for TCD to stimulate research-based spin-off firms is to create future co-operation partners for research. It was said that one third of income from industry cooperation came from TCD spin-off companies. We found a similar pattern in Oulu, especially with regards to medical technology and biotechnology. Compared to the other universities in this study, TCD is in a different situation; they also get income from equity and royalties.

To be involved in commercialization activities may be an alternative career path for university employees. At TCD it was said that most of the people at the university who want to set up a campus company are somewhat frustrated with their own situation. They cannot get research funding, get promoted, and they have a lot of energy, but no outlet to 'go further' with their career. The Innovation Centre has thus become an outlet for people to do things that are not possible in a traditional university context. In this way a broader range of activities is possible for university employees, making it easier both to retain and recruit personnel. Several informants also indicated that scientists with successful commercialization efforts very often are highly reputable within their field. At TCD, the Innovation Center's activity often provides researchers with an extra income, in some cases larger than their university salary. A significant incentive may be that royalties from patents for products where the R&D was carried out in Ireland are not subject to income tax.

Also patents and licenses attain an increasing focus on the universities in the study. Licenses seem to be a less common tool for commercialization than spin-offs at the case universities, contrary to the situation at many US universities. This may be due to different IPR regimes, patent laws and patent practices, and the lack of industrial costumers in the rather small countries represented in this study.

Relating to public policies, students with entrepreneurial knowledge, skills, and attitudes represent valuable output from a university. This is particularly evident when students commercialize their own ideas during or after their studies. In this respect, a university challenge is to educate and support students in their commercialization efforts. Another challenge is to integrate the general commercialization activity at the university in a way that could enrich the education rather than be a separate and perhaps interruptive activity. An interesting effort in this respect is Chalmers School of Entrepreneurship, where the students as a part of their study in some cases start new ventures based on inventions from university research.

Although government expectations and support for commercialization activities are high, none of the universities can prove any direct substantial impact on the economy from this activity. Anecdotal evidence implies that the benefits of including commercialization in the university activity are substantial both in a regional or national perspective, but also internally at the university. Thus government expectations might be too high with respect to direct yield from university commercialization, but in a wider and longer perspective the payoff may be ample. The long term payoff is also partly what motivates the universities, as commercialization is seen as a way to secure future research funding and a part of creating an exciting atmosphere attracting talented people.

4.6. Conclusions and implications

Undisputedly, universities of science and technology experience changes in their mission and activity. All four case universities have increased their commercialization activities and focus substantially the last two decades. This activity is not new to many university departments, but recent efforts from government authorities and university management have visualized and increased the activity.

We can perhaps separate between two 'waves' of commercialization. The first one mainly happened from the beginning of the 1980s. It can be recognized by the establishment of 'traditional' science parks, most often aimed at attracting advanced companies, and increased collaboration with existing industry reflected in more private funding for university research. The initiatives from

this first 'wave' have prevailed and can be observed at all cases in this study. These are often externally initiated.

The second wave, which has been the theme of this paper, accelerated around the last half of the 1990s. The second wave is distinguished from the first by a stronger focus on spin-offs and patenting/licensing rather than industry collaboration more generally, an increased involvement by students in commercialization, and ever-increasing perceived pressure when it comes to demonstrating the economic results of the university's activities. From our case studies we see that the pressure is not just related to new government policies for research and innovation, but also pressure from a new generation of students – conscious of the opportunities of entrepreneurship. This has resulted in processes of political and economic 'branding' of the university. Not all initiatives are based on pressure, however. Many actions may just as well be part of a strategy to make the university an even more important actor in the knowledge production system. The second wave is more integrated with basic research and teaching and with mechanisms on campus rather than close to campus.

Although some university students may have started spin-offs in earlier decades, the present volume and support structure (students helping other students write business plans, find venture capital etc.) seem new. Some respondents questioned the potential of these firms compared to those started on the basis of cutting edge research. This can be extended to a question about level of study – what are the differences (if any) between companies started by undergraduate students and those started by PhD students, for example. These issues require further investigation. Students starting companies could also be seen as part of their training, and thus the potential of their current start-up is of limited interest compared to their role and impact as future entrepreneurs through their whole working career.

Many earlier reports have focused on the problems of an increased university focus on entrepreneurial activities as related to the independence, orientation and autonomy of basic research and researchers. These problems are not very frequently mentioned at the case universities. One reason is perhaps that the right to publish scientifically is undisputable. Another reason may be that there

is little tension between commercialization and the traditional teaching and research activities. In fact, many pointed out that high quality research is a prerequisite for successful commercialization, and some also considered this relevant for teaching. This does not mean that the development is without problems. A recurring example in our cases, for instance in Oulu and Trondheim, is the conflict in commercialization units between acting as 'independent counselor' and acting as investor.

There is quite a large number of commercialization units, advisory organizations, incubators, innovation centers etc. At all four case universities, several such organizations – often quite small in size – compete for the favor of the professors with commercially interesting ideas. The majority of these organizations have a number of funding sources behind them representing government at various levels, public organizations like research councils, industry, and in most cases, the university itself. In total, all the universities now have a more or less full range of support mechanisms for entrepreneurship.

Differences can still be found in how large the commercialization units are and thus how much they are based on the activities of a few people only. There are different institutional strategies also in the cases where the legislation (e.g. related to IPR) is similar. We also see that institutional ownership of research results in practice means little if the competencies and mechanisms of commercialization are lacking. Although there are specialized mechanisms dealing with e.g. patenting and spin-offs, we see an increasingly blurred distinction between patenting/licensing and spin-offs. New companies are frequently formed based on one or several patents, in some cases after failed attempts at licensing to existing industry.

It can be claimed that the support structure, backed by mainly public funding, is the real risk-taker in commercialization projects. Neither the inventors nor the university contributes with substantial funding e.g. for patent applications or spin-off processes. A prerequisite to a successful transformation to an "entrepreneurial university" might be to get access to new funding (public seed capital, specialized programs) rather than being forced to redistribute basic research and teaching funds.

Although a positive attitude from the university leadership should be noted, this study confirms that most of the activities are initiated and run by one or a few dedicated and highly motivated persons. Behind all the support structure and mechanisms we find informal networks around these few key individuals. The importance of such persons in order to develop courses, study programs, incentives, advice services and incubators should be noted – as these individuals may have a significant impact on the ability of the universities to succeed in commercializing their knowledge.

Commercialization should be incorporated in the general activity to succeed. The overall challenge is how to find proper arrangements to link teaching, research and commercialization making the latter a positive contribution rather than a load on the others. The challenge is to motivate, create a culture and get interplay at all levels, using appropriate initiatives as tools to achieve this goal.

This study has examined four universities where natural science and technological disciplines constitute all or a major share of the activities. Other fields, like the humanities, may have limited possibilities for research commercialization, with some exceptions. Thus, increased focus on universities' contribution to industrial development measured e.g. in terms of new ventures created, may favor some institutions to others. Universities specializing in fields with high commercial potential, having tradition and prior experience with such activity, and are situated in regions with fertile ground for new venture creation may be in a separate class compared to other institutions. An interesting path for future studies would be to look at the extent and potential for commercialization of research at a broader spectrum of research institutions than analyzed in this study.

Finally, this study gives a brief overview of an ongoing process that are about to change the operation and mission of at least some universities. Whether the commercialization of research will be an integrated part of university activity in the future, or a marginal activity connected to some institutions, remains to bee seen.

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5. Paper 2 - Action-based entrepreneurship education

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5.1. Abstract

Innovativeness through creation of new companies and new business areas are seen as key factors to achieve economic goals at firm, regional, and national level. A restricting factor is the availability of competent individuals to manage projects and become entrepreneurs. Universities can address this need by increasing the motivation and competence of their graduates to become key persons in innovative and entrepreneurial activity. Entrepreneurship education has traditionally focused on teaching individuals, but many initiatives are increasingly becoming more action-oriented, emphasizing learning-by-doing. This paper presents a number of action-based activities at five Swedish universities. The cases show that entrepreneurship education focus less on teaching individuals in a classroom setting and more on learning-by-doing activities in a group setting and a network context. Several initiatives have multiple goals, such as educating entrepreneurs, establishing new ventures and commercializing university research. Implications for setting up an action-based entrepreneurship education program are provided.

Keywords: Entrepreneurship education, Start-up, University

5.2. Introduction

Entrepreneurship, through the creation of new ventures or taking place within existing firms, represents one of the major engines of economic growth. There seems to be an intimate relation between entrepreneurship and regional and local development (Malecki, 1997). Reynolds et al. (1994) found that high start-up rates is a necessary, although not sufficient, condition for economic growth. This has resulted in an explosion in the public and private initiatives to promote entrepreneurial activity, hoping to accelerate innovation, technology development and job creation (Reynolds et al., 2001). The public debate often focuses on R&D activity, public and industrial infrastructure, or seed- and venture capital as scarce factors to develop new economic activity. None of this would have much effect, however, without committed and competent persons to develop and manage new firms and new business activity.

Currently, universities are expected to play a new role in society, in addition to research and teaching, by applying a "third mission" of economic development (Etzkowitz et al., 2000). This development has been apparent at many US universities for decades, and is currently accelerating also in Europe (Rasmussen et al., 2006c). Universities can contribute to entrepreneurship both indirectly, through education of candidates, and directly by commercialisation of research and being the seedbed for new ventures. The flow of candidates, or "future innovators", constitutes a great potential and a responsibility for the universities to address the need for a more entrepreneurial workforce in general, and for highly qualified competence in this area. At the same time, the research conducted at universities constitutes a source of ideas and inventions with commercial potential that is far from being fully utilized at most institutions (McMullan and Melnyk, 1988).

The question whether it is possible to educate individuals to become entrepreneurs has been raised (Fiet, 2001b; Sexton and Upton, 1987). Numerous reports about successful programmes at single institutions, often measured in number of companies started, have lead to increased expectations. It is found that graduates with an entrepreneurship major are more likely to start new businesses and have stronger entrepreneurial intentions than other graduates (Kolvereid and Moen, 1997). As found by Peterman and Kennedy (2003), entrepreneurship education programmes can significantly change the entrepreneurial intentions of participants. Hence, in addition to the direct effects of entrepreneurship education programmes through new start-ups, the participants may repeat the entrepreneurial process many times during their entire working career, by starting new companies, new business areas in existing companies, run their businesses better, or by assisting other entrepreneurs.

The number of institutions offering, and the amount of resources put into entrepreneurship education programmes at universities is rapidly growing (Katz, 2003; Vesper and Gartner, 1997). This can be seen as recognition of the importance of entrepreneurship, and that this field needs professional education in line with other fields in business like management, marketing, or finance. Still, this field of education is in its infancy and there seems to be no common framework or agreed best practice for how to educate entrepreneurs (Brockhaus et al., 2001; Fiet, 2001b).

Although there is a high variation in topics taught, Laukkanen (2000) claims that the dominant pattern of education have been based on an individual-centred mindset. This individualistic entrepreneurship education strategy aims to give general education to individuals about how to become entrepreneurs. Laukkanen (2000) proceeds by suggesting a parallel strategy in entrepreneurship education; the business generation strategy, aiming to give specific training in setting up a business in a given context. This strategy seems to be in line with recent development in entrepreneurship education towards specific programmes where the establishment of an actual business is a part of the education (McMullan and Gillin, 1998).

The term entrepreneurship education can be interpreted in two ways; either learning about entrepreneurship as a phenomenon, or learning useful skills in order to become an entrepreneur. This paper focuses on how universities can educate successful entrepreneurs. This can be seen as a part of stimulating entrepreneurship in general. According to Klofsten (2000), there are three basic activities to stimulate entrepreneurship that should be found at a university. First, activities to create and maintain an enterprising culture on the whole at the university as an integrated part of all courses, research, and external activity. Second, to provide separate courses in entrepreneurship to students. Third, to offer specific training programmes for individuals who wish to start their own enterprise. As indicated by Klofsten (2000), these activities could beneficially be working together enriching each other.

The first activity might be the most important in order to succeed in the general task of creating entrepreneurial persons and commercialising university knowledge. The question of how to make an enterprising culture is difficult because it is a very comprehensive task and the concept itself is difficult to grasp. Thus, our focus in this study is on activities that more specifically aims to train graduates to become future entrepreneurs or improving the skills of existing entrepreneurs. Combinations are possible as there could be courses for students who are about to start their own enterprise.

In this paper we analyze initiatives to educate entrepreneurs at five Swedish universities in order to explore different approaches to entrepreneurship

education. Our aim is to find what lessons can be learned from these cases. Is there a best practice? In the following section a frame of reference for our analysis is presented. Next, our research design and the five cases are presented. Finally, the different approaches of entrepreneurship education are discussed based on the five cases and the corresponding role of the university in regional development.

5.3. Frame of reference

A dominant issue in entrepreneurship research has been the entrepreneur and what he or she does. Gartner (1988) argues that trait, or personality based approaches to explain entrepreneurship has been unfruitful and that behavioural approaches would be more productive perspectives. Processual and contextual issues have been added on, and Stevenson and Jarillo (1990:23) provide the following definition of entrepreneurship: "entrepreneurship is a process by which individuals –either on their own or inside organizations –pursue opportunities without regard to resources they currently control". Further, Bruyat and Julien (2001) argue that in order to understand entrepreneurship, the individual, the project, the environment and the links between them over time has to be in focus.

The role of opportunities (Gartner et al., 2003; Shane, 2003; Shane and Venkataraman, 2000) has been included in entrepreneurship research and many factors outside the individual is recognised as important for entrepreneurship. For instance the role of culture (Mueller and Thomas, 2000), teams (Kamm et al., 1990), networks (Burt, 2000; Grandi and Grimaldi, 2003), resources (Bergmann Lichtenstein and Brush, 2001), and environment conditions (Johannisson, 1990; Malecki, 1994), have come more into focus. Hence, entrepreneurship is seen as a complex process where the outcome is only partially dependent on the characteristics of the entrepreneur. As the identification of an entrepreneurial opportunity is a cognitive act (Gaglio and Katz, 2001; Shane, 2000), the individual is still considered to be the core element, whether it is as a sole entrepreneur, part of a team, or only during a part of the process.

The development in entrepreneurship research is also reflected in the development of entrepreneurship education. As stated by Swedberg (2000:278): "..the study of entrepreneurship has advanced quite a bit during the last ten-fifteen years, and that it today is possible to teach something that earlier many people thought not could be taught."

5.3.1. Entrepreneurship education

There has been a rapid growth in the number of universities offering entrepreneurship courses from just a few in 1970 to more than 400 in 1995 (Vesper and Gartner, 1997). An increasing number of universities offer more than one course, and study programmes of half a year or more is offered at many institutions. Reviews of entrepreneurship education programmes (Gorman et al., 1997) and courses (Fiet, 2001b) show that there is little uniformity and considerable diversity regarding objectives, philosophy, content, pedagogy, and outcomes.

The dominant pattern of education has been based on an individual centred mindset, with the aim of moulding single individuals to become entrepreneurs (Laukkanen, 2000). In short, the candidates receive knowledge and capabilities through a linear educational process, or what Gibb (1993) refers to as a didactic model. It is then expected that these individuals more likely will start new ventures after finishing their study. Although there is no reason to doubt the effectiveness of professional education programmes following this model, some critical remarks can be made (Laukkanen, 2000): First, the focus is on single individuals, and the role of teams, context, and business concepts are underplayed. Further, the belief that entrepreneurial capabilities are inborn rather than learned, might be overemphasised. Also, the programme may be too much generalising and too little contextualising, e.g. with little attention on selection and composition of the students.

The individual centred model reflects the traditional individual focus in the academic system. As argued by Etzkowitz (2003) there is currently a shift from an individualistic to a group focus in all three academic missions. Research groups have firm like qualities, especially when research funding is awarded on competitive basis. Education is not only focusing on individual students, but are

increasingly taking on the mission of shaping and training organizations before they leave the university, and firm formation from academic institutions has been systematised (Etzkowitz, 2002a). This might be an expansion of the individual centred model, or as observed by Etzkowitz (2003:112) "...although some persons may not be willing or able to become entrepreneurs individually; they are able to do so collectively..."

The traditional focus in entrepreneurship education is seen as inadequate (Gibb, 2002). As entrepreneurship is seen as the concrete enactment of new ventures, this calls for an action-oriented approach, and that it is important to stimulate the individual's action rationality (Johannisson et al., 1998). Johannisson et al. (1998) found that university training has an impact on students' action capability.

As an alternative to the individual focus, Laukkanen (2000) conceptualise the "business generation model" as an educational strategy for entrepreneurship education. Its aim is to foster the necessary conditions for new ventures and for the strategic expansion of regional SMEs: the emergence and fusion of viable business concepts, entrepreneurial actors, resources, and a munificent environment. In an educational setting the students should meet and internalise a realistic business concept from the outset. Further, they should be operationally involved in real business contexts. The educational process should be linked to resource bases in the business context and beyond (Laukkanen, 2000). A business generation model is addressing many aspects that seem overlooked in the more traditional individual entrepreneur model, like business concept, business context, networks, and team-skills.

An increased focus on the context and learning-by-doing implies a greater student involvement during the study. Involving the students in working on real business cases could range from case-based teaching, to involving the students in real start-ups (e.g: Erikson and Gjellan, 2003; Johannisson et al., 2001), and finally by letting the students start their own company. In addition to the degree of individual involvement from the students, the nature of the opportunity or business idea is important in entrepreneurship (Shane, 2003). The students could work on projects ranging from practical exercises which do not have any business potential, to real business projects with limited potential (e.g. regional

scope), and finally high potential global business ideas. The degree of student involvement, and opportunity or business idea potential is illustrated in Figure 5.1.

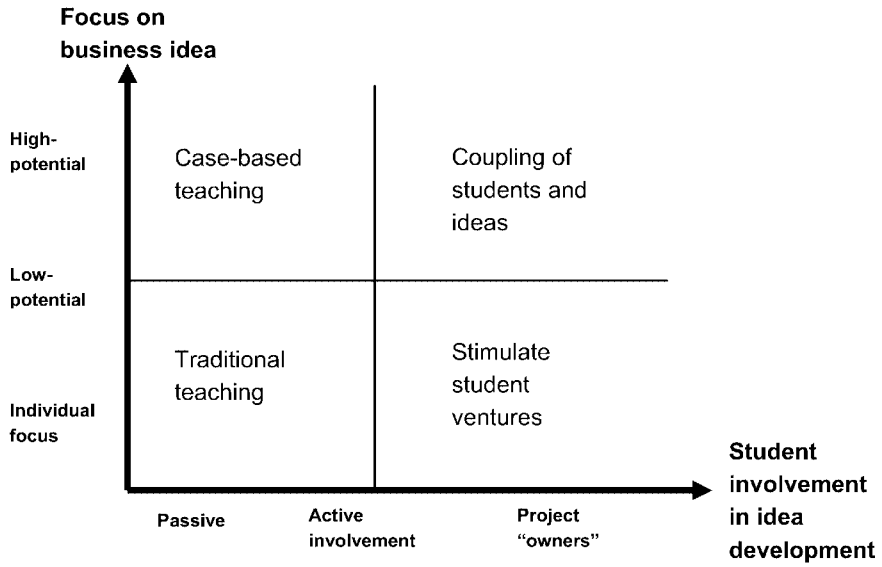

Figure 5.1: University strategies for entrepreneurship education

In the following we will compare initiatives at five universities with special emphasis on different implementations of the learning-by-doing approach by involving the students. We will also focus on the scope and potential of the projects, and the resources needed in order to set up the programme in its current context.

5.4. Method

In Sweden, the interest for entrepreneurship has been significantly growing during the 1990s. More professorships, new courses, and training programmes are clear evidences of this (Klofsten, 2000). Out of 70 academic programmes for entrepreneurship education in 1996, only 18 were established before 1990 (Johannisson et al., 1998). Also, a significant share of academic literature in this

field is written by Swedish researchers. Since the beginning of the 1990s there has been transformations in the Swedish university system towards more entrepreneurial institutions (Jacob et al., 2003). Thus, we concluded that Sweden would be a fruitful ground to investigate current trends and successful initiatives in entrepreneurship education. The study was conducted in a manner similar to the process suggested by Eisenhardt (1989). First, relevant issues for inquiry were defined, and a convenient sample of illustrative cases was selected among aknowledged Swedish entrepreneurship programmes. The investigation is based on data collected at the following five institutions in Sweden:

- Chalmers University of Technology, Gothenburg
- Jönköping International Business School, Jönköping
- Linköping University, Linköping
- Mälardalen University, Västerås/Eskilstuna
- School of Economics and Commercial Law at Gothenburg University, Gothenburg

Most information were gathered during a one day visit at each site during March and April 2002, with two researchers present. We conducted approximately 20 personal semi-structured interviews at the five universities. People in various positions were interviewed, including: managers, faculty, coordinators of entrepreneurship education programmes, and other individuals that engage in related activities such as incubator managers. Persons for interviews were selected on the basis of an overview of the formal organisation and in co-operation with well informed persons at each university. In addition, information was gathered through other secondary sources like books, reports, articles, and websites. By combining the different sources of data we wrote case descriptions about the context and the initiatives of entrepreneurship education at each case. From the issues emerging in the case descriptions, we were able to point out key themes during the data analysis.

5.5. Case presentations

This section contains an overview of entrepreneurship education at each of the five universities. Each case description have the same basic structure starting with a brief introduction about the institutional setting, followed by a description

of entrepreneurship education and business generation initiatives, and concluded by a short sum-up. The empirical findings are summarised in table 1.

5.5.1. Chalmers School of Entrepreneurship

Chalmers University of Technology in Gothenburg is the second largest technical university in Sweden with about 10 000 students, 2500 employees, and a strong focus on research. Chalmers has traditions for innovation support from about 1970, including an infrastructure for commercialization of research and a track record of 225 direct spin-offs as by 1998 (Jacob et al., 2003).

Chalmers School of Entrepreneurship (CE) began as a pilot project in 1996 aiming at commercialising research-based ideas, and at the same time educate students to become future entrepreneurs. This pilot has been continued and developed further towards its current form. CE recruits students from engineering, business, and design schools at a bachelor level. Each year 20-25 students are selected on the basis of comprehensive applications and interviews both by CE's staff and psychologists. About one third of the applicants are found qualified to participate in the one and a half year study program. The aim of the selection process is to identify students who are motivated and capable of becoming entrepreneurs.

The study is built around a real innovation project where groups of three students are establishing a new venture on the basis of a research-based idea. Many of the ideas are acquired from researchers at the Chalmers University. For an idea to be accepted, the inventor should be motivated to become a partner in the project group. Other criterions for an idea to be of interest to CE are that the intellectual property right issues are clear, that the idea has a high (global) potential, and that it is technically validated.

The students are provided with relevant courses, action-based projects, and after half a year they choose what team and what project to work with. A limited company is formed around each project and located in CE's incubator facilities. Experienced business people are involved as board members. The education is based on, and adjusted to, the challenges and needs of each company. The operating cost of CE is about one million EUR a year, funded by the university,

other public-, and private funds. Evaluations show that 12 new companies and 131 jobs were created by the first three classes from CE, which counted 45 students in all.

To sum up, the CE programme aims both at educating entrepreneurs and at establishing new businesses. The results are of interest in two ways. First, the students are fully involved as entrepreneurs in the start-up process, from idea selection, team composition, to venture formation and obtaining investors. This process gives a real experience of starting up. Second, the programme specializes in business ideas with a high (global) potential. The students get experience in setting up technology- and research-based firms, learning about the special requirements of such ventures. As an additional effect, a number of these start-ups would probably not been commercialised without this programme, as the students fill the role as entrepreneurs. The availability of high-potential ideas is scarce, however, and the resources put into such programme are substantial. Hence, this kind of programme can only be offered to a limited number of students. An initiative such as CE requires a setting with access to both ideas with commercial potential and sufficient resources. In addition backing from the leadership at the university is necessary, because the cross-disciplinary arrangement and pioneering pedagogy do not fit with the traditional norms of university education.

5.5.2. Jönköping International Business School (JIBS)

JIBS is a part of Jönköping University with a total of 6500 students and 600 staff within the schools of education and communication, engineering, and health science in addition to the Business School. JIBS was established in 1994 and has an international approach with focus on entrepreneurship and renewal in industry and commerce. The focus on entrepreneurship is apparent through a strong research activity in this field and a range of education and support initiatives.

All students at JIBS get an introductory course in entrepreneurship in the first semester, and there are a number of voluntary activities and events related to entrepreneurship throughout the study. In addition, there are a number of courses in entrepreneurship and related areas, but no defined study programme

or major. Rather than having extensive study programmes, the philosophy is to have entrepreneurship as an integrated part of all activity and to support entrepreneurial activity among the students. All students can have a personal mentor from a company in the region, and the university is flexible towards students running their own business when it comes to deadlines etc.

"Future enterprise" is a course available for all students at Jönköping University where teams of student can establish their own company in parallel with their study. The students get access to experienced mentors and relevant teaching activities during the study. Many activities are coordinated by Creative Center (CC), which is a non-profit organisation at the university. CC runs the Business Lab, a pre-incubator where persons get an environment to explore the potential of their ideas. The Business Lab contains office space, assembly rooms, creative rooms, and is the joint location for many activities. At the next floor there is an incubator for start-up firms. CC has assisted more than 200 start-ups during a five-year period.

One of CC's activities is the Summer-entrepreneur programme where projects that can be accomplished during the students' summer holiday are obtained from regional industry. Instead of being employed by the companies, the students have to start their own company and carry out the work as self-employed. Some advisory service is available during the summer. It is reported that both the employers and the students have positive experiences, and more than half the student companies carry on their business activity. The concept has been implemented at seven other locations in Sweden.

To sum up, the JIBS offer their students both traditional entrepreneurship courses and facilities for students who want to start their own business. Many students set up their own business in parallel with their study. Considerable resources such as mentors and incubator facilities are needed to organise such activity, and significant support is obtained from both the university and the local business community. Most activities are very action-oriented emphasising a high degree of student involvement, such as the Summer-entrepreneur programme, while requirements on the potential of the business ideas seem less prevalent. This allow for a high volume of activity and low threshold for students to participate.

5.5.3. CIE at Linköping University

Linköping University constitutes 3000 employees and 23 000 students within technological, humanity and medical studies. Centre for Innovation and Entrepreneurship (CIE) is a small network-based organisation, which have been in operation since 1993. CIE runs two initiatives for entrepreneurship education, the SMIL Entrepreneurship School (SMILES) and the Entrepreneurship Programme (ENP) (see: Klofsten, 2000). Linköping is known as a successful city in developing new technology- and knowledge-based ventures (Klofsten et al., 1999), and the people we interviewed emphasized the strong cooperative spirit among the actors in the local innovation system. CIE is a neutral actor operating in the early phases of new venture development.

SMILES offer a series of five university courses within technology- and knowledge-based entrepreneurship with both a theoretical and a practical focus. The courses are not a part of a study programme, but are offered as an elective to students and other persons with sufficient background. The courses are planned and carried out in cooperation with a regional network of SMEs (SMIL), enhancing the regional cohesion (Autio and Klofsten, 1998).

