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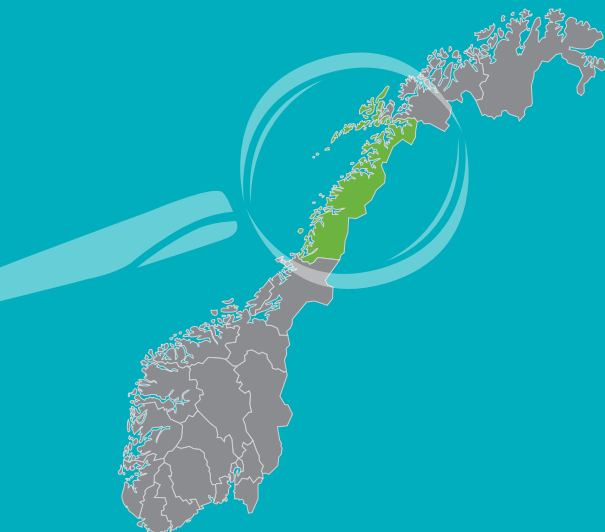
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The Impact of Science-Based Entrepreneurial Firms

- a Literature Review and Policy Synthesis



Einar Rasmussen
Oxana Bulanova
Are Jensen
Tommy Clausen



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By

**Einar Rasmussen
Oxana Bulanova
Are Jensen
Tommy Clausen**

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Forfattere Einar Rasmussen, Oxana Bulanova, Are Jensen og Tommy Clausen	Project Manager (sign.) Einar Rasmussen	
	Research Manager Einar Lier Madsen	
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Summary We have conducted an extensive search in high quality international journals and identified 162 scientific articles dealing with SBEFs. We observed that the number of studies on SBEFs has grown rapidly over the last decade and has contributed to a better understanding of the role and the particular characteristics of this type of new ventures. The literature is dominated by studies from North America and Western Europe, particularly the US and the UK.	Keywords	
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PREFACE

We would like to thank the Research Council of Norway for supporting this literature review by a grant from the FORFI-program. Key findings from this project were presented to the FORFI-program Board in January 2012. The work has been done in collaboration between Bodø Graduate School of Business at the University of Nordland and Nordland Research Institute. We hope this report can spur a more informed debate on the impacts of science-based entrepreneurial firms among policy makers and researchers. We also hope to inspire further research that can provide more knowledge on these issues.

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ABSTRACT

How to convert scientific and technological knowledge developed in public research institutions into economic and societal impact is a key concern for both research and innovation policy. Policy makers and universities have spent considerable resources to promote the creation of science-based entrepreneurial firms (SBEFs) as a tool to create value from investments made in research. The impacts of SBEFs are, however, highly debated among both practitioners and researchers. Some argue that these firms play an important role in terms of revenue and job creation, but also as technology transfer agents. Thus, SBEFs are considered to have an important role in the innovation system by transforming scientific knowledge into application. Others question the impact of SBEFs and argue that exceptional success stories cannot be generalized and that most SBEFs are technology lifestyle firms that remain small, despite strong public support.

We have conducted an extensive search in high quality international journals and identified 162 scientific articles dealing with SBEFs. We observed that the number of studies on SBEFs has grown rapidly over the last decade and has contributed to a better understanding of the role and the particular characteristics of this type of new ventures. The literature is dominated by studies from North America and Western Europe, particularly the US and the UK.

A subset of 14 articles explicitly considered the impacts generated by SBEFs. Two different perspectives can be identified. Some studies explored the economic impacts of SBEF, often in terms of contributions to regional development. Other studies discussed the impacts of SBEFs as technology transfer agents serving a role in the dissemination of research into application. Most studies portray a highly positive image of the impacts generated by SBEFs. However, the literature is dominated by a handful of successful case examples and some authors question whether the general prominence given to SBEFs in government policies can be justified. SBEFs seem to be a special type of firms that have other purposes than other start-ups in terms of technology transfer and other societal benefits. However, many potential types of impacts have not been sufficiently explored by empirical data. For instance, successful acquisitions are rarely included in the datasets used. Much work remains before any general conclusions can be made whether and under which conditions SBEFs creates an impact that exceeds the alternatives.