ENP is a programme for students, researchers, and other persons with their own business idea who are considering to, or are about to, start their own venture. The programme is built around making a business plan for the idea, and consists of 12 workshops combined with practical work during a four months period. Each idea is coupled with an experienced mentor and gets access to networks with other companies in the region. Usually there is arranged two ENP programmes in Linköping every year, each with 15-20 participating ideas. An evaluation shows that eight ENP programmes resulted in 80 businesses with about 800 employees (Klofsten, 2000). There is no fee to participate in the programme, as it is sponsored by regional and national public funds. The total cost of one programme is about 50 000 EUR, and participation in the ENP programme is compulsory for a start-up company to be accepted in the incubator at the local science park. The programme concept has also been implemented at several other locations in Sweden.

To sum up, the Linköping case have both traditional courses in entrepreneurship (SMILES) and programmes aimed directly towards individuals in the process of starting a new venture. Even with limited backing from the university and modest resources available, the initiative shows significant results in aiding new business generation. This is made possible through active use of mentors and by building networks between entrepreneurs and other companies in the region. By establishing groups of entrepreneurs facing the same challenges, both an inspiring milieu for the entrepreneurs are created, and it becomes easy to give specific advice on important issues facing the entrepreneurs. The initiatives in Linköping do not so much address the need for educating students to become entrepreneurs in the first place, but focus on supporting those who are in process of starting a new venture, and to include them in the regional business environment.

5.5.4. Mälardalen University

Mälardalen University is a young and expanding university with 13 000 students and 800 staff at two campuses. The local science park, Teknikbyn housing 120 companies, is active in stimulating entrepreneurship and has aided about 80 start-up companies in four years. Their most important initiative is the Kick Start programme, based on the same model, and assisted by, the ENP programme in Linköping.

At Mälardalen University there is an entrepreneurship education pilot offering a one-year extension programme to students that wants to specialise in this field. The Entrepreneur-school consists of courses in business development and practical commercialisation projects from industry, university, or in some cases the students' own projects. External funding counts for about 100 000 EUR annually. So far, the experience is that very few students apply to the one-year study. According to faculty, one reason might be that the students do not get any formal university degree from the programme. As such, this programme falls between two categories; being of no particular interest to students looking for a university degree, neither of any interest to persons in the process of starting their own company.

Another project connected to Mälardalen University is the Idelab (idea-lab), an initiative to stimulate idea-generation, idea-development and new business formation among the students. In 2001, Idelab were in contact with 248 ideas, whereof 68 were developed further, resulting in 35 new companies. Idelab has a staff of five, and an extensive network of mentors and they are located in two-floor premise centrally at one of the two university campuses. The ground floor is a flexible gathering area with meeting facilities, while first floor contains office space, creative rooms, etc. In these facilities, persons with an idea can work a few months to verify if the idea is feasible and find out whether they are motivated to start a business or not. Idelab arranges courses, lectures, meeting-points, and has a high profile at the university. There is no incubator facilities connected to the university, but companies started from the Idelab seem to find office space nearby the university campus and maintain contact with each other and the Idelab. Most funding comes directly from the government and altogether there is available about 400 000 EUR annually to run and build up the activity at Idelab.

To sum up, the Mälardalen University has extensive activities in order to stimulate students to start their own companies with a high volume of activity. The entrepreneurship education pilot suffers from limited commitment among the partners involved, and lack of integration with the existing structure of study programmes. Hence, the action-based initiatives and support are well-developed for students who want to explore entrepreneurial opportunities, having a low threshold when it comes to the potential of the business ideas explored. The academic initiatives for general and specialist education are, however, less developed.

5.5.5. School of Economics and Commercial Law at Gothenburg University

As a part of Gothenburg University, the School of Economics and Commercial Law comprises 7000 students and 300 staff. The school established an entrepreneurship education in 2001, partly on initiative from the students.

All students with a minimum of three years higher education can apply for a degree qualifying one-year programme. Based on a comprehensive application

and an interview, 15 students are selected each year. The study consists of courses paralleled with developing a real business idea. A number of ideas are obtained from researchers, inventors, or the students themselves. 12 ideas are investigated in a feasibility study before the students select the five ideas to be further developed by teams of three students. The inventor of the idea keeps the intellectual property rights. The teams get office space and access to a network of mentors within relevant fields like law, business consulting, and accounting. Most ideas are developed into an established business run by the inventor, the students, or both. Some extra personnel resources have been made available from the university, but running costs (rent etc.) are sponsored by public funds, and the programme is based on considerable voluntary efforts from private sources.

To sum up, this is primarily an entrepreneurship education with a strong focus on learning by doing, which incorporates business generation as a "side effect". The concept is in many ways similar to Chalmers School of Entrepreneurship although it is younger, have shorter duration, and have access to fewer financial resources.

5.5.6. Empirical findings summarized

The empirical findings are summarized in Table 5.1.

Table 5.1: Empirical findings summarized

		Main focus:						
Univ-ersity	Initiative	Focus on Student start-ups	Focus on ext. start-ups	Dependence on external resources	On-campus student facility	Focus on business genera-tion	Focus on idea potential	Focus on student involve-ment
Chalmers	CE	High	No	High	Yes	High	High	High
Linköping	ENP	Low	Yes	High	No	High	High	High
	SMIL	-	-	Medium	-	Low	-	Low
Mälardalen	Idelab	High	No	High	Yes	High	Low	High
	Entrep. School	Medium	No	Medium	Yes	Medium	Medium	Medium
Gothenburg	Entrep. education	High	No	Yes	Yes	Medium	Medium	Medium
Jönköping	Summer entrep.	High	No	Pre-incubator	Yes	Low	-	High
	Business lab	High	No	Pre-incubator	Yes	High	Low	High

5.6. *Analysis and discussion*

This study has revealed intriguing aspects related to the importance of regional context and regional networks when setting up an action-based entrepreneurship programme. Several of the programmes reported in this study are developed in cooperation with other regional actors and are highly dependent on both financial and practical support from these actors. This suggests that developing action based entrepreneurship programmes to some extent is related to the opportunities given in the regional context. Moreover, the initiatives mapped in this study utilise a large amount of voluntary resources, such as experienced business people and successful entrepreneurs who seems motivated and willing to contribute as mentors, advisors, and board members of the student-based companies. This is a very important contribution for many reasons. First, the voluntary support makes it possible to offer higher quality and quantity on education than allowed within the existing university- and financial resources. Second, the external resources contribute with relevance and up to date real-life experience, which is especially important in an action-oriented field like entrepreneurship. Third, these external persons provide a network and access to

other networks, thus helping the participants to build their own networks and relate to external contacts. Fourth, external entrepreneurs constitute role-models and can contribute significantly to move the project or start-up company forward. Nevertheless, this study shows that these initiatives can not solely rely on voluntary resources. There is a considerable need for public and private funding in order to facilitate the development of action based entrepreneurship programmes. These sponsored facilitators are of vital importance in order to release voluntary resources in the regional context.

We also see that some of the programmes can contribute to the university mission of technology transfer by commercialising university inventions. Research results might provide entrepreneurial opportunities, while the researchers do not want to become entrepreneurs themselves. Research results often require further involvement from the researchers to be developed into a commercial concept, and need more development to be of interest to existing companies (see e.g. Jensen and Thursby, 2001). Hence, entrepreneurial students might be in a good position to further develop research-based ideas in cooperation with the inventors. Combining students and research based ideas as a strategy for entrepreneurship education is indicated in the upper-right quadrant of figure 1. This might be a daunting task, but if succeeded several objectives are obtained. First, this approach leads to further development of ideas that otherwise might have been neglected. Second, students who wish to start their own company get access to better ideas than they would normally come up with themselves. Third, working with such high-potent ideas gives the students training in developing high-growth businesses. Finally, this approach may lead to the establishment of successful firms. An example of this approach is found at Chalmers where all these objectives have been realized.

In addition to increase the number of entrepreneurs, another aim of an entrepreneurship education programme is to make more competent entrepreneurs with the ability to develop new ventures with high growth potential. With some exceptions the students' ideas are reported to have a rather limited commercial potential. It could be questioned whether launching a one-person consulting business as a student would develop the skills necessary for founding a high-growth venture later. As such, linking the students with highly potent ideas might provide an education which is more relevant for building

high-growth businesses. Inevitably, it is difficult to get a good quantitative measure of the success in this task. Still, we see that Chalmers School of Entrepreneurship, the most extensive programme in this study, can show to both a number of new companies created and considerable growth in these companies.

The cases show that entrepreneurship education does not only focus on traditional teaching of individuals, but have increased the focus on the business opportunity and contextual issues. The entrepreneurship education also pays less attention to teaching cases and focus more on active involvement by the students (see figure 1). Hence, entrepreneurship education to students can be seen in relation to other objectives such as commercializing research and new venture creation. Table 5.2 summarises how the initiatives at the universities investigated in this study is related to different objectives of entrepreneurship education programmes.

Table 5.2: Objectives of entrepreneurship education programmes

University:	Chalmers	Gothenburg	Jönköping		Linköping		Malärdalen	
Initiative: / Main focus:	CE	GU	Sum. Ent.	Bus lab	ENP	SMIL	Ide lab	Entrep school
Teaching entrepreneurship to students	X	X	X	(x)	(x)	X	(x)	X
Commercialising university knowledge	X	(x)	-	-	(x)	-	-	-
New venture establishment	X	X	(x)	X	X	-	X	(x)

One of the most intriguing findings in this study is that the extent of entrepreneurship education has grown dramatically the last few years, as evidenced by the young age of all programmes investigated. Perhaps the most striking evidence for the growing interest for entrepreneurship is all those who are involved in activities on voluntary basis. This was especially apparent in Jönköping, a university with no full study programme, but entrepreneurship were said to be an integrated part of the activity at the university. With more than 200 student start-ups in five years, this could be viewed as an

implementation of a business generation model of entrepreneurship education where learning-by-doing and student involvement is the core activity. Having access to sufficient infrastructure and mentoring capacity, it has been possible to build an extensive activity and to give many students the opportunity to explore and develop their entrepreneurial skills.

The main contribution from the various entrepreneurship programmes is that they play a key role as facilitators for entrepreneurship. The business generation programmes give students the possibility to gain experience in a real business context where the formation of entrepreneurial teams is emphasised. This is in line with the reasoning outlined by Etzkowitz (2002); that some individuals will not be able to become entrepreneurs individually, but is able to take part in a collective start up. Most initiatives in this study promotes team start-ups, and often the students also have to operate in close cooperation with inventors (e.g. Chalmers and Gothenburg), and external mentors having board positions etc.

The focus on action-based learning and the substantial resources required for these entrepreneurship education programmes may be in conflict with existing teaching practice and the university culture. The requirements of a start-up process do not fit perfectly into the timetable of university studies. Neither can the idiosyncratic learning process of starting a new venture be standardised in a course description. These challenges call for flexibility from the university management, and attention towards legitimising the initiative internally at the university. For instance, the low number of applicants for the Entrepreneur school at Mälardalen might be because this study does not lead to any standard university degree. Other cases have either developed the entrepreneurship education into a degree awarding study programme (e.g. Chalmers and Gothenburg), or stimulated student entrepreneurship without formal connection to the study programmes (e.g. Idelab, and Business lab).

5.7. Conclusion and implications

To fill a new role as active contributors to regional economic development, universities are asked to promote entrepreneurship in general and commercialisation of knowledge and research in particular. A natural role for universities to play in this respect is to provide education of entrepreneurs. The

traditional approach to entrepreneurship education has been indirect, aiming to educate individuals that subsequently are supposed to start new ventures. Newer conceptions of entrepreneurship adds the role of opportunities and context (Gartner, 1985; Shane, 2003), and emphasises learning-by-doing (Fiet, 2001b). By broadening the perspective and actually include the formation of new ventures as a part of the education, a better match with these conceptions can be achieved. In addition, new venture creation will be in line with the overall university mission to contribute to economic development. To succeed it seems necessary, however, to include a broader range of activities than those conducted in a classroom setting, and to employ substantial resources compared to most other study programmes.

Many of the initiatives in this study are student-based or rely heavily on involvement from the students. Other models where students are coupled with business ideas that are assumed to have a high (global) potential may demand more resources, but will also satisfy several aims, for example through the establishment of viable new ventures and commercialization of university research. The cases show a variety of activities to educate entrepreneurs and to stimulate the formation of new ventures. Most initiatives can be characterised as action-based or learning-by-doing. The cases in this study indicate that action-based entrepreneurship education can be accomplished in many different ways depending on both the operational context and the university ambitions (i.e. if their primary focus is learning or being an assistant in the business generation process). The operational context is related to both the internal university support as well as the entrepreneurial environment in the region. Any university planning to set up an initiative following the business generation logic must tune their ambitions according to the opportunities and boundaries in their regional context. Such action-oriented initiatives rely on external resources and a well developed network toward a regional business community for developing ideas, access to mentors, funding, etc. It seems, however, possible to acquire considerable external resources both from public and private sources.

Although it has been questioned whether it is possible to educate entrepreneurs, the cases in this study show that teaching entrepreneurship can be very successful for example measured by the number of companies started by the participants. All universities in this study have initiatives where the generation

of new businesses is either a direct goal or an important part of the entrepreneurship education. The participants are, however, likely to be recruited among people initially motivated to become entrepreneurs, so a high start-up rate could be expected independent of the education programme. It could also be asked whether individuals with a strong entrepreneurial orientation will participate in entrepreneurship education programmes, or if they see this as a waste of time and rather start their own business right away. Nevertheless, these individuals may not be the target group for programmes aiming to increase the number of entrepreneurs, as they probably will start their own business anyway.

To address the long-term effect of the different approaches to entrepreneurship education would be important for future studies. Assessing the effect of entrepreneurship education programmes on individuals (e.g. entrepreneurial intentions or track record), or venture creation and survival is important but challenging. Such studies should address variables such as; the amount of resources employed, the degree of student involvement (including team composition), the potential scope and impact of the business idea, and the regional context of operation. Entrepreneurship education involves many ambiguities as the aim is to stimulate the process of developing idiosyncratic new ventures. Hence, qualitative longitudinal studies might be an important tool to add new understanding to this phenomenon.

5.8. Acknowledgements

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6. Paper 3 - Spin-off venture creation in the university context - a process view

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6.1. Abstract

The process of new venture formation in institutional contexts has been sparsely examined. By using the four basic theories or 'motors' to explain processes outlined by Van De Ven and Poole [Acad Mgmt Rev 20(3) (1995) 510], the aim of this paper is to provide a theoretical explanation of how new research-based spin-off ventures develop within a university context. The paper argues that the four process theories; life-cycle, teleology, dialectic, and evolution can be used to explain different aspects of the spin-off venturing process. Longitudinal case studies show that the viability of each theory seems to differ at different times in the spin-off process.

Keywords: Entrepreneurship, Process theory, University spin-off

6.2. Introduction

Scholars within fields such as entrepreneurship, innovation, science policy, regional development, and technology transfer find the creation of new ventures based on university knowledge important. University-based spin-off firms are found to be very robust, having significantly higher survival rates than other start-ups (AUTM, 2001; Mustar, 1997; Shane, 2004), and policy makers see universities as engines of local economic growth (Candell and Jaffe, 1999). Shane (2004:4) defined a university spin-off as *"a new company founded to exploit a piece of intellectual property created in an academic institution"*. Spin-offs often commercialize research results where existing firms show little interest in applying the knowledge (Jensen and Thursby, 2001; Matkin, 1990). Thus, a distinct feature of spin-offs is that the commercialization process is initiated inside the university organization. For the perspective proposed in this paper, a university spin-off is defined as: *a new venture initiated in a university setting and based on technology from a university*. Hence, the spin-off projects are affected by and will affect the university operation; they can be stimulated and supported, but also inhibited by the university setting.

In order to facilitate spin-offs, however, a better understanding of the process leading to the emergence and development of university spin-offs is needed. The

factors influencing the commercialization of university inventions are poorly understood (Shane, 2004) and the application of a variety of frameworks and methodologies has resulted in a fragmented set of observations (Mowery & Shane, 2002). Many have called for more multi-level and process research on the university spin-off phenomenon (Lockett et al., 2005; Mustar et al., 2006; Wright et al., 2004a). Such knowledge is vital for policy makers, universities, and persons involved in facilitating the emergence of such new ventures. This paper investigates the initial periods of the spin-off formation process; from the moment that a commercial opportunity is recognized within the university until the project is developed independently of the university context. The research question of this study is: "*How does the process of spin-off venture formation unfold within a university context?*"

Existing studies asserts that not only the creation, but also the development process of university spin-offs played a critical role (Vohora et al., 2004). Business models are modified as the entrepreneurs' improve their knowledge about opportunities and resources (Druilhe and Garnsey, 2004). It is found that the entrepreneurial team of academic spin-offs evolves over time and changes in composition (Clarysse and Moray, 2004; Vanaelst et al., 2006) and resource configurations are modified as the spin-offs develop (Vohora et al., 2004). According to Mustar et al. (2006), a dynamic view on how business models of university spin-offs evolve over time is largely absent from the literature. Hence, there is a need to go beyond studies of the factors and conditions influencing the process in order to make more detailed investigations of the process as it unfolds over time.

Although the majority of university spin-off research have been empirically driven and descriptive (O'Shea et al., 2005), several theories have been employed. A literature review by Mustar et al. (2006) found that the type of resources, the business model, and the institutional link were the main dimensions differentiating between the types of research-based spin-offs. This paper will extend these dimensions by keying into the process of how resources are configured (by individuals), how the business model develops (opportunity development), and how the institutional links (university context) influence the spin-off process. It is commonly accepted that the combination of several theories can enhance the understanding of complex phenomena such as

university spin-off formation. There is a lack of theorizing on process within entrepreneurship research in general and spin-off research in particular (Davidsson and Wiklund, 2001; Ucbasaran et al., 2001; Van de Ven and Engleman, 2004). A more developed framework for the study of processes can be found within organizational research where Van De Ven and Poole (1995) have identified four basic theories to explain processes of organizational change and innovation. This study employs these four basic theories, or motors of change, to explain different aspects of the spin-off process within a university context.

University spin-offs are usually a result of long and complex development paths (Roberts, 1991a). Hence, a process approach is chosen, taking into account mechanisms leading to change over time, and not only associations that exist at one point in time (Van de Ven and Hargrave, 2004). Theories that do not assume the operation of equilibrium forces imply that static cross sectional tests cannot be used to explain the phenomenon (Eckhardt and Shane, 2003). A constructivist perspective emphasizing the entrepreneurial process and the development of the business opportunity in this process is emphasized (Baker and Nelson, 2005). Section 2 builds on central concepts from the field of entrepreneurship combined with the four process theories to develop propositions about how the university spin-off process emerges and develops. Next, the data from a longitudinal case study of four university spin-off processes are presented and analyzed. Finally, policy implications and suggestions for future research are provided.

6.3. The process of university spin-off firm formation –the different perspectives

Explaining how new ventures emerge is one of the major questions addressed in entrepreneurship research. For instance, Low and MacMillan (1988) defined entrepreneurship as the "*creation of new enterprise*". The university spin-off company is an outcome of an entrepreneurial process based on the exploitation of a university technology. Definitions of entrepreneurship often include the individual(s), the opportunity, the context, and the process over time (Bruyat and Julien, 2001; Gartner, 1985; Stevenson and Jarillo, 1990). Hence, the creation of a university spin-off can be explained as a process where an opportunity,

individuals, and a context create the necessary properties for a new organization to emerge.

The literature on entrepreneurship in general and university spin-offs in particular has elaborated on three perspectives influencing the spin-off process. First, the development process of a technology or business opportunity from being an idea to becoming an independent new venture (Ardichvili et al., 2003; Gartner et al., 2003; Klofsten, 2005; Vesper, 1989). Second, the role of individual(s) or entrepreneur(s) in the business development process (Franklin et al., 2001; Gartner, 1988; Shane, 2003). Third, the role of the context and how it influences the venturing process (Etzkowitz, 2002b; Jack and Anderson, 2002; Van de Ven, 1993). Within the university spin-off literature, special emphasis has been on the institutional context within a university and how this particular setting influences the business development process (Lockett et al., 2003; Markman et al., 2004; Roberts and Malone, 1996). The next sections examine theories that may explain the entrepreneurial process within a university.

6.3.1. Process theories

Mohr (1982) argues that there are two distinctive types of theories that should be aimed for in social research; variance theory and process theory. Further, Mohr claims that the confusion of the types, and attempts to mix them constitute significant impediments to theory development. In variance theory the independent variable is both a necessary and a sufficient condition for explaining the dependent variable. Long-term efforts by social scientists show, however, that it is extremely difficult to find solid relationships of this kind. In process theory, the independent variable merely needs to be a necessary condition for the outcome. Where variance theory deals with variables and causality, process theory deals with discrete states and events where the time ordering among the events is critical for the outcome. According to Van de Ven and Engleman (2004), the process approach is necessary to address questions about how the entrepreneurship process unfold over time.

Van De Ven and Poole (1995) have developed a typology of four distinct process theories about the complex processes of organizational change and innovation. The life-cycle theory assumes that change processes proceed

through defined steps or stages of development (immanent program). The teleological theory assumes that it is the purpose or final goal that guides the development process. Hence, the developing entity is purposeful and adaptive, and the process can be seen as a repetitive sequence of goal formulation, implementation, evaluation, and modification of goals (purposeful enactment). Dialectic theory explains development processes by conflict between entities, and refers to the balance of power between opposing entities (conflict and synthesis). Finally, evolutionary theory assumes that change processes goes through a continuous cycle of variation, selection, and retention (competitive selection). Hence, each theory relies on a different motor driving the change process; a life-cycle motor, a teleological motor, a dialectical motor, and an evolutionary motor.

These four explanations can be identified in the literature on entrepreneurship and spin-off formation processes, both in pure form and mixed. First, the development of the business concept or opportunity is frequently seen as evolving in a prescribed order through a set of phases or stages (Kazanjian, 1988; Shane, 2004; Vohora et al., 2004). The stage models, however, usually fail to explain why the process moves from one stage to another. A richer explanation might be achieved by introducing the role of key individuals in the spin-off process. These individuals seem to influence the spin-off process by purposeful actions that can be explained by teleological theories. Individuals are, however, embedded in contexts which highly influence their priorities, their actions, and the outcomes of the processes they engage in. Entrepreneurial processes taking place inside organizations, such as universities, have to cope with stimuli and barriers related to this context. This dialectical relationship may influence both the pace and direction of the spin-off process. Finally, the spin-off process is also influenced by external conditions at the macro level. These conditions may influence the process in an evolutionary way, where both random and planned variations lead to a natural selection where the spin-off process may prosper or cease. Table 6.1 summarizes some main characteristics of each process theory and how each theory may contribute to understand different aspects of the university spin-off process.

Table 6.1: Theories for explaining the university spin-off process

	Life-cycle	**Teleological**	**Dialectic**	**Evolutionary**
Theory characteristics	Stages/phases, linear models	Strategy, planning, networks, learning	Conflicting roles and cultures	Random and planned variation
Central topics in spin-off literature	Technology and business development	Spin-off strategy, learning, motivation	University structures, policies, culture	Industry differences
Unit of analysis	Project/spin-off firm/technology	Inventor/ Entrepreneur(s)	University setting	Environment adaptation
	The theory is salient to explain:			
Development of the opportunity/idea	X			
Role of individual(s)/ Entrepreneur (team)		X		
Influence by the university setting			X	
Influence by the external environment				X

It is unlikely that a single process theory or motor can capture or explain the entire spin-off process, but as asserted by Poole and Van de Ven (2004b), the incompleteness of one of these four motors of change can often be accounted for by one of the other theories. Theories of organizational change and innovation processes are often built around two or more of the basic theories or motors operating together at different levels or different time periods (Poole and Van de Ven, 2004b). Seeing all four theories together will probably provide a better understanding of the university spin-off phenomenon than any single theory alone. The different units of analysis associated with each theory also make it possible to address the lack of multiple-level designs in entrepreneurship research (Davidsson and Wiklund, 2001; Low and MacMillan, 1988). How each theory may contribute to explain the university spin-off process is discussed in the following sections.

6.3.2. Life-cycle process

A life-cycle model describes a process as progressing through a necessary sequence of stages or phases (Poole and Van de Ven, 2004b). Due to their simplicity, stage or life-cycle models are very appealing and have made a great impact on how innovation processes are understood. For instance, the linear model of innovation has had tremendous impact on policy and research (Rosenberg, 1994). Although the linear model is now seen as incomplete in order to explain innovation processes (Rosenberg, 1994; Stokes, 1997), it is still influential on practice, such as the operation of university technology transfer offices (Carlsson and Fridh, 2002). Also the literature on organizational change often describes processes as typically occurring in multiple steps (Armenakis and Bedeian, 1999), and the most prevailing way of representing the process of new venture formation is by dividing it into different stages of development (Bhave, 1994; Hansen and Bird, 1998; Kamm and Nurick, 1993). The widespread use of life-cycle, stage, or phase models to explain new venture development and growth is also reflected in their widespread normative use as recipes for how entrepreneurs and consultants should structure their work.

Many people have proposed the sequences in new venture creation. According to a summary by Gartner (1985); the entrepreneur locates a business opportunity, accumulates resources, markets products and services, produces the product, builds an organization, and responds to governments and society. The founding of technology-based new ventures is typically described as a sequential process consisting of identifiable stages, such as access to technology, product development and testing, marketing, and finally the establishment of a business operation (Hansen and Bird, 1998). Galbraith (1982) suggests that new high-technology ventures pass through five identifiable development stages; proof of principle prototype, model shop, start-up volume production, natural growth, and strategic maneuvering. Likewise, new product development processes are often described by using stage-gate models (Cooper, 1993). University spin-offs are developed from research-based ideas developed within an academic setting, making it easier to identify a uniform set of stages or phases compared to firm formation processes in general. Several studies have suggested four stages in the university spin-off process (Clarysse and Moray, 2004; Ndonzuau et al., 2002). Following Vanaelst et al. (2006), this paper will refer to the following phases in the spin-off process: the research commercialization and opportunity screening

phase, the organization in gestation phase, the proof of viability phase, and the maturity phase.

Stage models have been criticized for being too rigid (Neergaard, 2003), and the models are often adjusted with feedback loops and overlap between stages (Fayolle, 2003). The strength of life-cycle models is that they provide a clear start and end to the process. Stage or life-cycle models might be proper for describing the technological development and the development of the spin-off firm, but are incomplete in explaining how and why the project moves from one stage to the next (Drazin et al., 2004). Life-cycle theories are rarely used to explain creative processes, but are commonly used to explain firm growth (Churchill and Lewis, 1983; Galbraith, 1982; Scott and Bruce, 1987). Hence, life-cycle theory may be better suited to explain the later phases of a new venture development. Further, stage models do not account for several ways to reach the same goal, or equifinality (Van de Ven and Engleman, 2004). Moreover, the life-cycle motor does not account for chance or serendipity to occur as a process unfolds. Despite a number of weaknesses, it seems like the life-cycle approach can explain some aspects of the university spin-off process, as outlined in the following proposition:

Proposition 1: Life-cycle theories are more salient than other theories in explaining how the opportunity or business idea develops during the formation of a university spin-off venture

6.3.3. Teleological process

Where the life-cycle theories assume a prescribed process or set of events, teleological theories allow processes to develop from constructive action. Many theories rely on the ability of individuals or organizations to set goals and modify their actions in a process of purposeful enactment. Most of the management theories involving strategic planning and decision-making describe teleological processes (Poole and Van de Ven, 2004b). Teleological processes are also found in adaptive learning theories (March and Olsen, 1976), which assume that an entity is modifying its behavior based on what is learned.

Teleological theories are connected to individual behavior, and the identification of entrepreneurial opportunities is seen as a cognitive act, hence being connected to individuals (Gaglio and Katz, 2001). The nexus of individuals and opportunities is at the heart of entrepreneurship (Shane, 2003) and research shows that entrepreneurship involves a significant component of learning by doing (Carroll and Mosakowski, 1987). In their dynamic model of entrepreneurial learning, Minniti and Bygrave (2001) emphasize that knowledge is acquired through a process of learning-by-doing. Hence, *"... any act of entrepreneurship is a change in the content of the entrepreneur's knowledge in some area."* (p7). In their model, the learning process is mostly teleological, emphasizing the individual's accumulation of useful knowledge for reaching her individual goals. The learning itself also maintains an evolutionary element that includes the influence of random events and path dependency. Another theory which strongly emphasizes teleological processes is Sarasvathy's effectuation theory (2001). This theory emphasizes the entrepreneurs' decision making process in the development of a new venture. Individuals and their motivations and capabilities are changing throughout the process. Also the goals and behavior of individuals may change depending on the means available in a current situation (Sarasvathy, 2001).

A teleological process allows a wider set of outcomes than stage or life-cycle theories, and may also provide an explanation for the transition from one stage to another. A combination of both teleological and life-cycle motors is found in Vohora et al. (2004) who use a resource-based approach in combination with a stage model of the university spin-off process. This model describes four critical junctures which must be overcome in order to progress from one stage to the next; opportunity recognition, entrepreneurial commitment, credibility, and sustainability. Hence, the individuals involved are assumed to play a critical role when the new venture progresses from one stage to the next. The resource-based theory is frequently used to explain how individual firms can lever their resources to build sustainable competitive advantage (Barney, 1991). This approach also has a strong adaptive orientation, relying on managers' ability to navigate according to the environment (Lewin et al., 2004). The resource-based view is frequently used in the spin-off literature (Druilhe and Garnsey, 2001; Druilhe and Garnsey, 2004; Heirman and Clarysse, 2004; Lockett and Wright, 2005; Powers and McDougall, 2005b). Although it gives implications for the

teleological or planning process of new venture creation, the resource-based view tend to be equilibrium oriented (Lewin et al., 2004) and more occupied with content than process.

The prevailing view in most theories is that the entrepreneurship process is emerging as a result of purposeful and planned actions by key individuals (McMullen and Shepherd, 2006). The role of key individuals, such as the researcher or inventor (Henrekson and Rosenberg, 2001; Jensen and Thursby, 2001; Stankiewicz, 1986), the academic or the surrogate entrepreneur (Franklin et al., 2001), entrepreneurial team (Clarysse and Moray, 2004; Vanaelst et al., 2006), or a privileged witness (Vanaelst et al., 2006), is found to be of crucial importance for the university spin-off process. Hence, teleological process theory seems suitable for explaining the human agency in the university spin-off formation process as outlined in the following proposition:

Proposition 2: Teleological theories are more salient than other theories in explaining the role of the entrepreneur or entrepreneurial team during the formation of a university spin-off venture

6.3.4. Dialectical process

That the entrepreneurs are embedded in the environment is seen as a key aspect in the creation of opportunities and the entrepreneurial process (Jack and Anderson, 2002). Entrepreneurs initiating university spin-offs are embedded in a context where for instance environment support (Reitan, 1997), local group norms (Louis et al., 1989), university culture (Franklin et al., 2001), and policies (Di Gregorio and Shane, 2003; Roberts and Malone, 1996) have been found to affect their behavior. Hence, the university as an arena for entrepreneurial activity influences the spin-off process. Universities are characterized by a high degree of complexity and a large set of loose couplings (Weick, 1976). Diverse goals and outputs such as teaching, research, societal utility, and a combination of non-profit and commercial activity add to this complexity (Lee, 1996; Navarro and Gallardo, 2003).

The complexity of the university spin-off process is evident from the many actors at different levels involved and their often different and unclear objectives

(Mustar et al., 2006). Universities are often considered a part of the public sector where other stimulants and constrains to entrepreneurship than in the private sector may apply (Sadler, 2000). The academic culture values publishing and disinterested research, while entrepreneurial activity may be a sensitive issue (Ndonzuau et al., 2002). Thus, the difference in culture and work practice between university and industry is substantial (Anderson, 2001) and constitutes a challenge for spin-off processes (Argyres and Liebeskind, 1998; Meyer, 2003; Miner et al., 2001; Stephan and Levin, 1996).

Dialectical theories explain processes by reference to the relative balance of power between opposing entities (Poole et al., 2000). University spin-off projects emerge from a university setting and become an independent business entity. During this process, the technology and the persons working with the project change the scene from an academic to an industrial setting where inherent disputes between the academic culture and the commercial culture need to be resolved. As noted by Samsom and Gurdon (1993), the clash of business and scientific culture often leads to difficulties and sometimes to failure of the new venture. Based on their study of professorial entrepreneurship, Kenney and Goe (2004:679) suggests that "*being embedded in an academic department and disciplines with cultures that are supportive of entrepreneurial activity can help counteract the disincentives created by a university environment that is not strongly supportive of these activities*". This indicates a complex structure where academics is part of different cultures in their discipline, department, university, and external environment.

Academic entrepreneurs are dependent on networks and integration between a wide variety of actors (Mustar, 1997; Nicolaou and Birley, 2003b). It has been documented that the resource endowments of spin-offs are influenced by the way technology transfer is organized at the parent organization (Moray and Clarysse, 2005). The institutional link is a prominent dimension early in the university spin-off process, while becoming more a background variable in the further development process of the new venture (Mustar et al., 2006). Hence, using the dialectical motor for explaining spin-off processes may be particularly suited in the early stages of the spin-off process. As the new venture matures and becomes more independent of the university context, other external factors outside the university setting may play a more important role. Still, many spin-

offs maintain their relationship to their university of origin which becomes an important resource provider for the venture (Oliver, 2004). The ambiguous relation between the academic university context and the commercial spin-off project leads to the following proposition:

Proposition 3: Dialectical theories are more salient than other theories in explaining the role of the university context during the formation of a university spin-off venture

6.3.5. Evolutionary process

A number of macro-level characteristics are found to influence the spin-off process, such as geographical location (Degroof and Roberts, 2004; Friedman and Silberman, 2003), government regulations (Bozeman, 2000; Goldfarb and Henrekson, 2002), university characteristics (Grandi and Grimaldi, 2005; Smilor et al., 1990), and initial resource endowments (Shane and Stuart, 2002). The life-cycle, teleological, and dialectical theories are not able to explain how external variation influences the spin-off process, while evolutionary theories incorporates the macro level influence on processes.

Evolutionary processes are dependent on the three sub-processes of variation, selection, and retention (Aldrich, 1999). Both intentional and blind variation influence the spin-off process in a not predetermined way (Aldrich, 1999). Such variations could be both internal and external. Hence, the variation generated by stage-wise development of the business opportunity, the teleological action by the entrepreneur(s), and the dialectic relation between academic and business culture may serve as input to the variation, selection, and retention process. For instance, Roberts (1991a) describes how the technology spin-off entrepreneurs change the focus of their firms. Sometimes this is a conscious decision (teleological), while in other cases this happens by chance or in an evolutionary manner. Networks with industry and the business community is another important element in creating university spin-offs (Carayannis et al., 2000; Nicolaou and Birley, 2003b; Pérez and Sánchez, 2003). Such networks need time to develop, and the development of networks can be viewed as an evolutionary process (Hite and Hesterly, 2001).

In addition, a large number of external random and planned factors influence the evolutionary process in a not predetermined way. Examples of such external conditions are access to capital, governmental regulations, labor market conditions, and regional industry composition (Nelson and Winter, 1982; Shane, 2004). Hence, the evolutionary theories include a role for serendipity and chance to influence entrepreneurial processes through the variation mechanism. They may add to the explanation of the university spin-off process as follows:

Proposition 4: Evolutionary theories are more salient than other theories in explaining the role of environment adaptation during the formation of a university spin-off venture

6.4. Methodology

A longitudinal research design including several cases was chosen to observe the development process of university spin-off creation in context, and to include the significance of various interconnected levels of analysis (Pettigrew, 1990). This study examines the initiation and establishment of four university-based start-up companies.

6.4.1. Research Setting and Case Selection

The spin-off cases were chosen in order to achieve a high degree of variation on key variables identified in the literature (Eisenhardt, 1989; Yin, 1989). This study includes two Norwegian universities, each representing rather typical segments in the European university system. University A is quite large with a history of more than a hundred years, while university B is a smaller and younger university. University A has traditionally strong ties to industry and a number of companies have spun off throughout the years. University B traditionally had much weaker ties to industry and fewer examples of spin-off companies. Prospective cases were identified in cooperation with well informed persons at each university. The cases were in an early phase where neither the product, first costumer, nor the funding were in place. To fit with the definition of a university spin-off, I chose cases where the technological basis for the spin-off was university research and where the university researchers played an important role in the initiation and development of the spin-off project.

6.4.2. Data Collection and analysis

Several sources of data were used to map out the situation and critical events prior to and during the development of the spin-off projects (Van de Ven and Poole, 2002). Primary data was collected by 7 to 17 personal interviews at each case conducted throughout a 12-15 month period. I interviewed people in various positions including: company founders and entrepreneurial team members, researchers, university managers, people involved in commercialization support, and industrial partners. Following a narrative approach (Polkinghorne, 1988), the interviews induced the interviewee to describe his or her involvement in and knowledge of the spin-off project from its inception up to date, with a minimum of interruption by the interviewer. This type of narrative interviewing (Czarniawska, 1998:29) was done in order to ensure a higher degree of proximity to the actual events and to avoid that personal views and theoretical perspectives interfered with the data collection. Most interviews were recorded and transcriptions were done as a part of the data analysis process. In addition, relevant written documentation was collected both from the informants and other sources like press articles and the internet. Archival data such as memos, financial reports, business plans, and market analyses were achieved.

By combining the different sources of information and collecting data over a period of time by conducting repetitive interviews with central informants, an in-depth description of the research and the commercialization process was obtained. Although the cases still interacted with their universities of origin, they had become established projects having a separate organization and non-university funding when the collection of data ended. The cases are anonymized, and some of the factual information has been slightly adjusted. Confidentiality has resulted in a richer set of data due to better access to documentation and more honest statements from the informants.

The collected data provided both narrative accounts of the process (Pentland, 1999) and factual descriptions of context, actors, and events from a large number of sources. Critical characteristics and events related to the spin-off process were identified through induction. In order to derive at theoretical

explanations for the processes observed, observations that matched theoretical concepts were identified (Borch and Arthur, 1995). Several different theoretical perspectives were used to capture different aspects of the same process (Pettigrew, 1990). The theoretical concepts were formed to match the empirical data in an interactive process. As the analysis proceeded, the overarching logical frame shifted from exploring data using retroduction to verifying theory through deduction (Van de Ven and Poole, 2002). Data collection and analysis was conducted in an interactive process as summarized in Table 6.2.

Table 6.2: Summary of main steps in the data collection and analysis process

Step in data collection and analysis process	**Data sources, collection, and analysis**
Mapping the national context and the universities	National level: attending policy/practitioner conferences, conversations, and documents. University level: visits, conversations, and personal interviews
Case selection	Identified commercialization projects based on prior work experience, network, and general information search
	Identified case contacts through well-informed persons and network
Initial case investigation	Internet search and informal conversations
Interviews	Interviewed central persons over a 12-15 month period (49 interviews)
Document collection	Obtained plans, presentations etc. from interviewees
	Searched the Internet for web pages, press articles, etc.
	Obtained student thesis, including source material (2 of the cases)
Data transcription	Transcribed the interviews (most from tape), focus on revealing the process
Mapping central events over time	Writing narratives about the spin-off process and making tables describing time, actors, and critical events
Matching theoretical concepts	Working with theory and empirical data in an interactive process

6.5. Findings and discussion

This section presents the four cases emphasizing the process theories outlined above. The development process of each case is briefly presented in the Appendix and central properties are summarized in Table 6.3.

Table 6.3: Properties of the four university spin-off cases

	Alpha University A	**Beta** University B	**Gamma** University A	**Delta** University A&B
Field of technology	Engineering/ software	Biotechnology	Engineering/ electromec.	Engineering/ electromec.
Time from initial research idea to spin-off project	14 years	8 years	10 years	30 years
Source of initial idea	Industry need	Basic university research	Researchers and industry partner	University research (A)
University IP ownership	No	Yes	Yes	No
Company founders	4 professors + 2 team members	2 professors and the university	University-industry joint venture	1 researcher at university B who is not the inventor
Industry experience in founding team	Extensive industry and spin-off experience	From industry sponsored research	Extensive industry and spin-off experience	Limited
Source of basic technology and competence	University research and industry experience	Industry sponsored university research	University research and prior university spin-off firm	University research (A)
Most critical resource for initial opportunity development	1 professor's industry experience	Prior industry cooperation	Prior spin-off and industry network	Founder's own practical experience
Major performer of technology development	Founders	University	University	Founder
Other performers of technology development	Industrial partners	Additional research partners	Prior spin-off from same university gr.	Technology inventor at university
Major roles in market development	Founding team	Founders and new management	Interaction: CEO, professors, and ind. Partners	Founder and science park advisor (B)
First funding commitment	Public grants	University	University	Public grants
Major funding source	Public grants	Public grants	Public grants	Public grants
Additional funding	Industry	Investors	Industry	None

6.5.1. The opportunity development as a stage process

Following a stage-based logic of four steps (Vanaelst et al., 2006), it seems clear that some aspects of the development process of all cases can be categorized into predefined stages (see Appendix). First, the research commercialization and opportunity screening phase appeared to be long and complex in all cases. Academic freedom and curiosity driven research formed the basis for all the business opportunities and the role of a strong technological basis and accumulation of knowledge over many years is strongly emphasized by most interviewees. Case Alpha is based on knowledge emerging from the innovative combination of two engineering fields. The medical effect exploited by Beta was initially discovered by a group of young and curiosity driven researchers. The technology which forms the basis for Gamma is a result of both academic and applied research activity for about a decade, and Delta have a similar story going even longer back in time.

Second, the organization in the gestation phase involved a process of obtaining the resources necessary to launch the new venture project. Examples of critical resources was for case Alpha to engage in a creative process with industry partners to build a business model, for case Beta to get ownership of the patents, for case Gamma to hire a CEO to run the project, and for case Delta to get an arrangement between the technology owners and the new entrepreneur. For all the cases there was a need for a committed entrepreneur or entrepreneurial team and for obtaining financial and other resources to continue the spin-off project. Public funds have been an important source of funding for the early-stage technological and business development in all four cases.

Third, the proof of viability phase was also evident in this study as all the spin-off projects planned and conducted the development of a prototype. When the prototype development started it seemed that the university spin-off process entered a more structured phase involving more detailed development plans including milestones to be achieved. Fourth, the maturity phase was entered by only one of the spin-offs; Alpha. In this phase the company had achieved significant milestones such as expanded the staff, contracts with customers, and significant funding from industrial investors.

While the contours of a stage-wise process are visible in all the cases, the process was not linear and uniform. The initial opportunity often seems to need substantial revision over time. The technological competences were perceived as fairly strong, but all cases matured through a process of adding on market knowledge and re-shaping the business idea. Case Alpha started with a strong competence base and a desire to start something, while the idea was revised and concretized several times before a viable business model was found. Also the organizational structure developed in different ways. Case Beta attracted investors and acquired a strengthened management team early in the process, while milestones related to technology development had a longer time horizon. In contrast, Gamma and Delta worked on a fairly well specified technology with shorter time to market, but lacked the organizational structure of the two other cases in this study.

Interestingly, the formal registration of the spin-off firms seems not to be connected to any particular stage in the technology or organizational development. Legal establishment was rather a practical arrangement in response to a need for an organizational entity. For example, Alpha was legally established as a consulting business some years before the spin-off idea came, Beta was established in the research commercialization phase due to a need for a legal entity to own the patents, while Delta was still not legally established after development grants had been obtained and a prototype was tested. Hence, the frequent use of founding dates to categorize spin-off firms and phases in prior studies may lead to false conclusions.

Despite the unstructured emergence of the spin-offs, it seems clear that some events precede others in a stage- or phase-like manner. This is especially related to the development of the business concept, where an idea needs to be clearly articulated before resources are committed to develop it further, and the viability of the idea need to be tested before the new venture can attract costumers and significant investments. The early phases of opportunity screening and idea development seemed more unstructured than described by stage models, while the projects became more structured later in the development process. Here, the conventional wisdom of textbooks, consultants, and investors often relies on stage models, which may lead to self-fulfillment of stage models to explain entrepreneurial processes.

Although stage models point out challenges and problems to be dealt with at different times in the process, they have a number of weaknesses in explaining how university spin-off firms emerge. Most notably, they do not explain how the process proceeds from one stage to the next. Further, it is often difficult to point at a specific point in time when the project moves from one stage to the next, due to difficulties of finding objective criteria to categorize a project into a specific stage (e.g. legal establishment, external funding, and first costumer).

6.5.2. Teleological action moving the process

In all four cases, the identification of an opportunity was dependent on someone seeing the connection between the technology at hand and some market need. It was the broader set of knowledge combined with the individuals involved that determined how the business idea of the new venture was formed. The opportunities do not seem to exist independently of the individuals and the specific context, but seem in all cases gradually to mature in a cognitive process by the entrepreneurs. The decision to pursue the entrepreneurial opportunities seems to be a result of supportive elements in the persons' environment combined with events creating a new situation where starting an entrepreneurial action is perceived as a viable option. For instance, in case Alpha and Beta, the founders see themselves more as professors than entrepreneurs to begin with, but they are increasingly becoming more committed to their role as entrepreneurs. Individual motivations were diverse. Some are very explicit about their role as professors, seeing the creation of domestic industry and the creation of jobs as important. Other motivations varied from a desire to work together as a team, see the research results applied, and creating a commercial success. The process of establishing Beta came as a response to a crisis in the research project, not from a deliberate choice made by the entrepreneurs. The motivation of the researchers might affect the focus of opportunity development. The founders of Beta initially seemed motivated by obtaining funds for doing more research, while the commercial orientation emerged as the process proceeded.

In addition to the academic research, contacts with industry and possible users of the new technology were crucial for the opportunity to emerge and develop. Although the professors in case Alpha saw an opportunity to start a new venture,

the business concept was not clear from the start, but it took some time before the founders saw the commercial value. In the case of Beta the idea was developed in cooperation with an industrial company. Gamma emerged as a result of discussions between researchers and industrial partners. Delta's technology was offered to industry with a lukewarm response, but the founder's user-experience made him see a commercial opportunity. Hence, the researchers' network, experience, and knowledge of industrial application was crucial for being able to see entrepreneurial opportunities by connecting research findings to potential areas of application.

In all cases the entrepreneurs changed their primary focus and strategy as the projects developed. The academic entrepreneurs in Alpha were very much aware of the need for external resources, and intentionally included two external persons in the start-up team. The team worked on external relations and business concept development the first year. When the business model and customers were in place they focused on technical work where they knew that they possessed sufficient competence. In case Beta, the academic entrepreneurs gradually changed the company focus (e.g. board composition) from being targeted to gaining internal support within the university, to directing the focus towards external resources important for business development when the internal support and legitimacy in the university was established.

Just as links to the commercial environment was critical in forming the business concept, these links also developed the personal competencies, network, and experience of the founders. In case Alpha the professor with industrial background has a key role. According to the other founders he got the market contact and provided the links to customers which made the project possible to accomplish. Professors within Nordic universities rarely have strong links to the industry as part of their academic career. Hence, the founders of Beta were considered as atypical researchers because they have worked for an industrial partner for many years and had other attitudes than the average researcher. Also the university professors involved in Gamma and Delta had experience from prior spin-offs and many industrial contacts.

Committed individuals seem to be able to drive the project forward in a purposeful or teleological way, and the stages of development are modified by

entrepreneurial action. Thus, teleological theories may help to explain why processes are moving from one stage to the next, and why spin-off processes do not proceed in a strictly linear fashion. A weakness of teleological theories is their focus on individuals, while a number of contextual factors might be decisive for the development of the spin-off process. Factors such as serendipity, availability of time, personal relations, motivation, and other external personal circumstances may influence the degree and type of involvement by individuals. Many of these factors are related to the university context.

6.5.3. University dialectics influencing the spin-off process

The relation to the university is seen as a source of valuable resources, but the university context can also constrain the spin-off process. The four cases have a number of different relations to the university, as summarized in Table 6.4.

Table 6.4: Institutional integration between the university and the spin-off project

University role	Alpha	Beta	Gamma	Delta
Use of university R&D facilities	No	Extensive	Extensive	Informal small scale use
Use of physical administrative facilities	University incubator on campus	Science park incubator near campus	University incubator on campus	No
Use of advisory/ business services at university	No	University management and science park	University TTO	Science park
TTO involvement	No direct, informal and through policy	TTO role handled by the university	TTO involved and partly IPR owner	No
University resources employed to support spin-off project	4 professors on sabbatical year	Effort and funding to obtain patents and establish Beta	University is technology partner providing research	No
Use of researchers at university department	None, except of the founding team	Hired by Beta to do R&D project	Important partner in R&D project	Minor involvement at university A
Student involvement	Recruiting base	Recruiting base and doing thesis	Recruiting base and doing thesis	Project thesis

Gamma and Beta have several couplings to the university, such as ownership, the use of laboratories, and research cooperation. Alpha and especially Delta are to a lesser extent integrated with the university. The university's relation to the spin-offs is not consistent, but involves many separate couplings. One of the Alpha founders listed eight different units the spin-off project related to; one university research center, two institutes, two departments, a cooperating research institute, the university TTO, and the university management. Case Beta has a similar relation involving several units within the university and the university hospital. The universities seems more positive to support the creation of spin-offs at central level, while the situation is more mixed at department level where the spin-off projects causes strain on resources.

There seems to be a dual relation between the spin-off project and the university context. On the one hand, the university environment is generally considered to be a good place for creative spin-off processes. Early in the process the university can contribute with resources which lower the initial cost and risk associated with exploring a business idea, such as available time, equipment, business consulting, and incubator facilities. Opportunities for taking leave and sabbaticals made it possible for the Alpha professors to be involved in commercialization projects without leaving their position at the university. In case Beta the university actively used the latent contacts of persons in the organization to access specialist competence when needed. As the spin-off projects develop, the university seems important as a research partner and source for recruiting highly skilled graduates to the new venture. PhD- and Master-students conducted thesis and smaller projects and was a source for future employees. It is, however, difficult to connect specific resources to distinct stages of development in a way that can be verified across the cases.

On the other hand, some conflicts and critical voices occurred as the spin-off process developed. Some department managers clearly expressed spin-off activity as positive, showing output from the research activity and positive publicity for the department, while others feared that spin-off activity would undermine the research by occupying resources and create a difficult relation to collaborating research partners and industry partners by bringing commercial interests into the department. An interwoven relation between different university stakeholders and the spin-off project makes them very vulnerable to

accusations, and conflicts of interest might be difficult to solve. To keep a tidy university relation and avoid questions about IPR ownership, Alpha chose to do all development work in the spin-off company without using university infrastructure or personnel. Becoming an incubator company made it easy for the spin-off entrepreneurs to maintain a clear relation to the university, both by separating the business activity and because the spin-off then had a legitimate position within the university. Due to the limited experience within the universities to handle the role as owner and research partner with the spin-off companies, several conflict-of-interest issues emerged and much energy was devoted to find viable solutions. A difficult area for the university was to balance the degree of support with securing a proper return on these investments, for instance through ownership in the spin-offs. Another challenge was to establish clear routines and guidelines in the relation between students and the spin-off company.

The role transition from being an academic to becoming an entrepreneur differs between the cases. Alpha and Delta immediately made a clear distinction of roles, while the Beta and Gamma cases show that this might not always be an easy task when the spin-off project is embedded in the university operation. The academic entrepreneurs have to break some ties to be able to go on with their idea. Pursuing an entrepreneurial opportunity in the university setting had to be perceived as viable behavior by the individuals involved. Signals from policy makers and university management that spin-offs had their support were important both for the decision to start the process, and for the further development.

The relation with the university context called for solutions to be made which affected the further development of the spin-off. Using dialectical theories to explain the spin-off process seems, however, most relevant when the project undergoes the transition from being a research project to become a commercial venture. Hence, the use of dialectical theories seems only to explain one aspect of the university context's role in the spin-off process. The university's resources and capabilities support the spin-off process in the different stages of development, both strategic and evolutionary. It should also be noted that the university is not a static entity, but can change during the spin-off process, for instance because new solutions are made and learning occurs.

6.5.4. The role of external context and evolution in the spin-off process

The business ideas, the individuals involved, and the relation with the university context have in all cases changed radically during the spin-off process. Some of these changes are a result of external factors and unpredictable events which may hinder, change direction, or open new possibilities for the spin-off process. For instance in case Delta, the commercialization process halted until the business opportunity was discovered by an external entrepreneur located at another university. In case Beta, a sudden fall in the stock value made the industry partner pull out of the project, an event leading to the creation of a spin-off company. The technology developed by Beta was also discovered partly by chance. The initiation of the Alpha project also happened almost by coincidence, as the professors for different reasons have ended their relation to prior industrial partners and were looking for new industrial projects when the idea came up. As a result of a conflict between central persons and interests, one of the spin-off projects was put on ice for several months, although the conflict was not related to the spin-off project. These and several other examples show that numerous unpredictable events influence, or even become decisive for the spin-off process.

The prior history leading to each business opportunity was also long. For instance, the history leading to Gamma was dependent on a previous spin-off based on core technology from the same inventors, which for years has been in an almost symbiotic relation to the university research group. An extremely difficult financial situation in the industry made it difficult to get industrial partners to commit resources on technology development in the Delta case. Hence, the creation of a spin-off became an alternative due to a lack of interest from existing industry combined with an incidental contact with a prospective entrepreneur.

Another evolving process influencing all the spin-off cases was the current policy efforts at the national level to promote the commercialization of research. These policy changes influenced the spin-off processes in several ways, such as: more ample public funds early in the commercialization process, better

conditions for university employees to be involved in spin-offs, and a more supportive university setting. Several persons said that it would have been less viable for them to start a new venture some years earlier, due to a different attitude among administrators and colleagues. Now it has become more accepted within the university to start a spin-off venture, and an infrastructure is established. The availability of resources also constrains and shapes the opportunity to be pursued into a business model that is adopted to the specific business context. In this process, all cases have been dependent on considerable external resources through networking with industry and funding from public grants, often matched with own effort from the entrepreneurs, the university, and industry partners.

The stage, teleological, and dialectical theories only to a limited extent include the role of the external context and evolutionary forces when explaining the spin-off process. External forces often play a decisive role in the spin-off process, giving timing, serendipity, and unpredictable events a prominent role in deciding how the process unfolds. These factors are often outside the control of both the individuals involved and the university setting. Hence, macro level events outside the scope of stage models, individual agency, or organizational setting should be accounted for in order to understand the spin-off process. Here, the variation, selection, retention (VSR) mechanisms of evolutionary theory gives additional insights, and can account for macro level development, serendipity, and unpredictable events. The stage, teleological, and dialectical processes at the micro-level may also induce variation into the evolutionary VSR process.