Another subset of 28 articles included empirical data regarding the links between the start-up conditions and the performance of SBEFs. It seems clear that SBEFs face particular opportunities and challenges compared to other new ventures related to their academic origin and their need to develop links to commercial actors, particularly in the earliest stages of venture development. The studies investigate a number of factors have been found to influence the performance of SBEFs in different contexts, but how these factors interrelates remains scarcely studied. There is no doubt that policies and support can promote the performance and impacts of SBEFs, but the mechanisms leading to successful outcomes appears to be highly context specific. Thus, policy actions need to be differentiated according to the particular regional and institutional context, the phase of development, and the business model chosen by the SBEFs, as well as the type of impacts sought.

In the 42 studies reviewed above that considered impact and performance, we observed that a broad range of indicators were used. Most studies were looking at firm level performance using indicators such as survival, employment, resource acquisition, financial indicators and growth measures. Although indicators to measure impact at regional level and in terms of technology transfer were discussed in several studies, it seems very difficult to measure these types of outcomes. None of the studies explored the non-economic and societal impacts generated by SBEFs in any detail.

SBEFs have long development paths and successful firms typically remain small for a rather long time period before they start to grow. To be able to capture this development there is a need to measure their impact over a longer period of time than most current studies have done. Studies following the development of a cohort of SBEFs or university technologies over an extensive period of time, where different economic and societal outcomes are considered, would yield important new insights.

1. INTRODUCTION

Many studies have demonstrated the potential value of academic research and basic science discoveries for technological change and economic growth (Cohen et al., 2002; Feldman et al., 2002). However, the process of converting scientific knowledge into new products and services is extremely difficult (Fleming and Sorenson, 2004; Meyer-Krahmer and Schmoch, 1998). The knowledge of universities is often 'less targeted' to firms' particular needs and concerns and therefore difficult for firms to assimilate and apply (Cohen and Levinthal, 1990). As a result, only a limited number of firms draw directly from universities as a source of innovation (Laursen and Salter, 2004).

Governments and universities increasingly rely on the creation of science-based entrepreneurial firms (SBEFs) as a mechanism to commercialize knowledge and inventions from universities and other public research institutions (Rasmussen et al., 2008; Wright et al., 2007). European policy makers have attempted to emulate the US success in generating employment and economic growth through the establishment of SBEFs (Mowery and Sampat, 2005). Like in many other countries, Norwegian policy makers have issued legislative changes and spent considerable funds on initiatives to increase the commercialization of research, for instance through the FORNY program (Borlaug et al., 2009a; Rasmussen and Gulbrandsen, Forthcoming). Since 1995, more than one billion NOK has been invested through the FORNY-program alone to promote SBEFs and most universities and larger research institutes have established technology transfer offices (TTOs) with an explicit aim of promoting SBEFs. Within universities, several institutional arrangements like technology transfer offices (TTOs), incubators, and internal seed funds are set up to facilitate spin-offs (Rasmussen et al., 2006b). The number of SBEFs that have been created has increased significantly in recent years (Mustar et al., 2008). For the perspective used in this report, a SBEF is defined as: *a new venture based on technology from a public research institution*. These firms have also been referred to as university spin-offs, academic spin-offs, research-based spin-offs, science-based new ventures, etc.

The academic literature has paid increasing attention to the role of SBEFs in converting scientific findings into commercial products and services. New ventures are often commercializing more innovative and radical technologies than incumbents (Chesbrough and Rosenbloom, 2002; Danneels, 2004) and empirical studies assert that new technology-based firms have an active role in the

development and dissemination of technology (Autio, 1994; Autio and Yli-Renko, 1998). SBEFs often commercialize early-stage inventions where existing companies fail to commercialize the technology (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). Some argue that SBEFs provide a missing link between investments in new knowledge and economic growth, and their economic impact is likely to be more indirect than direct (Fontes, 2005; Garnsey and Heffernan, 2005; Leitch and Harrison, 2005b). Thus, SBEFs may play an important role as technology transfer agents (Autio and Yli-Renko, 1998; Fontes, 2005; Rasmussen et al., 2006b). Other studies, however, have found that the growth rates of SBEFs are rather disappointing (Harrison and Leitch, 2009), also among Norwegian SBEFs (Borlaug et al., 2009a). Thus, the role of SBEFs is debated and a significant share of the existing literature is based on studies of a small number of highly successful research institutions, particularly in the US (O'Shea et al., 2005; Rothaermel et al., 2007).