6.5.5. Timing of theories

All four process theories provide additional insight into the spin-off process, but each theory seems more prevalent at different times in the spin-off process. In the initial phases of opportunity identification and commitment, the role of individuals and their motives seems to play a particularly important role. Hence, the teleological theory is more prevalent than the other theories in the very early phases of spin-off development. Immediately after the spin-off project is launched, the relation with the university is especially important. The transition from being a research project to becoming a commercial venture brings forward

conflicts to be resolved. Hence, dialectical theories seem to have a more prominent role in order to explain this particular phase of the spin-off process. These findings are in line with Cule and Robey (2004), who suggest a constructive process model of organizational transition based on a dual teleology and dialectic motor. After the new spin-off venture has secured initial support and funding, it seems to enter a more structured phase where the process proceeds as implied by the life-cycle theories. Hence, the life-cycle theories seem more prominent later in the process. Finally, the three theories provide limited explanation for macro-level influence on the spin-off process and for the role of serendipity and chance. Hence, the evolutionary theories may play a prominent role in explaining the long-term progress and timing of events throughout the entire spin-off process. That is, how both planned and unpredictable events evolve and determine the spin-off process and its outcome.

6.6. Conclusions and implications

Little is known about how entrepreneurial processes develop and the drivers influencing their development paths, particularly within a university context. This study has addressed the lack of both process approaches and multi-level studies within entrepreneurship research by applying four different process theories to explain different aspects of the university spin-off process. Based on longitudinal data from four spin-off processes, this study revealed that the spin-off process is much more unstructured and messy than assumed by many prior studies. Hence, the use of single theories provides only partial explanations of the spin-off process. This study contributes by using four process theories to explain different aspects of the spin-off process. Prior studies have often relied on single theories to analyze the spin-off process, notably stage-based theories. By adding on teleological, dialectical, and evolutionary theories this study provides a better explanation of why spin-off processes moves from one stage of development to the next. Further, the findings suggest that the different theories may be more or less prominent to explain the development at different times throughout the spin-off process.

6.6.1. Implications for future research

This study has revealed several aspects of university spin-off formation that has received little attention in the literature. First, the cases in this study confirm that business models often change over time (Gartner, 2004), making it difficult to compare categories of firms because the firms may move between categories over time. Many prior studies treat the opportunity or technology as given, while this study indicates that the opportunity is developed in a process depending on the individuals involved, the organizational context, and external evolutionary influence. Such changes in the business opportunity during a spin-off process are little investigated (Mustar et al., 2006). Although the stage-based models provide contours of the opportunity development process, they need to be supplemented and extended by other theories.

Second, it seems clear from these cases that the academic researchers becoming entrepreneurs undergo a steep learning process. This individual development is likely to have a strong impact on the spin-off process. In order to understand the role of individuals in the spin-off process, the motivation and competence of individuals should not bee seen as static. This paper suggests using teleological theories to capture the role of human agency in the spin-off process, but more work is needed to develop this approach more in detail. The use of entrepreneurial learning theories (Harrison and Leitch, 2005), social capital theory (Murray, 2004), and network theory (Nicolaou and Birley, 2003b) might yield additional insights. Furthermore, there is also a lack of research on changes in the team composition during the spin-off process, and how such changes internally in the spin-off project influence its development (Vanaelst et al., 2006). The cases in this study indicate that the development in team composition is dependent on individual networks and strategic choices.

Third, many have studied the differences between the academic and the commercial culture, but little is known about how the transition from academia to business influences the spin-off process compared to other start-up processes. Future studies should not treat the university context only as a static actor in the relation to the spin-off process, but also address the changing role of the university context throughout the spin-off process. This study suggests dialectic theories as a viable route to investigating the spin-off – university relation. In addition to the conflicting goals of academic and commercial activity, an under

researched topic is the relation between spin-off projects and university-industry cooperation where there might be conflicting goals. The dialectical perspective pays most attention to the problems in this area. In addition, the university setting is an important, and often crucial, resource provider for the spin-off venture. Hence, theories about organization-level capabilities (Lockett and Wright, 2005; Teece et al., 1997) and decision making (Cohen et al., 1972) may provide a fruitful avenue for exploring how the university context influence the spin-off process.

Fourth, the role of external or macro-level events is rarely included in studies of the spin-off process, but this study shows that the role of serendipity and unpredictable events also needs to be accounted for. Evolutionary approaches are well developed within organization theory (Aldrich, 1999) and provide rich opportunities for creating better theoretical foundations to study the university spin-off process, by including the relation and impact from the external environment.

This study has used concepts from the entrepreneurship literature combined with process theories (Van de Ven and Poole, 1995), but insights from other theories and perspectives can be useful as well. Many studies have drawn attention to the heterogeneity of university spin-offs and developed typologies (Mustar et al., 2006). A weakness of these typologies is that a spin-off may move between different types over time. Hence, it might be more relevant to study whether spin-off firms follow different trajectories or development patterns over time. Cross sectional studies fails to account for the internal changes in the variables measured, relating to the technology or business idea, the individuals involved, or the university context. Hence, longitudinal case studies following spin-off projects as they evolve may be particularly suited to develop a more precise model of the entrepreneurial process in a university setting. In order to makes explanations that are close to the process being studied, such studies should use narrative data (Pentland, 1999). Narratives are particularly sensitive to the temporal dimension of human existence because they pay special attention to the sequence in which actions and events occur (Polkinghorne, 1988).

6.6.2. Implications for policy

This study indicates that the prevailing linear or stage-models are only able to explain some aspects of spin-off processes, and that additional insight can be found in teleological, dialectical, and evolutionary models. Policies are not likely to be generally applicable throughout all phases of the spin-off process, as the opportunity, the individuals, and the university context are not static, but change over time. Following the process theories explored in this study, four implications for policies to promote spin-off creation can be drawn. First, stage models points to the specific challenges emerging at different times in the development process of a spin-off firm. Policies should pay attention to the characteristics of each stage in order to stimulate and removing barriers for the projects to proceed from one stage to the next. In particular, the key role of individuals early in the process, the important transition from being a research project to become a commercial venture, and the external conditions need to be considered.

Second, committed and competent individuals may be made available to the projects both through a learning process and by changes in team composition. Individual's motivations and incentives may be a key factor to achieve this, for instance through training programs and networking activities. Third, policies directed at regulating the dialectical relation between the academic and business culture in a way that stimulate rather than hamper the spin-off process may be fruitful. This relates to the university culture, policies, and experience in dealing with industry and commercialization projects.

Finally, external factors may be difficult to plan for, but policy makers can increase the likelihood of evolutionary processes to occur by feeding the evolutionary VSR process. This may be achieved by stimulating events and situations (variation) that may result in initiation and further development of spin-off processes. Variation can be stimulated by supporting research areas, technology and market competence, and networking arenas, while the selection process can be delayed by addressing areas of market failure such as lack of early stage funding for commercialization projects and spin-off ventures.

6.7. Appendix: Spin-off case descriptions

6.7.1. Spin-off Case Alpha within University A

Case Alpha is based on the specialized competence of the professors in the founding team, which has developed since two of the founders were pioneers in combining two engineering fields during their Master and PhD studies. One of them continued at the university and became a well renowned Professor, while the other made a career in industry for about ten years before becoming Professor at the university. The research group they are a part of is connected to two departments and is well renowned internationally in their niche. The initiation of the spin-off happened by coincidence. The professors usually had close relations to industrial partners, through projects or part-time positions. When the spin-off idea came up, each of the professors had for different reasons reduced their relation to their main industrial partner. The professors discussed the possibility of starting a company. "*All four of us professors were actually looking for some new industrial projects, and then this idea came up, and it was very good*". During informal conversations and based on their research based competence combined with their industrial knowledge, they decided to explore the possibility to start a new venture. None of the professors had started a business like this before and they acknowledged a lack of knowledge about such a process, so they decided to include additional competence in the founding team. The founding team had to go several rounds with industrial partners and customers, and the final idea was a result of an iterative process. "*When you think you have found the solutions, and then discuss with customers, new changes have to be made, and this is a time consuming process*". The founders managed to obtain a mixture of public and industrial funds to proceed with the development project and hire 3 employees. The professors could work for the spin-off while maintaining the position at the university. Alpha has successfully developed the product and signed the first contracts with costumers.

Table 6.5: The spin-off process of case Alpha

Phase / Alpha	Research commercialization and opportunity screening	Organization in gestation	Proof of viability	Maturity
Opportunity	-Innovative combination of two engineering fields -Applying existing technology in a new industry	-Build business model in interaction with industry -Obtain funding from industry and public sources	-Developing prototype and on-site testing	-Preparing for expansion into new areas of application
Individuals	-Motivated to become entrepreneurs -Critical competencies intentionally included in the founding team	-Committed team -Creative processes to develop business idea -Well organized business development	-Hire staff for product development -Entrepreneurs' network important	-Expanding staff
University context	-Spin-off seen as viable option -Adaptation to university policies	-Internal legitimacy in university incubator -Focus on separating university and commercial activity	-University as recruiting arena	-University as informal collaboration partner
Extern. context	-Spin-off was an alternative to industry collaboration	-Support from external "god-fathers"	-Public funding sources available for this type of project	-Industrial investors provides funding

6.7.2. Spin-off Case Beta within University B

The history of case Beta started when a group of researchers partly by chance discovered a medical effect. The researchers obtained funding from a pharmaceutical company that gave substantial funding for research at the university. A research group was build up, which provided good scientific results, several PhDs, and promising results from an industrial viewpoint. After six years, just as the research activity was about to give the basis for more development work, the pharmaceutical company made a general decision to pull out of such projects due to economic difficulties. This caused great uncertainty about the future for both the research group and the project, and triggered the two research managers to try to commercialize the technology on their own. This was an extremely challenging task for the research managers. "*We were very frustrated, and this took a lot of time*". The process of taking over the project and the related patents from the pharmaceutical company was long and cumbersome. The university was heavily involved in this process. "*I do not know how this had ended if it had not been that we had this backing from the university management*". With considerable financial and administrative support from the university the two professors were able to retain ownership of the technology. Retaining the competence in the research group and learning about spin-off processes were important for the university which became a major shareholder in the company Beta that was established to commercialize the technology. The founders and the university managed to obtain funds from several public support programs and some new owners provided equity. During the process of obtaining the IPR and establishing Beta, the founders had developed an extensive network and knowledge about the industry. "*We got much advice and many contacts, so we came out much stronger in order to be able to develop a company*". Based on this, experienced people were hired to strengthen the management of Beta. As Beta develops into an independent venture, the distinction between university activity and business activity creates discussion about calculating and pricing of time and resources. The university lacks experience for how to handle such cases, and even if the attitude is positive, this issue requires much attention from both parties. Beta has now built a professional team, obtained the first round of funding, and have started to commercialize the technology.

Table 6.6: The spin-off process of case Beta

Phase / Beta	Research comm. and opportunity screening	Organization in gestation	Proof of viability	Maturity
Oppor-tunity	-Medical effect discovered -Many years of further research conducted in cooperation with industry	-Scope of research narrowed down to commercial target -Focus on application with shortest time to market	-Define development project with clear milestones	-Project has not entered this phase
Individ-uals	-Research team relates to industrial partner	-Research managers become entrepreneurs	-Entrepreneurial team strengthened by consultants	-Project has not entered this phase
Univer-sity context	-Houses applied research project	-Strong support from university resources -Focus on creating internal legitimacy	-Difficult to manage overlap between university and commercial activity	-Project has not entered this phase
Extern. context		-Industry partner pull out due to general situation		-Project has not entered this phase

6.7.3. Spin-off Case Gamma within University A

Although the university plays a central role, Gamma is formally a spin-off from another company that spun out of the same research group eight years earlier. This first spin-off (SPIN1) was established as a continuation of a cooperation with an industrial partner which had led to the development of the core technology. SPIN1 maintained close relations with the research group at the university and was by the researchers seen as an entity for applied projects and acted as a development company for the technology base which the research group specialized in. This technology has several applications, and a new opportunity emerged after a process where the university, SPIN1, and a large company in this area discussed the commercial opportunities. During an idea search process at the department initiated by the university (TTO), this idea was discussed further. The idea is within a field of strategic importance to the university that has decided to invest in laboratory facilities and support a joint venture to commercialize the idea. Gamma was established to commercialize the SPIN1 technology for application in this area. To lead this project, the CEO of

the industrial partner who initially led to the establishment of SPIN1 was hired as CEO and entrepreneur of Gamma. Gamma is established as a subsidiary of SPIN1 and has become tenant in the university incubator. Gamma started on a prototype project where the university and SPIN1 play central roles and substantial funds from public sources and industry were obtained. The CEO built a business case including a broad industrial network and public funding for building a prototype in the university lab. Due to an unsettled disagreement within SPIN1 the Gamma project ceases to develop for a period. This situation is now cleared, and the product development is continued with funding from industrial partners and public sources.

Table 6.7: The spin-off process of case Gamma

Phase / Gamma	Research comm. and opportunity screening	Organization in gestation	Proof of viability	Maturity
Opportunity	-Academic and applied research activity -Use of technology in new area of application	-Search for possible industrial partners -Product specifications defined	-Technology development at university lab including building a prototype	-Project has not entered this phase
Individuals	-Idea discussed among university and industry collaborators -Consultants develop business plan	-Person with prior relations to the research group hired as spin-off CEO -Unclear commitment from owners and partners	-Professors central in technology development	-Project has not entered this phase
University context	-Idea discussed in a university initiated idea search process -Funds to develop business plan obtained	-University laboratory established -Spin-off established as university-industry joint-venture located in university incubator	-Multiple university roles, some not settled	-Project has not entered this phase
Extern. context	-Project within an emerging industry - Project within one of the strategic areas for the university	-Good opportunities for public funding within the field	-Public funds achieved for technology development -Industrial partners join the project	-Project has not entered this phase

6.7.4. Spin-off Case Delta within University A and B

For more than 30 years, a professor renown for being innovative and his group at University A have actively commercialized several research results. One of the professor's first PhD graduates has during the last 20 years founded or managed several companies based on university research from both this and other research groups. Patents and technology from the professor's research have been managed by a company which has been owned by the professor together with both industrial partners and the entrepreneurial graduate. This professor was also the source of the current idea, that was further developed through a student thesis and finally in a PhD project from 1996 to 2000. An attempt was made to sell this idea to the Norwegian industry, with little success. Approximately during the same period another of the professor's Master's graduates took his PhD and had a position at university B. He had family background among the potential users of the technology, and when he occasionally heard about the research project he saw its commercial potential and made contact. As the technology lacked an entrepreneur, this request was highly welcomed. The technology owners gave him the opportunity to commercialize the technology and supported him in this effort. The entrepreneur did not officially involve his employer (University B) in the spin-off project, but support measures and the advisory service connected to the science park at the university have supported the project. The entrepreneur has got a public grant to develop a prototype and has now left the university to focus on the project.

Table 6.8: The spin-off process of case Delta

Phase / Delta	Research commercialization and opportunity screening	Organization in gestation	Proof of viability	Maturity
Oppor-tunity	-30 years of research -Technology developed in PhD thesis	-Market opportunity perceived by former graduate at another university (B)	-Feasibility study and testing of prototype -Many practical problems to solve	-Project has not entered this phase
Individ-uals	-Persistent work on technology over many years by professor -Business partner and professor attempts to commercialize idea	-Prior graduate becomes entrepreneur and obtains rights to use the technology	-Some support provided by technology inventors	-Project has not entered this phase
Univer-sity context	-Several prior spin-offs from same university group (university A)	-Some support initiatives used for business planning (university A&B)	-Entrepreneur leave university work to focus on spin-off	-Project has not entered this phase
Extern. context	-Downturn in industry causes reluctance to invest in new ideas	-Public grants available	-Small scale cooperation with industry	-Project has not entered this phase

7. Paper 4 - University capabilities facilitating spin-off venture formation

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7.1. Abstract

This paper investigates the organizational routines within a university facilitating the creation of new ventures based on academic research. We look at the particular challenges related to the exploration and the exploitation of entrepreneurial opportunities within the university setting and introduce both de-coupling and integration mechanisms to configure resource for spin-off development. We introduce a set of four dynamic capabilities facilitating entrepreneurial processes within the university, emphasizing the creation of new paths of action; the creation of new knowledge resources; balancing past, present, and future positions; and the reconfiguration and integration of resources. These capabilities are explored by longitudinal studies of four spin-off cases. Implications for further research and policy are provided.

Keywords: Dynamic capabilities, Entrepreneurship process, University spin-offs

7.2. Introduction

Scientific knowledge becomes increasingly important for innovation, business development, and wealth creation. Government innovation policy states a new role for universities with respect to the commercialization of research results or 'entrepreneurial science' (Mansfield and Lee, 1996). Policy makers at the national, regional, and university level have allocated substantial financial and administrative resources to make the university more entrepreneurial and promote the creation of university spin-off ventures. Within universities, several institutional arrangements like technology transfer offices (TTO), incubators, entrepreneurship centers and internal seed funds are set up to increase the commercialization of research (Rasmussen et al., 2006c). The introduction of these new tasks at universities is not without controversy (Laukkanen, 2003). Conflicts are imminent between the new entrepreneurial tasks towards a market orientated ideology, and the traditional Humboldtian ideology of free education and open research. The commercialization process may therefore create new challenges for the university management. In spite of the numerous studies of different outputs from universities such as patents, licensing agreements, and spin-off ventures, we lack knowledge on how universities deal with and promote the formation of spin-off companies (Mowery and Shane, 2002; Nicolaou and

Birley, 2003a) and on how the new managerial tools for university entrepreneurship should be designed (Lockett et al., 2005).

This paper emphasizes the needs for organizational routines in order to facilitate the process of creating a spin-off firm within an organization characterized by a broad range of different stakeholders and partly conflicting objectives. We focus on the entrepreneurial process of creating new commercial spin-off companies based on university research, from the emerging research idea until the launch of an independent new firm. The university spin-off can be seen as the result of a corporate entrepreneurship process, with challenges related both to exploration of new commercial opportunities based on key personnel competence, and exploitation of resources redirected towards the venturing process (Sharma and Chrisman, 1999). The corporate entrepreneurship literature emphasizes the challenges of giving birth to new business within an existing organization and the transformation of organizations through a renewal of their key ideas (Guth and Ginsberg, 1990). This paper looks into the process of developing a new venture, and the interaction between the spin-off entrepreneur(s) and the university as the mother organization. Taking into consideration the potential for conflict and the organizational characteristics, we include an emphasis on actions needed to meet the specific organizational challenges of a university setting.

The barriers for entrepreneurship within a university setting are inherent in a decision making processes within university organizations characterized as complex and ambiguous (March and Olsen, 1976), conflict-loaded (Navarro and Gallardo, 2003), and with a high degree of autonomy within each research group reducing the opportunities for top-down governance (Etzkowitz, 2003; Weick, 1976). These features make the university different from a business corporation and strategic planning becomes a challenging task (Harvey et al., 2002). Thus, the university may contain barriers that severely hamper the facilitation and support of new research-based ventures. As suggested by Lockett and Wright (2005), referring to the dynamic capability literature, the university business development capabilities are important for spin-off creation. Prior research has, however, been more occupied with university characteristics leading to spin-off formation (Link and Scott, 2005; Roberts and Malone, 1996; Shane and Stuart, 2002), rather than how the universities can facilitate spin-off creation. More

knowledge is needed on the internal processes of channeling scarce university resources towards new firm creation, and the adaptations necessary to facilitate change in this particular setting. We contribute to the discussion on routines within the university organization that may help the university management to increase the number and performance of research-based spin-offs. The spin-off process has important strategic implications for the whole university, emphasizing the need to look closer into the strategic management of the university.

We introduce the dynamic capabilities perspective to illuminate possible organizational tools facilitating corporate entrepreneurship within this loosely-coupled and complex setting. The challenge of the university organization is to create unique, knowledge-intensive business ventures with high commercial value and competitive strength. The dynamic capability perspective highlights mechanisms that build, gain, integrate, reconfigure, and release internal and external resources to address rapidly changing environments (Eisenhardt and Martin, 2000; Griffith and Harvey, 2001; Teece et al., 1997). The dynamic capability approach has, in particular, contributed to an increased focus on the manipulation of the knowledge resources, and the internal processes needed to handle new bundles of resources in an organization pre-occupied with other tasks. This perspective may prove fruitful in a university context due to its emphasis on the process of reconfiguring present resources and on mechanisms for renewal and development of competence resources. Tailor-made dynamic spin-off capabilities may increase the pace of change and contribute to the formation of new business ideas and subsequent high-growth spin-off ventures. Thus, the dynamic capabilities are routines to facilitate change and a continuous entrepreneurial process within the university. They represent routines or working patterns that gain access to, modify, and integrate critical resources without generating new devastating conflicts within the university organization (Mauri and Michaels, 1998).

This paper contributes to the spin-off literature by illuminating the difficulties of integrating commercialization processes into a university organization, and by presenting a set of dynamic capabilities or routines that may facilitate the spin-off process without up-scaling internal conflicts and avoiding sub-optimalization within the present organization. The next section outlines the characteristics of

the university and the challenges connected to entrepreneurial and commercial activities within a university organization. Further, we present the dynamic capabilities perspective and outlines four propositions that may provide a broader theoretical platform for managing entrepreneurial spin-off processes in a university setting. We build upon explorative studies of four spin-off processes to illustrate the action patterns and the different dynamic capabilities needed to facilitate entrepreneurship. Finally, implications for further research and policy are provided.

7.3. Theoretical platform

7.3.1. The university context

The university has been regarded as a challenging type of organization providing composite products within education and basic research. To achieve its objectives, the university organization is characterized by a fragmented structure with loose couplings between different parts of the organization (Weick, 1976). Participation in the decision-making process is often fluid, and the number and role of actors involved, and the amount of effort they put in, are uncertain and changing (Cohen et al., 1972). Internally, this complexity is due to the highly specialized competence and autonomous work practice of the employees, the creative nature of work tasks, and the norms and structure of the science system (Merton, 1973b; Stephan, 1996). Externally, complexity is evident from the many stakeholders in the university operation such as government, students, funding agencies, industry, and other adopters of research results. Diverse goals and outputs such as teaching, research, social responsibility, and both non-profit and commercial activity add to this complexity (Lee, 1996; Navarro and Gallardo, 2003).

The characteristics of the university setting have given birth to the "garbage can" model describing the university as a decision-making arena with several streams of goals or problems, solutions, and decision-making opportunities, as well as uncertainty about whether decisions are made and their final outcome (Cohen et al., 1972; March and Olsen, 1976). The garbage can model illustrates the challenges of introducing new target-oriented and resource-demanding tasks, new processes requiring decision-making stringency, as well as commercial self-

interest into this type of organization. Hence, facilitating commercialization processes such as spin-off creation may be particularly challenging within a classic type of university building upon a Humboldtian tradition of public education and open research.

The description above illustrates the need to differentiate between different types of organizations when it comes to entrepreneurship (Morris and Jones, 1999). The university setting is different from both the individual and the corporate entrepreneurship context that have received most of the attention within entrepreneurship research. Table 7.1 illustrates some of the differences in the entrepreneurial context between the independent entrepreneur, the corporation, and the university.

Table 7.1: Differences between independent, corporate, and university setting

	Independent entrepreneur	Corporation	University
Stakeholders	Few	Many	Many, diverse objectives
Hierarchies	None	Several	Few
Rules and procedures	Low	High	Both high and low
Main orientation/focus	External	Internal and external	Internal
Main objective/ incentives	Personal gain	Shareholder, commercial gain	Public, non-commercial, academic
Internal communication	Person-to-person	Personal and organizational links	Individualized, limited couplings

In contrast to the university setting, the entrepreneurial process within a business firm is characterized by a sharp commercial focus, a more stringent decision-making process, and top-down manipulation of resources. Thus, in order to facilitate new commercial ventures, it may be expected that universities need not only to introduce activities to explore and exploit new opportunities. In addition, they have to develop the necessary structuring mechanisms to increase speed of decision-making, provide the internal and external communication links, and introduce mechanisms for reducing conflicts between tasks (Navarro and Gallardo, 2003).

The garbage can model implies that we should look more closely into integrative mechanisms governing the stream of entrepreneurial elements that add up to the

formation of a new business venture. Introducing routines and structures may influence the outcomes from a commercialization process in three ways. First, they affect the time pattern of the arrival of problems, choice opportunities, solutions, or decisions makers. In a commercialization process, the time pattern has to be structured to secure that all the building blocks of the firm is present at the right time in the business development process. Second, they determine the allocation of resources or energy by potential participants into the decision-making process. In a research-based spin-off, the contribution of persons with specialized competence and key decision makers is crucial for the development of a research idea into a commercial product. Third, they establish linkages among the various streams, both to increase speed of decision-making and to balance interests. With a broad set of stakeholders, and a broad set of responsibilities related to each of the researchers involved in the spin-off process, establishing linkages between different resource areas and interest groups is crucial both to achieve the necessary resources, and to reduce the risk of conflict. Thus, the university needs routines that are able to cope with extreme complexity and the transfer of energy towards new strategic tasks. Also, there have to be routines for reducing the conflict potential related to present tasks or, even worse, problem avoidance. These "anarchic" decision-making characteristics and the broad set of potential conflicts of interests have so far received limited attention within the university spin-off literature.

7.3.2. Entrepreneurship within the university context

Stevenson and Jarillo (1990:23) define entrepreneurship as "*... a process by which individuals – either on their own or inside organizations – pursue opportunities without regard to resources they currently control*". New firm venturing inside an organization may vary in terms of structural autonomy, the degree of relatedness to existing business, extent of innovation, and nature of sponsorship (Sharma and Chrisman, 1999). University spin-offs are characterized by knowledge-intensive products where the fundamental resource is the basic research conducted by a researcher or a research team. For instance, the intellectual eminence of universities is related to a higher spin-off rate (Di Gregorio and Shane, 2003).

In order to create commercial opportunities from research results, both the creative ability to explore new business models and the ability to exploit these concepts through transformation into a viable business platform is important (Katila and Ahuja, 2002; March, 1991; Schumpeter, 1934). During the explorative opportunity-seeking process, the research-based knowledge of the university faculty has to be transformed into commercial models showing how resources are linked to form a new venture and meet market needs (Shane, 2003). This act of entrepreneurship is strongly related to the capacity and motivation of the individual researcher (Gaglio and Katz, 2001).

In the process of exploiting possible opportunities, the access to university resources may represent a challenging task with a number of underlying tensions (Lockett et al., 2003). Establishing a new research-based knowledge-intensive firm is extremely resource-demanding. The university managers have to make difficult decisions on how much of scarce financial, organizational, and personal resources that should be channeled into the new commercial project. Due to differences in objectives and rationale of action, the university needs balancing capabilities to avoid too heavy emphasis on either activity, among others to avoid devastating organizational effects of too costly exploitation activity (Levinthal and March, 1993; Weick, 1976).

The resources needed in the entrepreneurial process may be locked into existing patterns of action like education and basic research. This means that internal de-coupling activity and integration towards external actors providing new financial and market-based knowledge resources may be crucial for the entrepreneurial process. Thus, the university needs organizational capabilities to reposition resources related to the faculty, and to achieve new resources such as entrepreneurial competence, market knowledge, and links to external resources like equity capital providers and actors within the regional innovation system.

Traditionally, the incentives within the university are in particular related to scientific and teaching capabilities, and not to commercialization skills. In contrast, external interests may be looking for direct economic activity emanating from investments in the university sector. For instance, the public, business interests, government, and regional authorities at different levels often have high expectations about the university spin-off role (Miner et al., 2001). As

a consequence, the university resources such as university professors, research facilities and laboratories, competent students, and financial support are in high demand.

The university management has to act strategically and develop the organizational routines that both encourage the entrepreneurial process towards creating successful new spin-off ventures, and at the same time protect intellectual properties and secure the optimal configuration of scarce resources towards the broader set of objectives at different levels. The university may also become an active stakeholder in the new commercial firm through patents and ownership. Increased complexity is imminent as the university enters a new area of activity; as investor where high values may be at stake.

We state that the university needs specific capabilities to facilitate the entrepreneurial spin-off process in order to provide the necessary resources and to avoid conflicts with other university stakeholders. These capabilities may have distinct qualities compared with commercial organizations due to the particular organizational characteristics of the university. Thus, we claim that action is needed along two main alleys, with consequences for the organizational capabilities of the entrepreneurial university. The first line of action consists of processes to develop new business concepts, where both exploration and exploitation efforts are needed. The second line consists of processes to reconfigure resources for spin-off development, where activities related to both de-coupling and commercial integration are present. Figure 7.1 illustrates these central lines of entrepreneurial action within a university.

Exploration is defined as the experimental process of creating a broader specter of opportunities and searching for new commercial ideas. This relates to action towards exploration of opportunities creating and amplifying fluctuations that initiate new order in the form of alternative commercial patterns. Exploitation is the process of effective allocation of resources into valuable and competitive business platforms based on existing knowledge (Holmqvist, 2004; March, 1991; Minniti and Bygrave, 2001). This relates to the exploitation of existing resources and competencies towards a new prototype and commercial concept. De-coupling is the process of releasing bindings between existing resources and breaking up old patterns within the academic university structure so that they

may be linked together into new patterns. The integration process is defined as activities to bundle both the existing and the new resources available into resource configurations that can form the resource base for a new independent spin-off firm (Chiles et al., 2004).

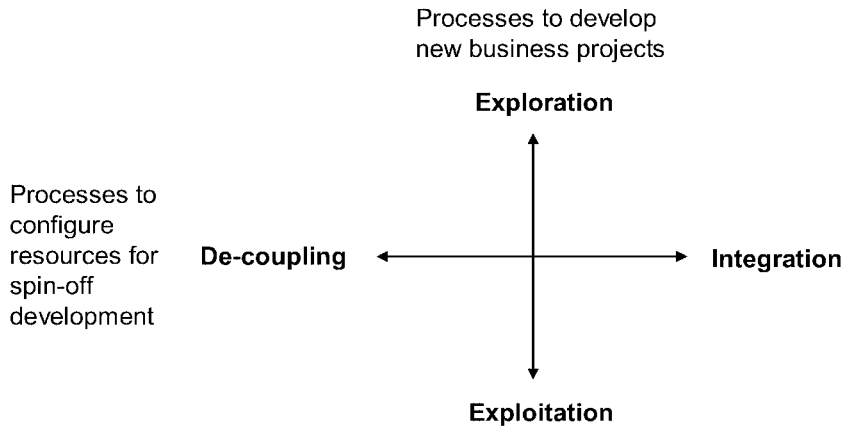

Figure 7.1: Capability dimensions within the university setting

7.3.3. Dynamic capabilities within the university

The presentation above describes several strategic challenges within the university related to multiple outputs, stakeholders, and goals as well as actions to overcome these barriers. We have pointed to a number of operational and cultural differences between the academic system and commercial entrepreneurial processes (Stephan and Levin, 1996). To facilitate entrepreneurial processes, the university has to develop organizational capabilities or routines that may stimulate action within the two action lines of exploration/exploitation and de-coupling/integration. Such mechanisms are, however, not easily tracked or managed, they are often individualized, based on tacit knowledge, and socially and emotionally embedded (McGuinness and Morgan, 2000).

The dynamic capability (DC) framework is about knowledge-handling routines that facilitate entrepreneurial change (Grant, 1996; Pisano, 1994). In particular, the focus is on latent rules and routines stimulating the creation of new distinctive and difficult to imitate advantages. Within the university, this includes research generating new knowledge resources, managing the creation of new business concepts, the operational management of present activities, and balancing or removing traces of earlier paths that may hamper the renewal processes. Path dependencies may be rooted in the classic university values emphasizing education, open debate, and transparent research.

The DC approach highlights in particular the development and manipulation of future knowledge resources (Grant, 1996; Kogut, 1996), making it especially relevant for the analysis of knowledge-intensive organizations. Hence, the DC framework may be particularly suited to the study of technology transfer and spin-off formation from universities. The framework deals with rapid technological change – which is the very basis for university entrepreneurship. Further, the DC framework leaves room for the idiosyncratic development of unique opportunities, addressing a weakness within the resource-based view of the firm by focusing on process rather than specific strategies and resources. The DC approach also pays attention to current positions and previous history making it possible to integrate the university's versatile missions and the principles of the science system together with the aim of increased commercialization of research. The DC view is not only concerned with resources inside the firm's borders, but also emphasizes processes towards achieving the necessary control over resources owned by others (Barney, 2001; Hitt et al., 2001). Thus, the DCs do not only affect the output for the organization in which they reside, but also indirectly through influencing operational capabilities (Helfat and Peteraf, 2003).

Many universities offer a range of support initiatives to stimulate and to protect the researcher such as leave of absence, the use of infrastructure and working time, scholarships and grants for project development, training programs for entrepreneurs, and consulting services (Rasmussen et al., 2006c). Organizational units like incubators, technology transfer offices, entrepreneurship centers, and commercialization units also play a role in bridging the boundary between the university and the commercial world. Still, we do not know how these tools are

related to the basic challenges of entrepreneurship within a university, and we lack a theoretical platform for designing such tools. There is a need for more research showing the relation between the activities within a commercialization process, and the university capabilities or routines needed to facilitate such dynamic processes (Lockett and Wright, 2005).

One reason for the problems in developing such routines may be that the capabilities for spin-off creation have to include and balance several different types of action. It might be that commercial exploration routines also need to contribute to the de-coupling of critical resources from traditional tasks within the organization, for example from traditional ideologies or ways of thinking. Stacey claims: "*...that for a system to be innovative, creative, and changeable it must be driven far from equilibrium where it can make use of disorder, irregularity, and difference as essential elements in the process of change*" (1995:490). Likewise, new behavior or properties might emerge that have to be aligned or 'resonated' into the organization (Macintosh and Maclean, 1999). The exploration supporting routines may also contribute to integrative action helping in transforming the research-based knowledge into new business models. For example, these routines may help reduce the risk of too much focus on the research findings and the technology, with emphasis on "technology-push" rather than "market-pull", regarded as a hampering factor in the new venture process (Samsom and Gurdon, 1993). There is also a need for routines to stimulate the exploitation of new commercial ideas that at the same time provide the necessary de-coupling from the academic setting, such as releasing the researcher from current activities of research and teaching. Further, there is a need for exploitation-supporting routines that integrate internal and external resources into commercial resource configurations.

Following the theoretical implications from the dynamic capability perspective, we may find a theoretical platform for the more complex routines facilitating the combined action patterns like (1) explorative and decoupling actions, (2) explorative and integrative actions, (3) exploitative and de-coupling actions, and (4) exploitative and integrative actions. Hence, we suggest four categories of combined dynamic capabilities. First, the university needs capabilities that may reduce the path dependency of earlier strategic adaptation and resource bundling, and stimulate the exploration of new paths showing the direction for

the new venture. Second, the university needs capabilities that explore new valuable resources through internal learning processes and that link up to external complementary competence. Third, to avoid conflicts and secure resources for a longer range of time, there is a need for capabilities that balance the present and the future interests of the organizational stakeholders, not least by protecting the new commercialization process from counter-acting interests within the university organization. Finally, the university needs capabilities that reconfigure the available resources into a suitable exploitative pattern and link them together into a commercial venture.

These four capabilities are illustrated in Figure 7.2, and a proposition related to each capability is outlined in the following sections.

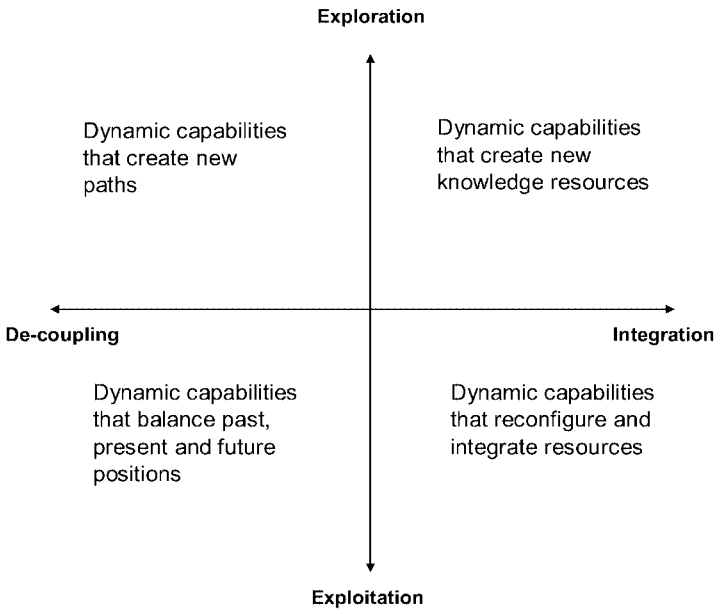

Figure 7.2: Capabilities facilitating entrepreneurial action within universities

7.3.4. Dynamic capabilities that create new paths

This category of DC is expected to facilitate combined explorative and de-coupling action. The present position of an organization, its repertoire of

routines and physical resources, may create a history that constrain future strategic action (Teece et al., 1997). Innovations are about finding and exploring new concepts and adapting these to a viable mode of exploitation.

Messeghem (2003) claims that organizations with a strong entrepreneurial orientation develop a specific managerial activity pattern suitable for corporate entrepreneurship related to the combined level of innovation, proactiveness, and risk-seeking. Entrepreneurial orientation suggests that some institutions are more willing than others to continually search for opportunities and solutions outside the realm of their current activities and look out for risky adventures (Lumpkin and Dess, 1996). Proactiveness reflects the firm's propensity to undertake a continuous search for opportunities, especially opportunities that do not pertain to the firm's current activities. Radical innovation comes from generating a new sense of destiny, from unleashing the imagination of people across the organization, and from looking for unconventional opportunities. These are all important properties for exploring new business opportunities within the university context.

The creation of university spin-off ventures is dependent on accessing resources mainly occupied by other stakeholders. There is a risk that the academic community puts constraints on the development of commercial concepts. Channeling faculty resources towards new entrepreneurial tasks means less focus on the traditional university objectives of education and basic research. Hence, there is a need for capabilities to patch or realign business concepts where resources are added, combined, or split (Eisenhardt and Brown, 1999). Greene et al. (1999) argue that in order to achieve spin-off success, the organization has to map a broad set of resources and competencies, both existent and emergent.

The decoupling process may prove easier in a university than in many other organizations. Universities may here benefit from their open structure with high autonomy and few formal borders. If properly handled, this may increase the flexibility, the speed of decision-making, and the opportunities for linking resources in different parts of the organization (D'Amboise and Muldowney, 1988). This also includes reducing the barriers towards resources in the environment, especially commercial partners. Linked to the exploration side,

this may represent a benefit for the university setting in particular. The dynamic capabilities are here inherent in the autonomy and motivation of each researcher and department. Hence, routines to make spin-off creation a viable part of the university operation might be needed.

P1: There is a positive relation between new action path mechanisms and spin-off based entrepreneurship within universities

7.3.5. Dynamic capabilities that create new knowledge resources

This category of DC is expected to facilitate combined explorative and integrative action. Exploration has to be balanced with action to adapt new ideas into viable commercial concepts that can be developed into new business platforms. This means adaptating to customer needs, government regulations, and the potential threat from competitors. From studying cases of university spin-offs, Vohora et al. (2004:161) propose that *"without developing or accessing the capability to combine scientific knowledge with a commercially feasible offering that satisfies an unfulfilled market need, academic scientists would not be able to proceed towards commercializing their technologies"*. Several studies points to the risk that advanced knowledge based ideas may fade away if the idea is separated from the creator or researcher (Henrekson and Rosenberg, 2001; Stankiewicz, 1986). The lack of business experience and management skills is recognized as a potential barrier to success for venturing scientists (Radosevich, 1995). Hence, routines that facilitate the integration of internal and external resources might play a crucial role. Personal interaction between university researchers and people with market knowledge leads to the identification of new opportunities and subsequently into the development of a business venture (Bird and Allen, 1989).

The university may develop capabilities that "make the thousand flowers bloom" by increasing the number of ties between the different parts of the university and towards creative resources in the environment. Several studies show that researcher networking and interaction with industry is associated with spin-off formation (Grandi and Grimaldi, 2005; Nicolaou and Birley, 2003b; Shane and Stuart, 2002). The integrative action is important to provide the

necessary broadness related to new competence resources, as the new venture often needs more general knowledge than the initial, often technology-based, innovation. This implies new knowledge creation in cross-disciplinary teams and links to other parts of the innovation system. The spin-off project needs significant new knowledge related to customers and the market mechanisms for input of capital and personnel.

P2: There is a positive relation between new knowledge creation mechanisms and spin-off based entrepreneurship within universities

7.3.6. Dynamic capabilities that balance past, present, and future positions

This category of DC is expected to facilitate combined exploitative and de-coupling action. The future possibilities of an organization are partly decided by its history and current position (Teece et al., 1997) and a university's previous success in technology transfer is found to be a key explanatory factor for spin-off creation (O'Shea et al., 2005). Further, several studies conclude that local cultures and norms are important for stimulating entrepreneurship at university departments (Chrisman et al., 1995; Franklin et al., 2001; Kenney and Goe, 2004; Louis et al., 1989). An important challenge, that may hamper the academic entrepreneur and the spin-off project, is the risk of conflicts with other faculty members and the university organization related to issues such as use of time and resources, intellectual property ownership and rewards (Stephan and Levin, 1996), and violation of academic norms (Nelson, 2004).

Within government institutions, such as universities, one may find bureaucratic regulations, red tape, and power play that may induce negative sanctions, especially related to new and unfamiliar activities. Previous failures and successes may facilitate and constrain future activities, and conflicts occur where basic values are contradictory. The capabilities of balancing the historic values and objectives of the academic research community with the new more commercially oriented focus is crucial for the entrepreneurial university. The high number of stakeholders within the university setting may represent a challenge as soon as resources are moved from one activity to another. Hence, there might be a need for routines to separate and protect the spin-off process

from the many other objectives and stakeholders in the university context. This might include meeting places for the significant stakeholders and conflict resolving mechanisms to balance the interests of the organization.

P3: There is a positive relation between university mechanisms that balance past, present, and future positions, and spin-off based entrepreneurship within universities

7.3.7. Dynamic capabilities that reconfigure and integrate resources

This category of DC is expected to facilitate combined exploitative and integrative action. To exploit the available resources in a market context, there has to be knowledge about how to run a firm and how to link possibly conflicting resources and interests. On the integrative side, a combination of resources is the impetus for the new venture creation process (Greene et al., 1999). New combinations of productive resources have to be identified in the organization and the capabilities could be extended by discussing synergies between resource combinations within and outside the firm (Venkataraman et al., 1992). Connecting several organizations with different resources also enhances the organization's ongoing adaptation. Such linkages both improve overall innovation management, enable the organization to reconfigure its resources, and provides ways to experiment with new ideas (Dougherty, 1992). Developing networks with industry and the business community might be an important element in integrating external resources into university spin-off processes (Pérez and Sánchez, 2003).

Linked to exploitation, the integration activities have to be target-oriented towards finding the building blocks towards a new business firm, based on both experience and new knowledge. Not least, there will be a need for the entrepreneurs to take part in the knowledge of persons with practical experience in the market. Hence, there might be a need for routines to bring in and integrate external resources strengthening the spin-off project.

P4: There is a positive relation between reconfiguration and integrating mechanisms and spin-off based entrepreneurship within universities

In the remaining part of this paper we use illustrative cases to elaborate on the specific contents of the four types of dynamic capabilities outlined above.

7.4. Methodology

A longitudinal case study research design was chosen to key into the development process of university spin-off creation and its different activities (Eisenhardt, 1989). This approach gave us a richer contextual insight, an opportunity to develop trust relations to the actors, and an in-depth understanding of a process that have been scarcely investigated in prior studies. Parallel to the case studies, theoretical constructs were developed from the entrepreneurship and dynamic capability literature to broaden the perspective and create a multi-disciplinary research platform (Borch and Arthur, 1995).

7.4.1. Case selection and data collection

This study includes two universities representing typical segments in the European university system. The two universities were of different age and size presenting high variety in context (Yin, 1989). University A is quite large with a history of more than a hundred years, while university B is smaller and thirty years old. The spin-off cases were chosen in order to achieve a high degree of variation on key variables. Two cases come from research groups within university A, having traditionally strong ties to the industry and from where a number of companies have spun-out throughout the years. University B traditionally had much weaker ties to the industry, and fewer examples of spin-off companies. We chose cases where the technological basis for the spin-off was based on university research, and the academic researchers played an important role in the initiation and development of the spin-off project. Table 7.2 shows central properties about the cases selected for this study.

Table 7.2: Central properties of spin-off cases summarized

Topics and events	Alpha (A)	Beta (B)	Gamma (A)	Delta (B)
Founder(s)	Four professors	Two professors	Joint venture	One researcher
University ownership	No	Yes, major	Yes, minor	No
Premises	University incubator	University incubator	University incubator	- (Entrepreneur)
Main R&D partner	Industry	University	University	Ad hoc.
Most critical source of opportunity development	One professor's industrial experience	Prior industry cooperation	Prior spin-off and industry network	Founders own practical experience
Field of research	Engineering	Biotechnology	Engineering	Engineering
Product	Software	Medicine	Electro-mechanical	Electro-mechanical

Data triangulation including several sources of data was used to map out the situation and critical events prior to and during the development of the spin-off projects. Secondary data from the universities was collected through documentary sources such as strategy plans, annual reports, and web pages. Primary data from each university was collected through visits, conversations, and interviews for a four year period at university A and a two-year period at university B. Primary data from the spin-off projects was collected by 6 to 16 personal interviews at each case conducted throughout a 12-15 month period. People in various positions were interviewed including: company founders and entrepreneurial team members, researchers, university managers, and people involved in commercialization support. Following a narrative approach (Polkinghorne, 1988), the interviews induced the interviewees to describe his or her involvement in and knowledge of the spin-off project from its inception up to date, with a minimum of interruption by the interviewer. This type of narrative interviewing (Czarniawska, 1998:29) was done in order to get closer to the actual events and to avoid that personal views and theoretical perspectives influenced the data collection. Most interviews were recorded and the transcriptions were done by one of the authors as a part of the data analysis process. For each of the firms, archival data, including financial reports, business plans, market analyses, and research documents, were achieved. In

addition, relevant written documentation was collected both from the informants and other sources like magazines, newspapers, and the internet. By combining the different sources of information and collecting information over a period of time doing repetitive interviews with central informants, an in-depth description of the research and commercialization process was obtained. For confidentiality reasons the cases are anonymized, and some of the factual information has been slightly adjusted. Confidentiality has resulted in a richer set of data including better access to documentation and more honest statements from the informants.

7.4.2. Data analysis

The data analysis has been an integrated part of the data collection process. The collected data provided both narrative accounts of the process (Czarniawska, 1998; Pentland, 1999) and factual descriptions of context, actors, and events from a large number of sources. From the data we identified critical characteristics and events influencing how the spin-off process emerged and developed in the university context. In order to derive at theoretical explanations for the processes observed, we identified observations that matched theoretical concepts (Borch and Arthur, 1995). The theoretical concepts were formed to match the empirical data in an interactive process. As the analysis proceeded, the overarching logical frame shifted from exploring data using retroduction to verifying theory through deduction (Van de Ven and Poole, 2002).

7.5. Findings

This section presents the findings from our cases by using the theoretical framework developed above. This framework emphasizes the role of the university context and the university mechanisms in facilitating the entrepreneurial process of developing the spin-off companies.

7.5.1. The spin-offs

Some characteristics of the four spin-off projects as they emerge and develop within the university context are outlined in Table 7.3. We see that the founders, the university and a number of both public and private actors have played significant roles.

Table 7.3: Characteristics of the spin-off projects

	Alpha	Beta	Gamma	Delta
Source of initial idea	Industry need	Basic university research	Industry partner	University research
Source of basic technology and competence	University research and industry experience	Industry sponsored university research	University research and prior spin-off company	University research
Major performer of technology development	Founders	University	University	Founder
Other performers of technology development	Industrial partners	Additional research partners	Prior spin-off from same university group	Technology inventor at university
Major role in market development	Founding team (professors and external members)	Founders and new management	Interaction between CEO, professors, and industry partners	Founder assisted by science park advisor
First commitment for funding	Public sources	University	University	Public sources

7.5.2. The interplay between the university and the spin off project

We have argued that spin-off processes within the university context are dependent both on processes to create new business concepts in the form of exploration and exploitation, and on processes to configure resources for developing spin-off ventures through de-coupling from the academic setting and integration with the commercial setting. Table 7.4 exemplifies how these processes were apparent in the four spin-off cases and how the university setting contributed.

Table 7.4: Spin-off processes and the university role in the four cases

		Alpha	Beta	Gamma	Delta
Processes to create new business concepts in a university setting	Explor-ation	-New combination of research fields -Creative idea development process in founding team	-Invention discovered from basic research -Search for a way to continue research project	-Searching for new business areas to apply technology -Idea search process initiated by the university	-Innovative university professor -Professor searching for ways to commercialize technology
	Exploit-ation	-Tenant in university incubator -Use of sabbatical year for firm formation	-Narrow project down to meet commercial requirements -Use of university laboratories and tenant in incubator	-Forming joint venture between university and industry -Establish laboratory at university	-Research projects and students used to develop prototype -Partner with entrepreneur due to lack of interest from industry
Processes to configure resources for developing spin-off ventures in a university setting	De-coupling	-Ending the professors' existing relations to industry partners -Less focus on research and teaching	-Move the research activity into spin-off firm -University management supporting spin-off project internally	-University TTO working on agreements and IPR issues	-Technology owned by professor's holding company -Entrepreneur leaves the university
	Integration	-Including external experience in funding team -Including industrial competence in business development	-Include industry experience in project team and board	-Hired CEO with industry experience -Inviting industrial partners to join project	-Informal relation to university resources -Resources from government support agency involved

The empirical findings illustrate that the process of creating university spin-offs includes a broader set of activities than emphasized in most existing spin-off literature. In the following sections, the four cases will be used to discuss how

the four types of dynamic capabilities outlined above may influence the university spin-off processes.

7.5.3. Dynamic capabilities that create new paths

The spin-off projects were initiated by creative and experimental behavior among university academics and all four cases were based on basic research activities within the university. The innovative combination of two engineering fields by two PhD students created the knowledge base on which Alpha is based. The medical effect exploited by Beta was initially discovered by a group of young and curiosity-driven researchers. Discussions between academics and practitioners were central for developing the technology which Gamma were based on. Hence, the university's emphasis on academic freedom, flexible conditions for doing fundamental research, and securing the activity of dynamic research teams were highly important in order to create the new knowledge that formed the basis for the subsequent spin-off project.

Another important condition, both for the decision to start the spin-off process and for the further development, was the signals from policy makers and university management that spin-off activity had their support. Due to recent national policy changes, the universities have been very supportive to the spin-off projects. New conceptions of what is viable behavior in a university setting make the step from traditional behavior possible. One of the founders of Alpha said that *"I was asked 10 years ago if it could be viable to start a new venture, but at that time I considered this to be impossible. The prevailing attitude was that it would be a personal defeat to fail and little credit to gain from trying. There where no incentives to leave a safe position at the university"*. Increased interest for entrepreneurship among students was also mentioned as one of the factors triggering the professors to look for entrepreneurial opportunities. In recent years *"the students started to gain interest in starting new ventures and writing business plans"*, and *"the issue of forming new ventures became a topic at the university and the signal from the central university management was that they looked favorable on such initiatives"*. *"Also the tremendous success of the company X which spun-off from another university department made great impression"* (Founder Alpha). Thus, in this situation the professors chose to

pursue a spin-off project instead of following the traditional industry consulting pattern.

In addition to the general acceptance and support of spin-off activity perceived by the university researchers, direct university support was sometimes crucial. In case Beta, the process of taking over the project and the related patents from the industry partner was long and cumbersome. The university was heavily involved in this process with considerable financial and administrative support. *"I do not know how this had ended if it had not been that we had this backing from the university management"* (Founder Beta). Another example of proactive university support can be found in case Gamma. Although the researchers had discussed the idea earlier, it was brought further after an idea search process conducted by the university TTO. An example of flexibility in the university can be found in case Alpha, where the professors were able to explore the possibility of starting a new venture without leaving the university position. The tradition for doing external work with the industry gave room for the professors to spend time on the spin-off project instead.

In the first proposition we suggested that there is a positive relation between new action-path mechanisms and spin-off based entrepreneurship within universities. The cases reveal that a learning process took place at the university level for how to handle spin-off cases. From our cases we found that increased legitimacy and supportive attitudes towards entrepreneurship among research teams and students may play an important role in the process of spin-off initiation. Likewise, the entrepreneurial objectives of university management may also play a role and direct university support can be an important catalyst for succeeding with the spin-off projects. For instance, good opportunities for taking leave and sabbatical arrangements make it possible for the professors to experiment without risking their jobs.

Because they are based within the university culture, it seems like some of the university capabilities take some time to build and cannot be implemented only by setting up structures and policies. Here, the attitudes among colleagues, role models, and even student attitudes can play important roles. In our cases, the cooperation with industry has been a central premise for being able to form the idea and having competence and networks to start developing the spin-off

project. There are, however, several ways to gain such competence, such as: mobility between university and industry, cooperative research and consulting, and contacts with former students. This indicates that university capabilities can be based at multiple levels in the organization. Hence, both bottom-up and top-down policies (Goldfarb and Henrekson, 2002) can be effective.

7.5.4. Dynamic capabilities that create new knowledge resources

The total competence and composition of the entrepreneurial team was frequently considered as the most valuable asset for exploring and developing the spin-off projects. Especially, the role of industry experience was seen as crucial. Traditionally, professors within European universities rarely have strong links to industry as part of their career. *"I think the founders of Beta are atypical as researchers. They have worked for an industrial partner for many years, so they probably have other attitudes than the average researcher"* (Consultant Beta). In case Alpha, the idea was identified by one of the professors who had a long career in industry. Also in case Gamma and Delta, the professors were generally eager to keep close contact with industry and conduct relevant research. *"By being involved in company X [industry partner] I know very much about how things work in the commercial world"* (Professor Gamma).

Although the entrepreneurial team is decisive, the university can also contribute to the spin-off projects by introducing new knowledge resources that are important for the exploration process. In the Gamma case, the university contributed to further development of the technology by investing in a new laboratory where the specifications partly were made to fit the needs of the spin-off project. Case Beta caused a radical learning process for the university organization, as prior experience and routines for handling commercialization cases was limited. Within the university, however, several individuals had relevant competence that was used to help the project in a difficult situation. According to one of the founders "*The competence at the university have had the same status as us [the founders], it has emerged as we have been working. I think both we and the university have learned a lot, but to learn as you go is not necessary the most efficient way to walk*" (Founder Beta).