1.1 RESEARCH QUESTIONS

Relatively recent literature reviews have showed that the number of studies on SBEFs are growing rapidly, but are fragmented (Djokovic and Souitaris, 2008; O'Shea et al., 2008; Rothaermel et al., 2007). The aim of this report is to review the contemporary scientific literature related to SBEFs to answer three research questions. The first question relates to the role of SBEFs in the society and how this role is materialized. Is it only directly through their economic performance that SBEFs generate value, or do these firms contribute by developing and disseminating technology to other firms and users, and fulfill an important role in the innovation system? Given the prominence given to SBEFs in government policies, we aim to check the empirical literature related to the impacts generated by these firms. By impacts we refer to the tangible and intangible effects of SBEFs on economic development. In addition, impacts of more social and societal nature are included, but these issues are rarely considered in this literature. A good understanding of the size and nature of these effects is of vital importance to policy makers seeking to use SBEFs as a tool for economic development or other purposes. Thus, we review the literature to answer the following research question:

RQ 1: What are the types and extent of impacts generated by SBEFs?

The second question is related to the use of policies, support programs, and other initiatives to promote the creation of SBEFs. Many initiatives have been launched at both university and government level, but whether such initiatives work and how they work are debated. Cross national comparisons show that the extent of commercialization seems to be closely related to the research expenditure, while it is difficult to point out specific initiatives or schemes that clearly increase the extent of commercialization (Heher, 2006). The 2009 evaluation of the FORNY program showed that the number of SBEFs in Norway was comparable to other countries, but the growth rate of the Norwegian firms was disappointing (Borlaug et al., 2009b). To understand the conditions and mechanisms leading to high economic performance of SBEFs is of vital importance for the design and implementation of policies to support such ventures. Thus, we scrutinize the empirical literature guided by the following research question:

RQ 2: What are the links between the start-up conditions and the subsequent performance and impacts generated by SBEFs?

The third question is related to the challenge of measuring the importance and performance of SBEFs. Common indicators include patents, licenses (royalty), innovations (products, services, processes), sales and profits, jobs created, investments (venture capital), second order spin-offs, regional effects (innovation, productivity, etc.). Many of these indicators are critiqued for either being too narrow to capture the impacts of SBEFs or very difficult to operationalize (Arundel and Bordoy, 2007; Langford et al., 2006; Rasmussen, 2006b). Having knowledge about relevant indicators and how to use them is important for policy makers seeking to evaluate the significance of SBEFs and measures to support these ventures. Thus, we review the empirical literature to answer the following research question:

RQ 3: What are the strengths and weaknesses of the different methodologies and indicators used to measure the impacts of SBEFs?

2. METHODOLOGY

The aim of this study was to make a systematic review of the growing academic literature relating to SBEFs. As an initial step we used the ISI Web of Science database to search for articles published in leading peer-reviewed academic journals. The ISI database covers leading journals from a broad range of publishers and it was therefore considered unlikely that we would leave out any leading journals in our search. Studies of SBEFs use many different terms such as academic entrepreneurship, university spin-offs, and research-based start-up to mention a few. To identify articles containing a broadest possible range of combinations we constructed a set of search terms reflecting the origin of the firm and the nature of the firm commonly used in the literature (Rothaermel et al., 2007). The combination of the 6 terms for origin and the 17 terms for firm, as shown below, created 102 possible search combinations.