In the second proposition we suggested that there is a positive relation between new knowledge creation mechanisms and spin-off based entrepreneurship. It seems clear that it is of crucial importance to integrate industry experience into the spin-off projects. This can be done in several ways such as: the establishment of cross-functional research teams, networking and cooperation with industry, training for academic entrepreneurs, personnel mobility, including industry competence in the entrepreneurial teams, and through a learning process involving the academic entrepreneurs.

7.5.5. Dynamic capabilities that balance past, present, and future positions

The adaptation to the business environment may represent a difficult task within the university organization. This challenge was dealt with through continuous information exchange and active dialogue where the expanded business-oriented activity of the professors was discussed and partly accepted within the university. *"The university is updated on what we do. We have put all facts on the table from the beginning"* (Founder Alpha). In the Alpha, Beta, and Gamma case the academic entrepreneurs had interactive processes with the university to find arrangements and regulations in the interface between the spin-off company and the university interests. This was important for legitimizing the spin-offs, both internally and externally. Another approach was chosen by the entrepreneur of Delta who left the university as soon as he had obtained enough resources to be able to develop the idea further. Still, he had access to some university resources through informal contacts.

The importance of having a clear and unambiguous relation to the university was emphasized by several informants. Legitimacy had to be gained at several levels in the university organization and this process might be both time and resource demanding. *"When we started the project, having a company funding our research and taking patents on it, this was not always perceived as being positive among our colleagues. This is a maturation process, but there are still some critical voices. As we have published quite a lot, graduated many students, and been a cooperation partner in research, the attitude to our work has gradually become more positive. It is also good to have contractual agreements with the university to have a clear relationship"* (Founder Beta). The CEO of

Gamma spent a lot of time in formalizing the relation to university resources such as use of personnel, laboratories, and IPR issues. Another important resource for the spin-offs may be the use of students, but also here some clear routines and guidelines need to be established, *"we need to make an agreement with the university that legitimizes use of these resources"* (Team member Alpha).

Even if the university management at the central level were supporting the spin-off project, it was not seen as unproblematic at department level: *"The philosophy here has been not to create companies, but to build a strong research group. When creating a company you change the focus from working with high motivation in the research group to using a lot of time and energy in the company"* (Department manager Alpha). Not only the loss of key personnel, but also the use of university resources created strain at the department level. *"The departments get paid for use of the facilities, regulated through agreements. Hopefully, this will be perceived positively by the departments. It takes some time to work out agreements, as this is the first case at the university"* (University manager Beta). Seen from the founders, *"this has been a tough process, because the university does not have any experience. This is the first company the university formally establishes, which means that we had to make many new roads as we moved along. There are many rounds to go to make agreements with the university. The university, however, have done all what they could do to help in this process, but lack experience"*. Hence, the founders generally acknowledge the importance of the university context, although a lack of experience and organizing has posed constraints on the process. *"The relation to the university was a little ambiguous in the beginning, but as we became an incubator company we do now have a clear and good relation to the university"* (Founder Alpha). The university was through this communication and formalization activity able to find acceptable solutions to the internal challenges raised by "bringing the market" into the university and adapting to a new type of activity. This also meant that the university became a stakeholder in the spin-off project creating new challenges through strong ties and dependency on the university in the spin-off process.

In the third proposition we suggested that there is a positive relation between university mechanisms that balance past, present, and future positions, and spin-

off based entrepreneurship within universities. It is increasingly recognized that university spin-offs are heterogeneous (Heirman and Clarysse, 2004; Vanaelst et al., 2006), and our findings suggest that interactive university governance adapted to idiosyncratic spin-off processes might be needed to respond to the particular challenges of each spin-off project. The development of university policies has been a central task in several cases. It seems more important to have clear policies than to have any particular set of policies, as the policy-related discussions were consuming both time and resources from the spin-off projects. Incentives are needed at different organizational levels, related to resource compensation, university management support, clear policies, and routines for handling controversies. For instance, an incubator facility seems to help in separating the academic and the commercial activity, while the spin-off project still maintains a close relation to university resources.

7.5.6. Dynamic capabilities that reconfigure and integrate resources

Going from university research to business application is a transition involving challenges for both the university and the academic entrepreneurs involved. The challenge for universities is to facilitate the creation of structure in the unstructured university environment. From the start, it was important that the spin-off projects were adapted to the commercial setting. The founders' prior experience and interaction with industry were crucial for all spin-off cases. The industry interaction was critical both in forming the business concept and in developing the founders' personal competencies, network, and experience of critical value for the spin-off project. In case Alpha, the professor with industrial background had a key role. According to one of the other founders, *"... he got the market contact, without him this project would have been impossible. He is a previous 'customer' and he thinks like a customer"* (Founder Alpha). In case Alpha the academic entrepreneurs were very much aware of the need for external resources, and in addition to the diversified competence among the professors, two external persons were included in the start-up team. The team worked on external relations and business concept development the first year, before doing technical work where they knew they possessed the sufficient competence.

Our cases emphasize the importance of support from 'godfathers' or influential persons in central positions that have the power and authority to push important decisions through. Such persons may be found in industrial partners, prospective costumers, investors, public agencies, and within the university. As seen in case Beta, the university actively used the latent contacts of persons in the organization to access competence when needed, and influential persons at the university took central roles in supporting the spin-off process in critical phases. Hence, the cases heavily emphasize the importance of university management support to legitimize the activity, to establish a clear relation, and in case Beta to directly help in a difficult situation. For three of the projects, a position in the university incubator helped to gain external legitimacy for the projects by showing that the project had been evaluated and the university was supportive. *"It is an advantage to be located at the university, it gives us credibility and help us in the relation towards industry"* (Founder Alpha). That the professors were able to maintain a position at the university in the early stages of the spin-off development was important for reducing the risk and keeping the costs down. In addition, the university generously granted leave of absent and sabbatical arrangements which allowed the professors to concentrate on the spin-off project.

The TTOs and commercialization units connected to the universities seemed, however, to play only a modest role compared to the latent networks of the academics and their ability to engage specialist competence. *"I know a lot of people in domestic and international industry. That is a strength being a professor. You only work with the best people in your field, some of them you learn to know very well."* (Founder Alpha). The access to PhD- and Master-students is also considered to be one of the main university resources for the spin-offs. Students contribute through theses and smaller projects, as a source for future employees, and former students constitute a valuable network in industry.

In the fourth proposition we suggested that there is a positive relation between reconfiguration and integrating mechanisms and spin-off based entrepreneurship within universities. A range of mechanisms are important, both internally in the university, but also at boundary organizations and through general public support. Specialized university coordination mechanisms, such as incubators and

technology transfer offices, can support the projects through gaining legitimacy and networking with external resources, like industry and venture capital actors. Former students can also be an important network. In addition, the existence of external support, such as government programs and seed funding are crucial for spin-off development (Mustar, 1997). The majority of government support initiatives aimed at facilitating spin-off activity is related to this category of DC.

7.5.7. The role of dynamic capabilities throughout the university spin-off process

It seems like the four dynamic capabilities outlined above may be more or less important at different times in the spin-off process. During the early opportunity development and creation of business models the processes related to exploration and de-coupling were especially important, while they in the later commercialization phase processes related to exploitation and integration played a more important role. Hence, the first capability of new path creation is important in order for new spin-off ideas to emerge. As the spin-off project develops, the capabilities creating new knowledge resources and the capabilities balancing past, present, and future positions become important. Finally, the capabilities that reconfigure and integrate resources becomes more important when the spin-off project is well established within the university and is about to become an independent new firm.

As an example, this transition or process was clearly articulated in case Beta where the academic entrepreneurs have gradually changed the company focus (e.g. board composition). First, the project was targeted to gain internal support and to use the competence within the university. After the internal support and legitimacy was established in the university, the focus was changed towards connections to external resources of importance for the business development.

7.6. Conclusions and implications

In this article we have proposed a dynamic view on the university spin-off process. Evidence suggests that complex processes within a university, like the creation of a spin-off venture, neither follow a prescribed pattern of development nor depend on a specific set of resources (Lockett et al., 2005).

Still, universities can through explicit and implicit choices build capabilities that promote and facilitate the development of idiosyncratic spin-off processes. Prior research has usually pointed at university characteristics determining the rate of spin-off formation. As found by Lockett and Wright (2005), however, not only the stock of resources, but also business development capabilities on the part of universities are significant. We contribute by suggesting four specific dynamic capabilities within the university setting that may promote the creation of research-based spin-off ventures, including the creation of new paths of action from academic research to commercial perspectives, the development of research processes creating unique and valuable knowledge resources, the reconfiguration and integration of specialized resources, and the creation of new vision and inspiration balancing past and future paths in the multi-faceted university organization. Although each of the DCs plays a more prominent role at different times in the spin-off process, they appear more as overlapping than sequential. Well developed university capabilities related to reconfiguration and integration will, for instance, give a signaling effect that the action path of spin-off formation is viable in the university context.

7.6.1. Implications for further research

The lack of theoretical approaches in the study of how universities facilitate spin-off creation provides abundant opportunities for further research. The findings in this paper, based on a dynamic capability approach, call for further knowledge on the in-depth characteristics of the dynamic capabilities, how the dynamic capabilities of the university facilitating entrepreneurship will differ as the process evolves over time, and their mutual interaction. To investigate these complex issues further, our theoretical concepts and propositions should be developed further through in-depth studies taking a holistic perspective of the university spin-off process. We need further knowledge especially during the first phase of development where intentions are developed and opportunities are recognized at the faculty level.

Only by understanding the dynamics of the spin-off process in a broader context including the faculty, the university, and its environment can we uncover what organizational mechanisms being most critical in different parts of the process. In this respect, we may also find significant differences across the industries and

regions where the spin-off is taking place. Further, it could be fruitful to investigate the network development of the faculty involved throughout the spin-off process.

This paper has dealt with the university setting, but the theoretical framework and propositions developed may be well suited to study entrepreneurship in other settings, such as corporate spin-offs and public sector entrepreneurship.

7.6.2. Implications for policy

As each spin-off process is idiosyncratic, it is not enough to provide general resources and measures to support new venture creation at universities. The dynamic capabilities to respond to the specific needs of each spin-off project are important. Following the propositions in this paper, policy makers should strive for developing four specific dynamic capabilities or routines for spin-off development within the university setting.

First, new paths of action seeing spin-off formation as a viable activity within the university need to be stimulated. This might be achieved through establishing an infrastructure and a culture within the university supporting spin-offs. Bottom-up factors such as the role of prior spin-off successes, role models, academics with commercial background, and student interest in entrepreneurship clearly seems to have a positive influence on the initiation of new spin-off projects. In addition, top-down initiatives such as support from the university management, policies, and incentive systems can contribute to this type of capabilities.

Second, the creation of new knowledge resources suitable for spin-off formation needs to be stimulated. The existence of and access to market knowledge and industry experience is often crucial for the spin-off projects to develop. Establishing such resources is often time consuming, and policies stimulating university-industry collaboration, mobility of personnel, networking, and training programs for academics can contribute to create this type of capabilities.

Third, past, present, and future positions need to be balanced in order to remove barriers for spin-off formation. The high number of stakeholders at multiple

levels inside and outside the university creates many potential barriers to the spin-off process. Our findings stress the need for clear policies, but also active involvement by the university might be needed to protect spin-off projects from conflicting interests. Specific arrangements to balance commercial and academic objectives may be on-campus incubators and arrangements to compensate for resources used at department level.

Fourth, the university needs to stimulate the reconfiguration and integration of resources into a new spin-off venture. A number of initiatives to stimulate this type of capabilities can be identified, typically boundary organizations providing industry and market knowledge, such as TTOs, incubators, entrepreneurship centers, and networking arrangements. Still, it seems like the most important channel to access and integrate resources is through the academic inventors and their network and ability to include external competence in the start-up team. In addition, public funding sources, both in the form of grants and seed-funding, make it possible to develop and exploit the spin-off opportunity.

8. Findings and implications

8.1. Introduction

This thesis set out to investigate three research questions. What initiatives are used by universities to facilitate the formation of spin-off ventures? How does the spin-off venture formation process unfold within a university context? How can university capabilities facilitate the spin-off firm formation process? The main contributions of this thesis have been the use of process theories and a narrative approach to address these questions. This chapter addresses each of the research questions raised in Chapter 1 by summarizing the main findings derived from the three different studies reported in the four papers in this thesis. In total, these studies include data collected at 9 different universities and an in-depth study of four university spin-off cases, totaling about 135 personal interviews and a variety of other data sources. This chapter proceeds as follows. First, the main findings and contributions related to each research question are outlined. Then, limitations and implications for further research are given. Finally, the implications pertaining to policy makers, universities, and spin-off entrepreneurs are presented.

8.2. Findings related to university initiatives

The first research question is addressed by the first two papers in this thesis. The first paper (Rasmussen et al., 2006c) provides an overview of a broad set of initiatives at four European universities. This paper shows the diversity of initiatives and that these initiatives are initiated and based at multiple levels within and outside the university. The second paper (Rasmussen and Sørheim, 2006) looks at entrepreneurship education initiatives at five Swedish universities, providing a novel framework and empirical investigation of initiatives involving students in setting up research based spin-offs. In general, this thesis reports a significant increase in the volume of activities aimed at facilitating spin-off generation and a higher focus and more positive attitude towards entrepreneurial activity at all levels in the universities examined. The contributions from each paper to the existing literature on university spin-offs are summarized in the following paragraphs.

8.2.1. General university initiatives to facilitate spin-off firms

Prior research has mainly investigated how universities deal with patent-based spin-off formation (Agrawal, 2001; Shane, 2004) or investigated single cases and specific types of initiatives, especially the technology transfer offices (TTOs) at US universities (Carlsson and Fridh, 2002; Markman et al., 2004; Siegel et al., 2004). The first paper in this thesis contributes to the spin-off literature by investigating the total range of initiatives employed by four universities in Finland, Ireland, Norway, and Sweden. Despite a high level of public spending on research, the infrastructure for commercialization and the operation of TTOs at universities are less developed in the Nordic countries than in the US and the UK. This emergent context for spin-off initiatives may, however, reveal some basic challenges with spin-off support that are less visible in settings with a long track record in facilitating spin-offs.

The study reports on the diversity of initiatives to promote spin-off formation and shows that these initiatives are originating from different levels within and outside the universities. First, the universities themselves have introduced a number of initiatives such as entrepreneurship education, business plan development programs and advisory services, student organizations, commercialization services on campus, university on-campus incubators, and university controlled seed-capital funds. In addition, several policies had been developed to promote commercialization of research, such as sharing of revenue generated from commercialization activities with inventors and departments.

Second, a considerable share of university initiatives is emerging bottom-up, from departments and individuals inside the university. Although a positive attitude from the university leadership should be noted, this study revealed that most of the activities are initiated and run by one or a few dedicated and highly motivated persons. Behind all the support structure and mechanisms there are informal networks around these few key individuals. The importance of such persons in order to develop courses, study programs, incentives, advice services, and incubators should be noted. These individuals may have a significant impact on the ability of the universities to succeed in commercializing their knowledge.

Third, a number of initiatives are initiated and financially supported from the government level. Funding for specific initiatives at the universities is often provided through government schemes. It can be claimed that the support structure, backed by mainly public funding, is the real risk-taker in commercialization projects. Neither the inventors nor the university contributes with substantial funding e.g. for patent applications or spin-off processes. In addition, governments put pressure on universities to increase their focus on commercialization. So far, this pressure seems not to be enforced through the base funding from the state, but more informally and through additional grants for this activity.

Fourth, a number of initiatives are based in boundary organizations (Hellström and Jacob, 2003) such as science parks, commercialization units, and off-campus incubators. The numbers of actors involved are large, partly with interfering and unclear roles. Some of these actors are owned fully by the university, some being partly owned, some entirely private, and some being owned (partly of fully) by other public actors. In addition, some are located on campus, while others are located near the campus. Making the situation even more complex, these actors partly need to generate income, for example by giving advice to commercialization projects in return for an equity share. At the same time they may control resources needed by the entrepreneur, as "administrators" of public funds. For the individual entrepreneur, this might lead to uncertainty regarding motivation, the economic situation, and advice imparity related to 'the commercialization system' in or next to the university.

In total, the universities are characterized by active experimentation with different support measures such as commercialization units, advisory organizations, incubators, innovation centers, and even venture capital funds. The majority of these organizations are young and they have a number of funding sources behind them such as: the government and different ministries; government agencies like research councils and innovation support programs; industry; and in most cases the university itself. In addition, it seems clear that the informal support of university spin-offs has increased among scientists, university management, and the public in general. Although this development is not without controversy, the general trend supports authors like Etzkowitz et al. (2000) and Clark (2004; 1998) who claim that universities are about to include

entrepreneurialism as a part of their activity, thus becoming entrepreneurial universities (Jacob et al., 2003).

The cases show that the pressure for universities to become entrepreneurial is not just related to new government policies for research and innovation, but also from departments and individuals inside the university and from a new generation of students – conscious of the opportunities of entrepreneurship. Although some university students may have started spin-offs in earlier decades, the present volume and support structure (students helping other students write business plans, find venture capital etc.) seem new. An innovative approach identified in this study was the connection between entrepreneurship education and research-based spin-off firm formation. This approach has rarely been commented on in existing spin-off literature, except some recent reports from US universities (Boni and Emerson, 2005; Nelson and Byers, 2005). Paper 2 in this thesis contributes by investigating several entrepreneurship education initiatives and develops a framework for action-based entrepreneurship education and how students can take active part in the commercialization of research.

8.2.2. Entrepreneurship education to facilitate spin-off firms

The second study in this thesis is among the first investigations of how universities can set up study programs to facilitate the creation of research-based spin-offs by students. The creation of new ventures by university graduates has been documented as a significant source of new firms (Bank of Boston, 1989; Bartels, 2000). Educating students to become entrepreneurs has also become a part of the curricula at many universities and this topic has been investigated in many studies. How to make entrepreneurship education relevant and what should be the role that business schools can play in commercialization of research have been issues for questioning (Fiet, 2001a; Wright et al., 2004a). The conception of entrepreneurship as a process rather than a trait or skill (Gartner, 1988; Stevenson and Jarillo, 1990) and the incorporation of the context as an important part of the entrepreneurial process (Jack and Anderson, 2002) have implications for entrepreneurship education.

Paper 2 in this thesis outlines different strategies for entrepreneurship education emphasizing student involvement and the potential of the business idea (see Figure 5.1). This study shows that students can play an important role in all phases of the spin-off firm formation process. Students may contribute to a more entrepreneurial climate at the university and they might be directly engaged in starting up research-based new ventures. The entrepreneurial orientation of academics may partly be a result of activities and experiences made during their time as students, graduated students can be a recruiting base for the new spin-off ventures, and students can be directly involved in the projects by writing theses, part time work, etc. The role of the students has, however, been neglected in prior research on how universities facilitate research-based spin-offs.

Although some definitions of university spin-offs include new ventures started by students (Pirnay et al., 2003; Smilor et al., 1990), most student ventures are not based on the application of research findings. Still, some universities have set up initiatives where students can commercialize research-based inventions as a part of their study. This thesis reveals that such initiatives demand more resources than traditional teaching methods, but will also satisfy several aims. In addition to teaching, such initiatives lead to the establishment of viable new ventures and the commercialization of university research. Most initiatives are characterized by an action-based or learning-by-doing approach to teaching. Depending on the goal of the study program, several outcomes may be achieved by combining high-potential ideas with a strong commitment from the students. This setting provides an action-based pedagogy for teaching entrepreneurship while at the same time being an important tool for spinning-off research based ventures from universities.

The cases studied in this thesis indicate that action-based entrepreneurship education can be accomplished in many different ways depending on both the operational context and the university ambitions. The operational context is related to both the internal university support as well as the entrepreneurial environment in the region. To succeed, however, it seems necessary to include a broader range of activities than those conducted in a classroom setting and to employ substantial resources compared to most other study programs. Such action-oriented initiatives rely on external resources and a well developed network toward the regional business community which provides assistance for

instance in idea development, access to mentors, and funding. It seems possible for universities to acquire considerable external resources both from public and private sources in order to realize these expanded objectives of teaching.

Several conceptions of entrepreneurship includes the role of opportunities and context (Gartner, 1985; Shane, 2003), and emphasizes entrepreneurship education as a learning-by-doing activity (Fiet, 2001b). By broadening the perspective and actually include the formation of new ventures as a part of the education, a better match with these conceptions can be achieved. In addition, the new venture creation may be connected with the commercialization of research, thus becoming an important initiative to facilitate research-based spin-off firms.

8.3. Findings related to the spin-off firm formation process

The second research question of this thesis addresses how the process of spin-off venture formation unfolds within a university context. This thesis has outlined an entrepreneurship process perspective on the spin-off firm formation process, emphasizing the role of the opportunity, the individuals, the context, and the process over time. There are frequent calls for more multi-level studies on entrepreneurship (Davidsson and Wiklund, 2001; Low and MacMillan, 1988; Phan, 2004) and spin-off creation (Lockett et al., 2005). Furthermore, many scholars have called for more longitudinal research in order to explore the firm formation process (Davidsson and Wiklund, 2001; Mustar et al., 2006; Van de Ven and Engleman, 2004). The third study in this thesis addresses both the lack of process approaches and multi-level studies by providing longitudinal data on four new venture start-up processes.

8.3.1. The use of several process theories

Prior studies have investigated specific properties, actors, or stages in the spin-off process, but few have looked at how the entire process develops over time. As suggested by Van De Ven and Poole (1995), the use of several basic process theories might be necessary to explain organizational processes. Paper 3 in this thesis uses four different process theories to explore different aspects of a start-up process. This is a novel approach to investigate the spin-off process in a

university context, and even to investigate an entrepreneurial start-up process in any setting.

Based on longitudinal data from four spin-off processes, the study revealed that the spin-off process is much more unstructured and messy than assumed by many prior studies. The linear models frequently used in prior research are only able to capture a few aspects of the complex spin-off process. Prior studies have often relied on a single theory to analyze the spin-off process, notably stage-based theories (see Section 2.3.1). The use of single theories provides only partial explanations of the spin-off process. By adding on teleological, dialectical, and evolutionary process theories, this study suggests a broader explanation of why spin-off processes moves from one stage of development to the next.

Firstly, the research-based invention is refined to become a business idea and finally a business operation through a life-cycle process. Secondly, the individuals or entrepreneurs creating the new spin-off venture are involved in a process of purposeful enactment where their behavior and goals are modified in a teleological process. Thirdly, the relation between the academic and the business world is not easily aligned. As the development of a commercialization project emerges in the university context, conflicts between the open academic science and the business activity of the new spin-off venture have to be resolved in a dialectical process. Fourthly, the spin-off process is part of a macro environment where evolutionary processes, such as industry cycles, affect both timing and viability of the spin-off project. Each process approach is described in more detail in the following sections.

8.3.2. Development of the business idea as a life-cycle process

The founding of technology-based new ventures are typically described as a sequential process consisting of identifiable stages (Hansen and Bird, 1998). The opportunity has rarely been included in the analysis of entrepreneurial processes (Davidsson and Wiklund, 2001; Ucbasaran et al., 2001), and many scholars have called for more empirical research on entrepreneurial opportunities (Eckhardt and Shane, 2003). The third study in this thesis has mapped the development

process of four business opportunities from the initial research to they become the basis for a new spin-off venture.

By including the opportunity as a unit of analysis, this study shows that also research-based opportunities can undergo significant changes throughout their development process and the business models often changes over time (Gartner, 2004; Heirman and Clarysse, 2004). The initial idea goes through significant changes as the business model is developed in an interactive process in cooperation with industry, consultants, or persons with entrepreneurial experience. In addition, the spin-off projects are dependent on considerable external resources through funding from public grants and networking with industry, often matched with respective efforts from the entrepreneurs, the university, and industry partners. Further, the cases show that some sort of contact between the academic research environment and industry is crucial for spin-off projects to emerge and for a successful transition from academic research to industrial application. In addition to the technological competence involved, the university spin-off projects seem to mature during a process where market knowledge is added on.

Despite the unstructured emergence of the spin-offs, it seems clear that some events precede others in a stage- or phase-like manner. The early phases of opportunity screening and idea development seemed more unstructured than described by stage-models, while the projects became more structured later in the development process. This is especially related to the development of the business concept, where an idea needs to be clearly articulated before external resources are committed to develop it further, and the viability of the idea needs to be tested before the new venture can attract costumers and significant investments.

Although stage-models points out challenges and problems to be dealt with at different times in the process, they have a number of weaknesses in explaining how university spin-off firms emerge. Most notably, they do not explain how the process proceeds from one stage to the next. It is also difficult to point at a specific point in time when the project moves from one stage to the next, due to difficulties in finding objective criteria to categorize a project into a specific stage (e.g. legal establishment, external funding, and first costumer). Although

stage-based models provide contours of the opportunity development process, they need to be supplemented and extended by other theories. Paper 3 in this thesis proposes that this process of opportunity development is heavily influenced by other processes related to the individuals involved, the university context, and the external environment.

8.3.3. Development of the individuals as a teleological process

The prevailing view in most theorizing on entrepreneurship is that the new firm formation process is emerging as a result of purposeful and planned actions by key individuals (McMullen and Shepherd, 2006). Although prior studies have addressed different phases and competencies needed in the spin-off process, few have keyed into the individual or entrepreneurial team transition from an academic to a commercial setting (Clarysse and Moray, 2004; Vanaelst et al., 2006). Paper 3 in this thesis proposes that the role of the entrepreneur or entrepreneurial team in the spin-off firm formation process may be explored by using teleological theories.

The cases investigated in Paper 3 show that the identification of an opportunity was dependent on someone seeing the connection between the technology at hand and some market need. The usually long time span from the original idea is conceived to the start of the project is often due to a lack of industrial partners or entrepreneurs to pursue the commercialization project. The decision to pursue an entrepreneurial opportunity seems to be a result of supportive elements in the persons' environment combined with events creating a new situation where starting an entrepreneurial action is perceived as a viable option. The individual motivations are diverse. Some see the creation of domestic industry and the creation of jobs as important. Other motivations included a desire to work together as a team, see the research results applied, and creating a commercial success.

The researchers' network, experience, and knowledge of industrial application seem crucial for being able to see entrepreneurial opportunities by connecting research findings to potential areas of application. In addition to the academic research, contacts with industry and possible users of the new technology were crucial for the opportunity to emerge and develop. Moreover, signals from

policy makers and university management that spin-offs have their support are important both for the decision to start the process, and for further development.

In all cases the entrepreneurs changed their primary focus and strategy as the projects developed. Just as links to the commercial environment were critical in forming the business concept, these links also contributed to the development of the competencies, the networks, and the experiences of the founders. Becoming entrepreneurs involved a steep learning curve for the academics, and the utilization of networks and external competence was crucial as the spin-off projects evolve and become more complex. In addition, the composition of the entrepreneurial team might change throughout the process, often reflecting the different competence needed at different times in the spin-off process.

Committed individuals seem to be able to drive the project forward in a purposeful or teleological way, and the stages of development are modified by entrepreneurial action. Thus, teleological theories may help explain why processes are moving from one stage to the next, and why spin-off processes do not proceed in a strictly linear fashion. A weakness of teleological theories is their focus on individuals, while a number of contextual factors might be decisive for the development of the spin-off process. Factors such as serendipity, availability of time, personal relations, motivation, and other external personal circumstances may influence the degree and type of involvement by individuals. Moreover, the transition in role from being an academic to becoming an entrepreneur is not an easy task when the spin-off project is embedded in a university context.

8.3.4. Relations to the university context as a dialectical process

Contextual factors are seen as crucial in explanations of entrepreneurship (Davidsson et al., 2006; Ucbasaran et al., 2001), especially related to organizational settings (Parhankangas and Arenius, 2003). Paper 3 in this thesis proposes that the role of the university context in the spin-off firm formation process may be explored by using dialectical theories. Dialectical theories explain processes by reference to the relative balance of power between opposing entities (Poole et al., 2000). The difference in culture and work

practice between university and industry is substantial (Anderson, 2001) and constitutes a challenge for spin-off processes (Argyres and Liebeskind, 1998; Meyer, 2003; Miner et al., 2001; Stephan and Levin, 1996). As the development of a commercialization project emerges within the university context, dialectics between the open academic science and the business activity of the new spin-off venture have to be resolved. Many studies have addressed the role of university characteristics for spin-off formation, but few have adopted a dynamic view capturing how the university context influences the spin-off project and the change in this role over time.

The cases investigated in this thesis show that the university context may play both a supportive and a hampering role on the spin-off firm formation process. On the one hand, the university environment is generally considered to be a resourceful setting for the creative spin-off process. Early in the process, the university can contribute with resources which lower the initial cost and risk associated with exploring a business idea, such as available time, equipment, business consulting, and office space. Even more important is the informal support to legitimize the spin-off project internally and to release the latent resources, such as the know-how, the networks, and the external legitimacy connected to the university. As the spin-off projects develop, the university context may contribute as a research partner and source for recruiting highly skilled employees to the new venture. Hence, the university contributes with different resources early in the process compared to later on, and these resources can both facilitate and inhibit the spin-off process.

On the other hand, some conflicts and critical voices occurred as the spin-off process developed. Some department managers feared that spin-off activity would undermine the research by occupying resources and by creating a difficult relation to collaborating research partners and industry partners. An interwoven relation between different university stakeholders and the spin-off project makes possible conflicts of interest difficult to solve. Due to the limited experience within the universities to handle the role as owner and research partner with the spin-off companies, several conflict of interest issues emerged and much energy was devoted to find viable solutions. A difficult area for the university was to balance the degree of support with securing a proper return on these investments, for instance through ownership in the spin-offs. Another challenge

was to establish clear routines and guidelines in the relation between students and the spin-off company.

Using dialectical theories to explain the spin-off process seems most relevant when the project undergoes the transition from being a research project to becoming a commercial venture. Hence, the use of dialectical theories seems only to explain one aspect of the university context's role in the spin-off process. The university's resources and capabilities can support the spin-off process in the different stages of development, both strategic and evolutionary. It should also be noted that the university is not a static entity, but is changing during the spin-off process, for instance because new initiatives and organizational solutions are made and learning occurs. Furthermore, the university should not be seen as one consistent entity. Different levels within the university play different roles. Even if some levels are supportive of the spin-off effort, such as the university management, problems can be encountered at other levels in the university system, creating barriers impeding the spin-off process.

The spin-off firm formation process occurs, however, not only as a result from actions at the micro-level, related to the opportunity, the individuals, or the university context. There is also a need to look at the macro-level development influencing the operating conditions for the new venture project.

8.3.5. External influence as an evolutionary process

A number of macro-level characteristics and events outside the control of the university or spin-off entrepreneurs are found to influence the spin-off process. Paper 3 in this thesis proposes that the role of external variation in the spin-off firm formation process may be explored by using evolutionary theories. Evolutionary processes are dependent on the three sub-processes of variation, selection, and retention (Aldrich, 1999). Such variations could be both internal and external. Hence, the variation generated by stage-wise development of the business opportunity, the teleological action by the entrepreneur(s), and the dialectic relation between academic and business culture may serve as input to the variation, selection, and retention process.

According to evolutionary theory (Aldrich, 1999), both intentional and blind variation influence the spin-off process in a not predetermined way. In the cases studied in this thesis, the business ideas, the individuals involved, and the relation with the university context has changed radically during the spin-off process. Some of these changes are a result of external factors, serendipity, and unpredictable events which may hinder, change direction, or open new possibilities for the spin-off process, such as industry and market cycles, personal conflicts, persons who happen to be in a particular situation or place at a particular time, and other unforeseen events. This may also explain the long history of development leading to each business opportunity in the cases studied. The availability of resources also constrains and shapes the opportunity and all cases were dependent on considerable external resources through networking with industry and funding from public grants.

One example of an evolving process influencing all the spin-off cases was the current policy efforts at the national level to promote the commercialization of research. These policy changes influenced the spin-off processes in several ways, such as: more ample public funds early in the commercialization process, better conditions for university employees to be involved in spin-offs, and a more supportive university setting. Several persons said that it would have been less viable for them to start a new venture some years earlier, due to a different attitude among administrators and colleagues. Now it has become more accepted within the university to start a spin-off venture, and an infrastructure is established.

The stage, teleological, and dialectical theories only to a limited extent include the role of the external context and evolutionary forces when explaining the spin-off process. External forces often play a decisive role in the spin-off process, giving timing, serendipity, and unpredictable events a prominent role in deciding how the process unfolds. These factors are often outside the control of both the individuals involved and the university setting. Hence, macro level events outside the scope of stage-models, individual agency, or the organizational setting should be accounted for in order to understand the spin-off process. Here, the variation, selection, and retention mechanisms of evolutionary theory give additional insights, and account for macro level development, serendipity, and unpredictable events.

8.3.6. Different process theories are salient at different times

All four process theories, life-cycle, teleological, dialectical, and evolutionary, provide additional insight into the spin-off process, but each theory seems more salient at different times in the spin-off process. Firstly, the role of individuals and their motives seems to play a particularly important role during the initial phases of opportunity identification and commitment. Prior spin-off research has pointed out the role of motivational push- and pull-factors, business experience, networking, and characteristics of the research group and entrepreneurial team as important for the initiation of the spin-off (see Table 2.4). All these factors plays a particularly important role in the initial research commercialization and opportunity screening phase (Vanaelst et al., 2006). Hence, the teleological theory is more prevalent than the other theories in the very early phases of spin-off development.

Secondly, the relation with the university is especially important immediately after the spin-off project is launched. The transition from being a research project to becoming a commercial venture brings forward conflicts to be resolved. Many university policies and support initiatives have been set up to facilitate this transition (see Table 2.5). Hence, dialectical theories seem to have a more prominent role in order to explain this particular phase of the spin-off process. These findings are line with Cule and Robey (2004), who suggests a constructive process model of organizational transition based on a dual teleology and a dialectic motor.

Thirdly, the new spin-off venture seems to enter a more structured phase after it has secured initial support and funding, where the process proceeds as implied by the life-cycle theory. Here, the conventional wisdom of textbooks, consultants, and investors often relies on stage models, which may lead to self-fulfillment of stage models to explain entrepreneurial processes. Hence, life-cycle theories seem more prominent later in the process. Finally, the three preceding theories provide limited explanation for macro-level influence on the spin-off process and for the role of serendipity and chance. Hence, the evolutionary theories may play a prominent role in explaining long-term progress and timing of events throughout the entire spin-off process. That is,

how both planned and unpredictable events evolve and determine the spin-off process and its outcome.

The process perspective presented in this thesis has brought forward a number of specific challenges related to how the spin-off firm formation process unfolds within a university. The process approach has shown that it is difficult to identify specific university resources that may contribute to all types of spin-off processes. The initial resources, the need for new resources, and bundling of resources are unique in each spin-off case. Moreover, spin-off processes are dependent on resources embedded at several levels within the university. Hence, it might be necessary to identify routines or university capabilities that facilitate the spin-off formation process within universities. This is addressed in the next section.

8.4. Findings related to university capabilities

The third research question of this thesis addresses how university capabilities can facilitate the spin-off firm formation process. As outlined in Section 2.4.1, the dynamic capabilities perspective seems particularly suited to investigating how emerging processes such as spin-off firm formation may be facilitated within the complex and multi-faceted university organization. The complexity of the university spin-off process is evident from the many actors at different levels involved and their often different and unclear objectives (Mustar et al., 2006). At the university level, diverse goals and outputs such as teaching, both basic and applied research, societal utility, and a combination of non-profit and commercial activity add to this complexity (Lee, 1996; Navarro and Gallardo, 2003). Hence, the university needs organizational capabilities or routines in order to stimulate and facilitate entrepreneurial processes (Lockett and Wright, 2005).

The fourth paper in this thesis contributes by looking at the particular challenges related to the exploration and exploitation of entrepreneurial opportunities within the university setting and discusses the need for both de-coupling and integration mechanisms in order to configure resource for spin-off development. Prior research have been more occupied with university characteristics leading to spin-off formation (Link and Scott, 2005; Roberts and Malone, 1996; Shane

and Stuart, 2002), rather than how the universities can facilitate the spin-off formation process. This thesis contributes by developing a set of four university capabilities facilitating entrepreneurial processes within the university.

8.4.1. University capabilities facilitating spin-off firm formation

A number of mechanisms in the university context can both facilitate and inhibit the spin-off process. As shown by the first paper in this thesis, a broad range of initiatives are used to facilitate university spin-off processes. Evidence suggests that complex processes within a university, like the creation of a spin-off venture, neither follow a prescribed pattern of development nor depend on a specific set of resources (Lockett et al., 2005; March, 1991). It seems difficult to find specific measures to facilitate spin-off firm formation that can be applied in many different contexts. Still, universities can through explicit and implicit choices build capabilities that promote the development and provide resources to facilitate idiosyncratic spin-off processes (Lockett and Wright, 2005).

The empirical findings from this thesis suggest that the commercial process of creating university spin-offs includes a broader set of activities than emphasized in most of the existing literature on spin-offs. The university setting is complex, with multiple outputs, goals, and stakeholders. Spin-off processes might be in a dialectic relation to the university and meet challenges and the potential for conflict with traditional academic values and tasks. Hence, de-coupling from the academic setting may be an important task for the spin-off project to succeed. Spin-off processes may also meet challenges in obtaining market knowledge and commercial resources. Hence, integration and networking with business and industry may also be important tasks for the spin-off project to succeed. Furthermore, a spin-off is based on research results and researcher involvement is found to be important for spin-off projects to succeed. The ability to explore opportunities and business models needs to be present in the university organization, but also the ability and the resources to exploit these opportunities are needed.

Recent developments in strategic management theory place greater emphasis on the dynamic capabilities of an organization rather than its current assets and market position in order to be innovative. This literature emphasizes the

organizational capabilities or routines to stimulate dynamic processes. This includes internal and external resources as well as path dependency and future resources. Although the dynamic capability perspective has been outlined by several conceptual papers (Eisenhardt and Martin, 2000; Teece et al., 1997; Winter, 2003), the number of empirical studies on dynamic capabilities has been limited. Paper 4 in this thesis provides a novel use of the dynamic capability concept to explore how universities can facilitate spin-off firm formation processes.

As outlined in Paper 4, the university organization has to contribute both to exploration and exploitation, as well as de-coupling and integration processes related to both internal and external resources (see Figure 7.1). Facilitating action along these two dimensions may demand a composite set of capabilities within the university organization. This thesis proposes that the university capabilities to facilitate the creation of university spin offs are grouped into four categories (see Figure 7.2). These four types of university capabilities are presented in the following four sections.

8.4.2. Capabilities that create new paths

The present position of an organization, its repertoire of routines and physical resources, may create a history that constrain future strategic action (Teece et al., 1997). Innovation is about finding and exploring new concepts and adapting these to a viable mode of exploitation. At the same time, the exploration process may be hampered by the bindings between existing resources and the old patterns within the academic university structure. Hence, it might be an advantage to de-couple the exploration process from such bindings. Paper 4 in this thesis propose that in order to facilitate spin-off activity the university may need to promote a combination explorative and de-coupling action by creating new action paths mechanisms.

The cases reveal that a learning process took place at the university level for how to handle the spin-off cases. Increased legitimacy and supportive attitudes towards entrepreneurship among research teams and students played an important role in the process of spin-off initiation. Likewise, the entrepreneurial objectives of university management also played a role and the direct university

support can be an important catalyst for succeeding with the spin-off projects. For instance, good opportunities for taking leave and sabbatical arrangements make it possible for the professors to experiment without risking their jobs.

The university capabilities are partly based within the university culture. Thus, they are built over time and cannot be implemented only by setting up structures and policies. Here, the attitudes among colleagues, role models, and even student attitudes can play important roles. The cases revealed that cooperation with industry has been a central premise for being able to form the idea and to develop the competence and networks needed to start developing the spin-off project. There are, however, several ways to gain such competence, such as: mobility between university and industry, cooperative research and consulting, and contacts with former students. This indicates that university capabilities can be based at multiple levels in the organization. Hence, both bottom-up and top-down policies (Goldfarb and Henrekson, 2002) can be effective.

8.4.3. Capabilities that create new knowledge resources

Researchers' networking and interaction with industry is associated with spin-off formation (Grandi and Grimaldi, 2005; Nicolaou and Birley, 2003b; Shane and Stuart, 2002) and lack of business experience and management skills is recognized as a potential barrier to success for venturing scientists (Radosevich, 1995). Hence, routines that facilitate the integration of internal and external resources might play a crucial role for spin-off firm formation. Paper 4 in this thesis proposes that in order to facilitate spin-off activity, the university may promote a combination explorative and integrative action by creating new knowledge creation mechanisms.

Exploration should to be balanced with action to adapt the new ideas into viable commercial concepts that can be developed into new business platforms (Davidsson and Klofsten, 2003). This means adapting to customer needs, government regulations, and the potential threat from competitors. Integrative action is important in order to provide new competence resources, as the new venture often needs more general and market-oriented knowledge than the initial, often technology-based, innovation. The cases show that the total competence and composition of the team was frequently considered as the most

valuable asset for developing spin-off projects. Market knowledge and industry networks in the research team and in the founding team played an important role in the development of the spin-off projects. In addition, the university contributed with some support, for instance through the research labs and the TTO.

It seems clear that it is of crucial importance to integrate industry experience into the spin-off projects. This can occur in several ways such as: establishment of cross-functional research teams, networking and cooperation with industry, training for academic entrepreneurs, personnel mobility, including industry competence in the entrepreneurial teams, and through a learning process involving the academic entrepreneurs.

8.4.4. Capabilities that balance past, present, and future positions

Several studies conclude that local cultures and norms are important for stimulating entrepreneurship within the university departments (Chrisman et al., 1995; Franklin et al., 2001; Kenney and Goe, 2004; Louis et al., 1989). There is a risk that conflicts with existing norms and other university tasks may hamper the exploitation of entrepreneurial opportunities within the university setting. Hence, there might be a need for routines to separate and protect the spin-off process from the many other objectives and stakeholders in the university context. Paper 4 in this thesis proposes that in order to facilitate spin-off activity, the university may promote a combination of exploitative and de-coupling action by balancing past, present, and future positions.

One important challenge that may hamper the academic entrepreneur is the risk of conflicts with other faculty members and the university organization. Within government institutions there might be bureaucratic regulations, red tape, and power play that may induce negative sanctions. The cases revealed that the academic entrepreneurs engaged in interactive processes with the university to find arrangements and regulations in the interface between the spin-off firm and the university interests. These efforts were important for legitimizing the spin-off both internally and externally. Legitimacy within the university had to be obtained at several levels (colleagues, departments, central management) and

was also related to use of university resources such as personnel, equipment, and intellectual property. Furthermore, the academics' prospects for their future relation to the university played a role, as many of the spin-off entrepreneurs did not want to lose their position within the university.

It is increasingly recognized that university spin-offs are heterogeneous (Heirman and Clarysse, 2004; Vanaelst et al., 2006), and the findings from this thesis suggest that interactive university governance adapted to idiosyncratic spin-off processes might be needed to respond to the particular challenges of each spin-off project. The development of university policies has been a central task in several cases. It seems more important to have clear policies than to have any particular set of policies, as the discussions about unclear policies were consuming both time and resources from the spin-off projects. Incentives are needed at different organizational levels, related to resource compensation, university management support, clear policies, and routines for handling controversies. Finally, a university incubator facility seems to help in separating the academic and the commercial activity, while the spin-off project still maintains a close relation to the university resources.

8.4.5. Capabilities that reconfigure and integrate resources

A combination of resources is the driver for the new venture creation process (Greene et al., 1999). Hence, there might be a need for routines to bring in external resources and integrate these into the spin-off project in order to build the basis for a new venture exploiting the research-based business opportunity. In order to facilitate spin-off activity, Paper 4 in this thesis proposes that there is a positive relation between reconfiguration and integration mechanisms and spin-off based entrepreneurship within universities.

In order to get access to and exploit the resources in the commercial environment, there has to be knowledge about how to run a firm and how to link possibly conflicting resources and interests. The cases in this thesis emphasize the importance of support from 'godfathers' or influential persons in central positions who have power and authority to push important decisions through. Formal university support provides credibility to the project which makes it easier to access external resources. Also industry interaction constituted

important sources for resources to the spin-off firm, for instance through the inventors' networks and contacts with prior students and alumni.

A range of mechanisms are important, both internally in the university, but also at boundary organizations and through general public support programs. Specialized university coordination mechanisms, such as incubators, technology transfer offices (TTO), entrepreneurship centers, and networking arenas can support the projects through legitimacy and networking with external resources, like industry and venture capital actors. Prior students can also be an important network. In addition, the existence of external support, such as government programs and seed funding are crucial for spin-off development. The majority of government support initiatives aimed at facilitating spin-off activity are supporting this type of university capability.

8.4.6. Capabilities throughout the university spin-off process

The cases investigated in Paper 4 indicate that the four dynamic capabilities outlined above may be more or less important at different times throughout the spin-off process. During the initial opportunity development and the creation of a business model for the spin-off project, the processes related to exploration and de-coupling were especially important. In the later commercialization phase, however, processes related to exploitation and integration played a more important role (see Figure 7.2). Hence, the first capability of new path creation is important in order for new spin-off ideas to emerge. As the spin-off project develops, the capabilities creating new knowledge resources and the capabilities balancing past, present, and future positions become especially important. Finally, the capabilities that reconfigure and integrate resources become more important when the spin-off project is well established within the university and is about to become an independent new firm.

8.5. Limitations and implications for further research

This section discusses the limitations and implications for further research, regarding both the process perspective and the capability perspective. Then, the limitations and implications for further research regarding the research design

and methodology are discussed. Finally, some promising topics for future research on the university spin-off phenomenon are outlined.

8.5.1. Implications and limitations regarding the process perspective

Irrespective of how carefully the theoretical perspectives of a study are selected they will guide the attention and focus towards some aspects of the phenomenon, while the roles of other aspects are downplayed. The third paper in this theses used concepts from the entrepreneurship literature combined with process theories. By using four process models (Van de Ven and Poole, 1995), this thesis has suggested theoretical explanations for many aspects of the university spin-off firm formation process. Still, this approach is not much developed and there is a need to further investigate each of the four process models more in detail, but also the relation between them.

By applying a holistic approach to the spin-off process using a multi-level and longitudinal research design, the third paper in this thesis discussed many aspects of the university spin-off firm formation process within the same framework. This broad approach, I think, is very important for understanding entrepreneurial processes, but within this broadness also lies its limitations. The theoretical models becomes rather complex and does not provide any clear basis for further empirical testing using deduction and quantitative methods. Based in a constructivist view, however, it is not the aim of this research to identify variables and suggest causal relations between them. The trustworthiness of the theoretical findings from this thesis can only be established over time, by reference to whether they prove useful to understand the phenomenon. The four propositions derived in Paper 3 are aimed at clarifying the arguments and main implications from each of the process theories. Unfortunately, they are not fully able to express the complexity of the insights from this research. Further implications of the process perspective related to each process model are as follows.

First, this thesis relies on a stage-based explanation of how the opportunity develops. It might be difficult to find a common set of stages, as spin-offs seem to develop in different directions and along different time scales. Although the

frequently used stage-based models provide contours of the opportunity development process, they might be too simple, and thus need to be supplemented and extended by other theories. As suggested by Klofsten (1992), it might be that spin-off firms need to reach a "business platform" in order to succeed, but that the development of this platform does not need to take place according to a phase- or stage model. Hence, future studies might study whether university spin-off firms follow different trajectories or development patterns over time (Delmar et al., 2003). Furthermore, the connection between stage models and opportunities proposed in Paper 3 imply that in order to investigate the stages of spin-off firm development, the opportunity should be the level of analysis. Many prior studies treat the opportunity or technology as given, while the approach in this thesis asserts that the opportunity is developed in an interactive process involving individuals, organizational context, and external evolutionary influence. How and why such changes during a spin-off process influence the business opportunity are little investigated, and warrant further research.

Second, this thesis suggests the use of teleological theories to capture the role of human agency in the spin-off process, but more work is needed to develop this approach more in detail. With a few exceptions (Clarysse and Moray, 2004; Vanaelst et al., 2006), there is almost no research on the learning process of academic entrepreneurs. The use of entrepreneurial learning theories (Corbett, 2005; Harrison and Leitch, 2005), social capital theory (Murray, 2004; Nahapiet and Ghoshal, 1998), and network theory (Burt, 2000; Nicolaou and Birley, 2003b) might yield additional insights into how the individuals involved act in order to develop the spin-off firms. Furthermore, the connection between teleological models and individuals proposed in Paper 3 implies that in order to investigate the strategies and actions leading to spin-off firm development, the individuals should be the level of analysis.

A weakness of teleological theories is the focus on rational behavior by the actors. People are not capable of being fully rational (Simon, 1996) and entrepreneurs tend to effectuate rather than rely on causal rationality (Sarasvathy, 2003). The diverse motivations of the persons interviewed in this thesis also show that theories assuming rationality are not fully able to explain the entrepreneurial process. Thus, in order to understand the role of individuals

in the spin-off process, the motivation and competence of individuals should not bee seen as static. Future studies should address how individuals are changing throughout a spin-off process and how this change affects the process. Furthermore, there is also a lack of research on changes in the team composition during the spin-off process, and how such changes internally in the spin-off project influence its development (Vanaelst et al., 2006). The cases in this study indicate that the development in team composition is dependent on the networks and strategic choices of individuals.

Third, this thesis suggests dialectic theories as a viable route to investigating the spin-off – university relation, including the conflicting goals of academic and commercial activity. The dialectical perspective, however, pays most attention to problems and conflicts. In addition, the university setting is an important, and often crucial, resource provider for the spin-off venture. Hence, theories about organization-level capabilities (Lockett and Wright, 2005; Teece et al., 1997) and decision making within university organizations (Cohen et al., 1972) may provide a fruitful avenue for exploring how the university context influences the spin-off process. Furthermore, the connection between dialectic models and the role played by the university proposed in this thesis imply that in order to investigate how the university influences spin-off firm development, the university should be included as a level of analysis. The differences between the academic and the commercial culture are well articulated, but little is known about how the transition from academia to business influences the university spin-off process compared to start-up processes in other settings. Future studies should not treat the university context only as a static actor in the relation to the spin-off process, but also address the changing role of the university context throughout the spin-off process. Another under-researched topic is the relation between spin-off projects and university–industry cooperation, where conflicting goals might occur.

Fourth, the role of external or macro-level events is rarely included in studies of the spin-off process, but this thesis asserts that the role of serendipity and unpredictable events also needs to be accounted for. Evolutionary approaches are well developed within organization theory (Aldrich, 1999) and provide rich opportunities for creating better theoretical foundations to study the university spin-off process. Evolutionary theories do not account for the unique case.

Hence, they are not alone sufficient as an explanation of the entrepreneurship process. Still, in combination with other theories, the evolutionary approach is able to include the relation and impact from the external environment or context, which is often considered a weakness in other micro-level theories. Furthermore, the evolutionary approach is divergent (Poole and Van de Ven, 2004b), thus if combined with other process theories that are equilibrium oriented, it may be able to make an explanation for observed variations in the outcome.

Finally, the interaction between the four process models needs further investigation. This thesis has suggested that the different theories or motors play more or less important roles at different times in the spin-off firm formation process, referred to by Poole and Van de Ven (2004b) as a cyclical relationship among the motors. It has also been indicated that the stage, teleological, and dialectical process provides input to the evolutionary motor. Hence, these motors may be nested (Poole and Van de Ven, 2004b), and the evolutionary motor might be at a higher level that the other three motors. Alternatively, the evolutionary motor might be aggregated, meaning that it is strongly dependent on the other lower-level motors (Poole and Van de Ven, 2004b). These relationships between the different process motors should be investigated in future studies. In order to do this, multi-level approaches and longitudinal research designs are warranted.

8.5.2. Implications and limitations regarding university capabilities

As first observed in Paper 1 and further investigated in Paper 4 in this thesis, the university initiatives to facilitate spin-off firm formation are based at many levels both within and outside the university organization. Based on the dynamic capabilities approach, Paper 4 proposed four specific university capabilities associated with spin-off firm formation. Furthermore, the university initiatives develop over time and the process perspective provided in Paper 3 asserts that university initiatives have implications for the spin-off firm formation process and that the development of these initiatives over time partly can be seen as an evolutionary process. This supports the view of Eisenhardt and Martin (2000), who suggest that the dynamic capabilities of an organization are evolutionary.

Thus, this thesis asserts that the university capabilities are complex and their content are changing over time.

This thesis has investigated how universities may facilitate spin-off firm formation processes by identifying four dynamic capabilities. How these capabilities are created and developed has, however, not been explicitly addressed by this thesis, but warrants further studies. The resource-based view has been criticized for not paying enough attention to how resources are acquired and developed. The dynamic capability perspective partly answers this challenge by defining a number of higher-level routines needed to acquire and develop valuable resources. Still, the same problem persists, as the dynamic capabilities perspective does not fully answer how the higher-level routines are acquired and developed. That is, the question where dynamic capabilities come from remains open (Zollo and Winter, 2002).

One challenge that is not addressed by this thesis is the costs associated with developing and maintaining dynamic capabilities (Winter, 2003). All the four university capabilities suggested in Paper 4 require significant resources to develop and frequent exercise to maintain. Hence, a university has to weigh the strategic importance and potential outcome from spin-off activity against the costs of facilitating it. Although there are relatively few reports about negative effects, the complex and independent nature of university research might in the long run be affected by measures aiming at facilitating spin-off formation. Many US universities do not involve directly in spin-off companies because this is a problematic area where many conflicts of interest can occur (Matkin, 1990; Monotti and Ricketson, 2003).

The four university capabilities specified in this thesis call for further knowledge on the in-depth characteristics of these capabilities. Every spin-off process is unique, and the dynamic capabilities of the university facilitating entrepreneurship will differ as the process evolves over time. It is often assumed that a specific set of environmental conditions are preferable for promoting spin-off creation and little attention has been paid to the differences throughout the process of development. Hence, future studies should be more explicit on the university resources and conditions that are important at different times in the spin-off process. Moreover, future studies should not only treat the university

context as endogenous to the spin-off process, but also address the changing role of the university context throughout the spin-off process. Further knowledge is especially needed in the first phase of development where intentions are developed and opportunities are recognized within the research groups.

In order to uncover the organizational mechanisms that are most critical in different parts of the process, it is necessary to understand the dynamics of the spin-off process in a broader context, including the opportunity, the individual faculty members, the university, and its environment. In this respect, significant differences may be found across the industries and regions where spin-off activities take place. The theoretical concepts and propositions presented in this thesis could be developed further through in-depth studies taking a holistic perspective of the university spin-off process.

8.5.3. Implications and limitations regarding research design and methodology

This thesis consists of three empirical studies. The first two are representative for the bulk of qualitative studies related to university spin-offs. They seek to describe successful cases by collecting secondary data and by conducting interviews with well-informed individuals in retrospect of the development under investigation. This approach has some strength, mainly related to efficiency in data collection, but also a number of weaknesses related to limitations in data sources and their representativeness. In order to get closer to the process, the third study in this thesis used a longitudinal research design and a more theoretically grounded approach to examine both the development process and the university capabilities facilitating this process. The implications and limitations regarding this research design are discussed in the following.

The process approach

This thesis has used a process approach, as outlined by Mohr (1982) and by Van de Ven and Poole (1995). According to Mackenzie (2000), the process approach is another methodological paradigm than the dominating variable or variance approach in organization science. Hence, a different set of methods is needed to fully appreciate the advantages of the process approach. Many studies of university spin-offs are cross sectional, having difficulties in grasping the

development process by which such companies emerge. Cross-sectional studies fail to account for the internal changes in the variables measured, relating to the technology or business idea, the individuals involved, or the university context. Hence, longitudinal case studies following spin-off projects as they evolve are considered as particularly suited to developing a more precise model of the entrepreneurial process in a university setting (Vanaelst et al., 2006). The process approach has gradually emerged as a viable approach during the work with this thesis, but future studies would benefit from taking a clearer process approach from the outset.

In order to makes explanations that are close to the process being studied, such studies should make use of narrative data (Pentland, 1999). Narratives are particularly sensitive to the temporal dimension of human existence because they pay special attention to the sequence in which actions and events occur (Polkinghorne, 1988). The narrative approach emerged as a solution rather late in the work with this thesis. Hence in order to fully benefit from its strengths, a clear recommendation would be to incorporate this approach from the outset of a study. Still, the learning-by-doing approach I have relied on in the work with this thesis has some strength. Exploring different approaches before arriving at a viable solution is useful in order to develop the methodological awareness (Seale, 1999).

Units of analysis

Obtaining an understanding of the whole university spin-off process is a daunting task due to the complexity of the phenomenon and the lack of consistency in prior research. Applying several units of analysis together with a number of different levels of analysis such as the individual, the team, the different organizational levels, and the external context, is challenging but necessary in order to understand the spin-off process. As shown by this thesis, the core elements of the spin-off process, such as the individuals, the opportunity, and the context, go through a development process making it difficult to address one factor alone without including the interaction with other factors. Hence, future studies aimed at exploring the university spin-off firm formation process should include several units of analysis in order to capture the complexity of this phenomenon.

Data sources

The cases in the third study in this thesis were selected in a relatively early phase of development to avoid some of the limitations associated with retrospective research designs. Studies of university spin-offs usually include only cases that have succeeded in developing into an independent new firm. This outcome-driven (Aldrich, 2001; Van de Ven and Engleman, 2004) approach to the spin-off process has some disadvantages. First, such studies do not include start-up processes that fail. Second, the cases where the process has another outcome than the creation of a new spin-off firm are not included. For instance, spin-off projects that are bought by an industrial company are, however, equally successful in terms of technology transfer. Third, preceding events leading to a new spin-off project can only be seen in retrospect. Although it could be extremely time-consuming and difficult to find such cases, future research may consider obtaining real-time data from before and during the first commitment to a spin-off project. One possible way is to follow a number of research projects over time to see whether and how the commercialization issue emerges. Panel surveys of university scientists may also key into this issue. Such novel studies could compare the cases that fails versus those that succeeds. This may shed light on why and how some cases succeed while other cease.

The primary source of information for this thesis has been personal interviews, supplemented by other sources. This is the prevailing way of collecting qualitative data in entrepreneurship and management studies. A major weakness of this approach is that people often have difficulties in giving precise accounts for events which happened some time ago, and the data tend to be flawed by memory decay, rationalization after the fact, and hindsight bias. The third study in this thesis has addressed this issue by following cases early in their development. Still, the collected data about the history before the spin-off project were established and its first year of development had to rely on historical accounts. Future interview-based studies may, however, benefit from applying some of the approaches used in this thesis to deal with process data, such as repetitive real-time interviews, triangulation of sources, and narrative interviewing. Moreover, future studies should consider alternative data collection methods such as direct observation and obtaining diary notes from central persons. I have briefly experimented with such methods and find them to reveal interesting data about real time processes. Hence, the application of a

broader range of methods, for instance inspired by the work of anthropologists, would lead to a better understanding of the spin-off phenomenon. In order to reveal the complexity of spin-off development there is a need for more studies involving a close interaction with the field.

Generalization

The case study approaches used in this thesis do not allow for statistical generalization of the findings across any predefined population. Rather, the goals have been to rely on prior quantitative research to position the findings within the existing spin-off research, to use prior research to increase the validity of the findings, and to explore and expand theories by analytical generalization (Yin, 1989).

All the studies in this thesis have limitations related to the context of the studies and due to the small number of cases in each study. All cases are from the Nordic countries (except one case from Ireland in Paper 1), and the four longitudinal process cases are from Norway. Differences in the university systems and the national and regional conditions may influence how spin-offs are facilitated. Likewise, university spin-off processes in other countries may evolve differently due to differences in culture, policies, and resources both within the university context and the surrounding environment. In particular, this might be the case compared to the US, where the commercialization of research is more prevalent and has a longer history.

The aim of this study, however, has not been to study the outcome, but to reveal how spin-off firm formation unfolds and can be facilitated. Hence, in order to increase the ability to generalize from these findings, future studies could apply a common theoretical framework over a wider range of different settings. These studies may investigate differences in the university context related to university size, culture, policies, and regional setting. Success may be a result of prior successes and it has been questioned whether it is possible to generalize from a few success stories (Bania et al., 1993; Fogarty and Sinha, 1999). Studies of how spin-offs are facilitated and emerge in other contexts would add new knowledge and perspectives to the existing studies.

To isolate the reasons for historical success is difficult, and to directly transfer successful initiatives from one setting to another seems often to be impossible. This thesis shows that the total range of initiatives and the interplay between them might be more important than any specific initiative. Hence, the frequent practice of drawing conclusions based on the study of one type of initiatives across many settings, without taking the context in each setting into consideration, might lead to misleading conclusions.

Furthermore, the development process of university spin-offs seems to be affected by the field of research and by the industry sector. Hence, future studies should pay attention to industry differences by examining spin-offs in specific industries and make comparisons across industries. It would also be of great interest to apply similar approaches and theoretical frameworks in different settings, such as corporate spin-offs or public sector spin-offs from other organizations than universities. Differences in cultures, objectives, and resources are likely to make the insights from the study of university spin-off cases not directly transferable to other contexts. Thus, studies from other settings would help generalize the findings from this thesis, and at the same time reveal some of the particular characteristics of the university setting as arena for entrepreneurial activity.

8.5.4. Suggested topics for further research

The sections above have provided implications and suggestions related to the perspectives and methods used in this thesis. This section presents some general reflections on interesting topics and directions for further research.

This thesis has focused solely on the early phases of university spin-off firm development. The long development processes of university spin-offs leave the final outcome only to be seen by the future. The same applies to institutional changes aiming to facilitate such processes. Hence, there is a need for more longitudinal designs both at the university level and at the spin-off process level. To measure the outcome of integrated organizational and complex issues such as support measures and spin-off processes is extremely difficult due to the numerous external effects influencing the total outcome. Future studies could address how the early development of spin-off firms influences future

development and growth of these firms. How universities contribute to the spin-off firm's further development should also be addressed.

Moreover, the ongoing changes in universities aiming to facilitate spin-offs and how spin-off activity affects the university should be further investigated. Several effects are important to address. First, whether the creation of university spin-offs leads to success in terms of business performance. It has been found that university spin-offs outperform the average firm, but little is known about what leads to superior performance among university spin-offs. Further, the effect of university spin-offs on regional economies seems well documented, but how this effect occurs at micro-level is not very clear.

It is often claimed that university spin-offs lead to technology transfer and application of scientific results to the public good. The effect of university spin-offs compared to other models for technology transfer is, however, not very well documented. Measuring technology transfer is not straightforward. For instance, fast transfer may not secure the widest possible dissemination and vice versa. The intersection between technology transfer and entrepreneurship research is a promising area for future university spin-off studies. The investigation of university spin-offs is promising for understanding entrepreneurship in general because these enterprises are based on research results as an important element in the business opportunity. Research on university spin-offs shows how the mechanism of entrepreneurship can be used for university technology transfer (Audretsch et al., 2005).

The focus on commercialization and spin-off formation may have an effect on the universities and the science system in the long run. Whether spin-off activity within universities pays off better than alternative use of the resources is not very clear. Further, the introduction of commercial activity into academic institutions may also have long-term negative consequences on the science system that exceeds the positive effects. These issues have been widely discussed using anecdotal evidence, but too few studies have systematically addressed such effects over time. There is also a need for more longitudinal studies to key into the interaction between academic entrepreneurs and industry (Wright et al., 2004a).

As a final note, I will draw attention to the importance of more research on the university spin-off topic in general. There is a significant body of theoretical and conceptual literature regarding innovation processes (Rogers, 2003). Prior studies have often analyzed innovation processes in larger corporations, while the university setting rarely has been studied from this approach. As emphasized by Van de Ven et al. (1999), the integration of research on innovation processes across different settings may be beneficial for both research and practice. The university context poses particular challenges which might be of interest to the innovation process literature. For instance, the dialectic between the academic culture and the commercial culture creates specific challenges.

Moreover, most university spin-offs are initiated in a somewhat similar context - the academic, removing some of the contextual variance. An impediment to entrepreneurship research has been the mix of different types of entrepreneurial activity and different contexts for the entrepreneurial activity in the same studies. Heterogeneity in the samples makes it difficult to isolate central issues in the entrepreneurial process. Hence, models describing the university spin-off process may be useful for understanding entrepreneurial processes in other contexts, such as corporate entrepreneurship, public sector entrepreneurship, community entrepreneurship, or regional entrepreneurship.

8.6. Practical implications

The research in this thesis has been inspired by the challenges faced by policy makers, universities, and the spin-off entrepreneurs when trying to facilitate and actively engage in university spin-off firm formation processes. Their struggle in many different settings shows that there are no simple recipes to be found and that the successful initiatives and practices in one setting are not easily transferred to other settings. Nevertheless, I will in the following sections provide some implications for policy makers, universities, and spin-off entrepreneurs.

8.6.1. Implications for policy makers

This thesis focuses on the university spin-off as a channel for technology transfer, while policy makers have to take into consideration a broader set of

objectives, such as facilitating technology transfer in general and prioritizing resources among numerous other, and perhaps more important, areas. The increased amount of activities to facilitate and support the creation of spin-offs uses a considerable amount of resources. Hence, there is a risk that spin-off activity drains resources from other university activities in several ways. Changes in funding regimes in order to reward spin-off formation may take resources away from research areas where new firm formation is less common. Universities may also change their internal priorities in the same direction. Consequently, many academics may spend more time on the commercialization activities, leaving less time and talent for the research activity. Likewise, a high priority of spin-off formation as the route to commercializing new research findings may lead to less emphasis on the interaction and cooperation with existing industry. Using university resources to start new ventures might not be in line with the technology transfer argument, unless these ventures actually do transfer new research results into public use in a more efficient way than existing firms. These issues have to be explicitly addressed by policy makers to avoid that the benefits of some policy changes lead to long-term negative effects in other areas.

Prior studies have often assumed that policies and measures have the same impact across different settings. In contrast, the initiatives investigated in this thesis seem to be a result of a development over time in a specific context. It seems like all initiatives studied in this thesis are based in the specific university and regional setting, and it seems extremely difficult to transfer one successful initiative directly to another context. Still, it is clearly possible to learn from other contexts, and initiatives known as successful are often characterized by active experimentation and outreach activity to learn and bring in the best practice from other locations. It should be noted, however, that the difference is large between technopoles like Silicon Valley and Route 128 in the US (Saxenian, 1994) and the surroundings of a regional university in a small European country. Policy implications will differ depending on the size, history, culture, and regional context of the institutions. Hence, the need for the universities to be actively engaged in the creation of spin-offs might be more appropriate for universities in regions with few industrial actors and a weaker entrepreneurial culture than for US universities such as Stanford and MIT where the resources and capabilities to commercialize research are present within the

regional business community and external entrepreneurs. Thus, policy makers need to carefully consider the context before implementing new measures and allow the flexibility and time needed for these initiatives to be adapted to the specific location.

The third paper in this thesis shows that the prevailing linear- or stage-models, which have been very influential in forming current policy initiatives (Stokes, 1997), are only able to explain some aspects of innovation processes. In particular, stage-models point at the specific challenges emerging throughout the development process of the new firm (Drazin et al., 2004). Paper 3 suggests that additional insight can be found in teleological, dialectical, and evolutionary models. Hence, specific policies are not likely to be generally applicable throughout all phases of the spin-off process, as the opportunity, the individuals, and the university context are not static, but change over time. It should also be noted that there are differences between university contexts and other contexts, which calls for specialized policies targeted at universities. Such policies should in particular address the dialectic relation between the academic and the commercial culture.

In total, this study shows that initiatives to support spin-offs within universities involve much more than technology transfer offices (TTO) and formal policies, at least in the European countries investigated in this thesis. Hence, the numerous studies of university TTOs (Markman et al., 2005) and single initiatives (Link and Scott, 2005) would probably capture only a small part of the total set of initiatives at each university. Prior studies have discussed the difference between top-down and bottom-up policies (Goldfarb and Henrekson, 2002; Jacob et al., 2003). This study indicates that both are prevailing in the current changes taking place within the studied universities. Not only the university, but several actors, from single individuals to boundary organizations, play a significant role in facilitating spin-off firm formation.

8.6.2. Implications for universities

An important objective of this thesis has been to investigate how the spin-off firm formation process can be facilitated within universities. Hence, a number of implications for universities may be drawn.

The first study in this thesis shows that the universities to some extent have incorporated commercialization of research as a part of the general activity in the institution. The overall challenge was how to find proper arrangements to link teaching, research, and commercialization, making the latter a positive contribution rather than a load on the others. A further challenge is to motivate, create a culture, and facilitate interaction at all levels, using appropriate initiatives as tools to achieve this goal. In the complex university context, most initiatives seem to be dependent on the interplay with other initiatives to be effective. This may explain the weak findings of studies trying to measure the effect of specific initiatives on university commercialization (Audretsch and Lehmann, 2005; Carlsson and Fridh, 2002; Chapple et al., 2005; Di Gregorio and Shane, 2003). Hence, based on the studies in this thesis I agree with Siegel and Phan (2005) that universities should adopt a strategic approach to spin-off firm formation activity. The spin-off activity is to a large degree embedded with the other university activities and should not be seen as a separate activity.

As shown by Paper 2 in this thesis, the supply of entrepreneurs and team members in spin-off projects can be increased by including the students in the target group for policies to facilitate university spin-offs. The student collective seems to be neglected in policies to promote commercialization of research through spin-off firm formation. To include the students in technology transfer policies might be especially effective for universities in regions with a weak entrepreneurial culture and few industrial actors, as this might increase the supply of competent entrepreneurs. Implications for setting up an action-based entrepreneurship education were provided in Chapter 5.7.

The process theories explored in the third paper in this thesis leads to implications for policies to promote spin-off creation at four levels. First, stage models point to the specific challenges emerging at different times throughout the development process of a spin-off firm. The steps to commercialize a technology are basically following the same procedure at all US universities (Carlsson and Fridh, 2002) where the work-practice of technology transfer offices typically follows a stage logic (Siegel et al., 2004). This thesis has provided a more dynamic view. Still, policies should pay attention to the characteristics of each stage in order to stimulate and remove barriers for the

projects to proceed from one stage to the next. In particular, the key role of individuals early in the process, the subsequent transition from being a research project to becoming a commercial venture, and the connection with external resources need to be considered.

Second, this thesis supports the finding of Kenney and Goe (2004) that the academic entrepreneurs are socially embedded at several levels both within and outside the university. Hence, the university should develop both the formal and the informal support towards spin-off activity. This might be done directly by developing an infrastructure and policies for supporting spin-off projects and by sending clear signals that such activity is desirable. More importantly, informal support should be developed at the department level and among faculty members. Committed and competent individuals may be made available to the projects both through a learning process and by changes in team composition. Individual motivations and incentives may be a key factor to achieve this, for instance through training programs and networking activities.

Third, a strategic approach from the university might be necessary in order to avoid that the academic entrepreneurs are hampered by conflicts of interest in the dialectic relation between university interests and the commercial requirements related to the spin-off firm formation process. For instance, there seem to be areas of conflict between close cooperation with industry and conducting entrepreneurial spin-off projects within a research group. A close cooperation between university research groups and established companies may limit the possibilities to start a new venture based on the research findings. Likewise, spin-off activities may inhibit the possibilities to obtain research funding and cooperation with larger companies in the same research area. Conversely, spin-off activity might create long term benefits for the university that are considered as more important, such as better public relations, contribution to the region, economic revenues, and the creation of future industry partners. Hence, sometimes it is a strategic decision for a university to choose between spin-off creation and industry cooperation within a specific technology area. Moreover, the findings related to the differences between academic and business culture have implications for the competence needed within universities to address these issues. In particular, the TTO staff needs to have a specific competence which is not easily acquired from other settings.

Hence, there might be a need to develop proper training of the TTO staff in order to deal with this dialectic setting.

Finally, external factors outside the control of universities often play a decisive role. Such factors are difficult to plan for, but policy makers can increase the likelihood of evolutionary spin-off processes to occur by introducing variation into the evolutionary process. This may be achieved by stimulating events and situations (variation) that may result in initiation and further development of spin-off processes. Variation can be stimulated by supporting research areas, technology and market competence, and networking arenas, while the selection process can be delayed by addressing areas of market failure, such as the lack of early stage funding for commercialization projects and spin-off ventures.

Paper 4 in this thesis discussed how universities through explicit and implicit choices can build capabilities that promote the development of spin-offs and provide resources to facilitate spin-off processes. The spin-off process does not follow a prescribed pattern of development and seems not to be dependent on a specific set of resources. As each spin-off process is idiosyncratic, it is not enough to look at the specific resources and measures to support new venture creation at universities. The spin-off process does not operate in isolation, but will have an impact on the other university activities. Previous failures and successes may facilitate and constrain future activities, and conflicts occur where basic values are contradictory. In the case of spin-off support, this is affected by existing routines and new routines especially constructed to support spin-off formation. The dynamic capabilities to respond to the specific needs of each spin-off project are important. As proposed in Paper 4, universities should strive to develop four specific capabilities.

First, there might be a need to stimulate new paths of action seeing spin-off formation as a viable activity within the university. This might be achieved through establishing an infrastructure and a culture within the university that are supportive of spin-off activity. Bottom-up factors such as prior spin-off successes, role models, academics with commercial background, and student interest in entrepreneurship clearly seems to have a positive influence on the initiation of new spin-off projects. In addition, top-down initiatives such as

support from the university management, policies, and incentive systems can contribute to this type of capabilities.

Second, there might be a need to stimulate the creation of new knowledge resources suitable for spin-off firm formation. The existence of market knowledge and industry experience is often crucial for the spin-off projects to develop. Establishing such resources is often time consuming, and policies stimulating university-industry collaboration, mobility of personnel, networking, and training programs for academics can contribute to create this type of capabilities.

Third, there might be a need to balance past, present, and future positions in order to remove barriers for spin-off firm formation. The high number of stakeholders at multiple levels inside and outside the university creates many potential barriers to the spin-off process. The findings in this thesis stress the need for clear policies, but also active involvement by the university might be needed to protect spin-off projects from conflicting interests. It might be necessary to separate the university activity from the commercial activity in order to avoid conflicts of interest and mixing of roles. Specific arrangements to balance commercial and academic objectives may be on-campus incubators and arrangements to compensate for resources used at department level.

Fourth, the universities might need to stimulate the reconfiguration and integration of resources into a new spin-off venture. A number of initiatives to stimulate this type of capabilities can be identified. Typically, these are specialized university units or boundary organizations providing industry and market knowledge, such as TTOs, incubators, entrepreneurship centers, and networking arrangements. Still, it seems like the most important channel to access and integrate resources are through the academic inventors and their networks and abilities to include external competence in the start-up team. Thus, developing networks with industry and the business community might be an important element of creating a supportive environment for university spin-offs. In addition, resources from public funding sources, both in the form of grants and seed-funding, often make it possible to develop and exploit spin-off opportunities. Hence, a prerequisite to a successful transformation to an "entrepreneurial university" might be to get access to new funding (public seed

capital, specialized programs) rather than being forced to redistribute basic research and teaching funds.

The spin-off cases investigated in this thesis show that the university spin-off process is not a relay race with clear phases and roles. It takes both time and interaction to involve new actors in the process. Hence, attention needs to be directed toward the particular dynamics emerging throughout the entire commercialization process. One possible strategy to facilitate university spin-offs is to involve practitioners early in the research process, and to involve researchers in the later development phases. A closer cooperation may facilitate the transfer of tacit knowledge, and a higher awareness among academics about possible applications early in the research process may lead to a more conscious handling and protection of valuable intellectual property (IP). It seems like the balance between typical university resources, such as research competence, and the acquisition of external resources are critical for the new spin-off venture. Some projects are in need of more research to be conducted in cooperation with the university, while other projects may benefit from being detached from the academic setting and coupled with other more commercially oriented actors outside the university.

In total, the studies in this thesis reveal few conflicts between the commercialization activity and the traditional university activities of teaching and research. Still, the in-depth studies of specific spin-off projects revealed a number of problem areas, especially at the research group and the department level. Commercialization activities within universities demand time and resources which are rarely compensated for. The academic entrepreneurs are often highly productive researchers in their group. Hence, the loss of personnel resources might be critical for the further development of the research group. This stresses the need for clear policies, for instance related to IPR ownership and use of university resources, and that arrangements should be made prior to the identification of a commercialization project.

8.6.3. Implications for spin-off entrepreneurs

The research in this thesis is primarily addressing issues of particular interest to policy makers and universities in their effort to facilitate spin-off firm formation

processes. Still, there are several lessons to be learned also for the spin-off entrepreneurs, especially related to the findings on how the spin-off firm formation process unfolds within the university setting.

The stage models outlined in this thesis points at specific challenges related to each stage of development in creating a business concept based on academic research. The spin-off entrepreneurs need different competencies throughout the spin-off process. Thus, it is important that the spin-off entrepreneurs actively engage in a learning process in order to be able to handle the challenges emerging throughout the spin-off process. This learning process may start before the business opportunity is detected, as experience and relations with business and industry seem to play an important role early in the spin-off process. Furthermore, the spin-off entrepreneurs would often benefit from adding other persons with complementary competencies to the entrepreneurial team. Typically, the academic entrepreneurs have good technical knowledge, but lack skills related to the commercialization process and market knowledge. Moreover, the cases in this thesis show that the spin-off projects managed to get crucial support from influential persons in important positions, such as industry leaders, university managers, or capital providers. Hence, significant support can be mobilized by using networks and convincing others about the idea.

Furthermore, this thesis has discussed some of the particular characteristics of entrepreneurship within the university context. The spin-off entrepreneurs may find that the university is a source of valuable resources, but they should also be aware that the spin-off project needs to be adapted to a commercial context. Hence, it is of crucial importance to de-couple from the academic environment in order to avoid that the other university tasks and the academic culture hamper the new venture creation process. The separation between the role as entrepreneur and as university employee might be a difficult but important challenge for entrepreneurial academics. The findings in this thesis suggest that the spin-off projects are generally perceived more positively at higher levels in the university organization. Hence, one strategy for the entrepreneurs might be to gain commitment and support from the university management as a tool to legitimize the activity and push through decisions at lower levels in the university organization.

This thesis has suggested that external factors related to timing, serendipity, and unpredictable events play a prominent role in deciding how the spin-off firm formation process unfolds. This is in line with recent theorizing within entrepreneurship which stresses that entrepreneurs succeeds by adapting to the environmental constraints, making use of the resources at hand through bricolage (Baker and Nelson, 2005) and effectuation (Sarasvathy, 2001). Hence, spin-off entrepreneurs should be aware that environmental conditions impact the spin-off process and they should use such external factors to their advantage, rather than trying to overcome them.

Appendix: Personal experience

The importance of thorough knowledge about the topic and close interaction with the field in order to increase the relevance and credibility of the research has been stressed several times in this thesis. This appendix describes my own background and experiences that have been of relevance to the work with this thesis.

My work as a researcher at the Entrepreneurship and Innovation Group (now NTNU Entrepreneurship Center) at the Norwegian University of Science and Technology (NTNU) for about two and a half years before starting my PhD project gave me an invaluable experience and also triggered my interest in writing a thesis about university spin-offs. In this job I was involved in several projects. Two of them have been carried on and developed into the first two papers in this thesis (Rasmussen et al., 2006c; Rasmussen and Sørheim, 2006). Further, I coordinated a conference on commercialization of research (Rasmussen, 2001) and have in addition to the 135 interviews reported in this thesis interviewed more than 50 university employees about commercialization of research and spin-off formation (Halvorsen and Hubak, 2002; Waagø et al., 2001). Another relevant experience was a project examining government initiatives to support the commercialization of research in Canada, Finland, Ireland, the Netherlands, Scotland, and Sweden (Rasmussen et al., 2006a; Rasmussen et al., 2006b) involving an extensive data collection by the project team, including interviews with close to 100 persons.

Before and during the work with this thesis, I have attended about 15 conferences where practitioners have discussed the commercialization of research and spin-off formation, also as a speaker (Rasmussen, 2002; Rasmussen, 2003; Rasmussen, 2006a). Further, I have both given lectures and supervised student theses related to university commercialization and spin-off firms. I have also visited the US two times in order to learn about university technology transfer at US institutions (Bugge et al., 2003; Gjellan and Rasmussen, 2004; Rasmussen, 2006d). In order to get an in-depth understanding of the topics and political processes at the university level, I acted as an observer at NTNU's committee for commercialization of research. This committee

operated in a period when NTNU was planning and establishing a technology transfer office (TTO). My position as a member of the research committee at Bodø University has also given me an increased understanding of the academic system.

Among the most inspiring and instructive activities I have been involved in is the New Venture Accelerator at NTNU (Erikson and Gjellan, 2003) and in Bodø. During the last five years I have been the mentor for thirteen entrepreneurs or start-up teams who, in cooperation with a team of students, have scrutinized all sides of a business idea and developed a comprehensive business plan. I would also like to mention two other projects that helped me to better understand the entrepreneurial process. One is a study of the idea development in innovative ventures established by pupils in upper secondary school in Norway (Alsos and Rasmussen, 2006; Alsos et al., 2005). The other is my role as initiator of the university innovation center, SPIR Idelab Bodø (www.spir.hibo.no), which by some definitions could be regarded as an instance of academic entrepreneurship, or at least an example on how research-based knowledge from this thesis has been applied in practice.

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