Origin	Nature of firm
Academy	New venture
Faculty	New ventures
Research-based	Spin-off
Science-based	Spin-offs
Scientist	Spin-out
University	Spin-outs
	Spinoff
	Spinoffs
	Spinout
	Spinouts
	New firm
	New firms
	Entrepreneurial
	Entrepreneurship
	Start up
	Start ups
	Spinning out

To limit the number of unrelated articles retrieved we limited the search to the title, abstract, and keywords and used the SAME operator to include only articles where the search terms occurred in the same sentence. 919 articles were found that matched our search criteria. These articles were then manually checked.

First we removed items that were clearly unrelated (e.g. in other fields, such as natural science, medicine, and book reviews), and then articles that were considered to not deal with SBEFs were removed. Many of these articles concerned university technology transfer more generally, but the role of SBEFs was not included or only very briefly touched upon. Finally, we removed a handful of articles that was published in 1994 or earlier. 127 articles remained as relevant for our study.

To make sure that we have covered the core literature on SBEFs, we compiled a list of all references in the 127 articles and counted the frequency by which each journal or book was cited. The 15 most cited journals and the frequency of citations within the 127 articles are shown below.

456	Research Policy
187	Journal of Business Venturing
146	Journal of Technology Transfer
105	Technovation
98	Management Science
96	Strategic Management Journal
79	R & D Management
61	Industrial and Corporate Change
55	Small Business Economics
55	Entrepreneurship Theory and Practice
49	Administrative Science Quarterly
49	American Economic Review
47	Academy of Management Review
42	Organization Science
40	Academy of Management Journal

We then conducted a new search in the 15 journals that were most often cited by the articles. All 15 journals were covered by the ISI database, but in this search we extended our search to include the entire article text. Based on the most frequent terms used to describe SBEFs found in our first search, we constructed the following search term:

"academic entrepreneur" OR "faculty entrepreneur*" OR "scientist entrepreneur*" OR "science based entrepreneur*" OR "university spin*" OR "academic spin"*

After searching the 15 journals we found 946 articles that matched our search criteria. After manually checking these articles and removing duplicates from our first search, 35 new articles were added to our sample. Many of these were from journal issues that appeared before a journal was included in the ISI database, such as 13 articles from the Journal of Technology Transfer before 2008. As a validity check we compared our final sample of 162 articles with the lists of articles identified by the two systematic literature reviews in our sample (Djokovic and Souitaris, 2008; Rothaermel et al., 2007). No additional articles from the journal issues covered by our searches were identified, indicating that our search terms and manual sorting have covered the literature on SBEFs well.

Based on the retrieved papers, we created a database with key information about each paper including information about data, methods, and findings. The coding was done by carefully reading a paper version of the article and checked for mistakes by a second person. The coded categories are shown below.

Type of information	Coded categories	Coding
Basic information:	Times Cited	Number from ISI database
	Keywords	From database (ISI)
	Authors	From database (ISI)
	Year	From database (ISI)
	Title	From database (ISI)
	Journal	From database (ISI)
	Primary	0 or 1
	Secondary	0 or 1
	Research Question	Description
Data and method	Theoretical framework	Description
	Conceptual	0 or 1
	Qualitative	0 or 1
	Quantitative	0 or 1
	Cross-sectional	0 or 1
	Longitudinal	0 or 1
	Type of data	Description
	Method of analysis	Description
	Sample Size	Description
	Country – data	Country codes
	Country - authors	Country codes
	Level of analysis	Short description
	Dependent variable - description	Description
	Dependent variable - level	Short description
Findings	Performance - description	Description
	Performance - level	Short description
	Key Findings	Description
	Proposals for further research	Description
	Comments	Description

This database allowed us to identify patterns in the existing scholarly literature. Based on this comprehensive overview of the literature, we then revisited all 162 articles to answer our initial research questions. Regarding the first research question, only 14 of the articles had empirical data that to some extent shed light on the types and extent of impacts generated by SBEFs. For the second research question on the link between the start-up conditions and the subsequent performance and impacts generated by SBEFs, 28 of the articles were considered relevant. The third research question on different methodologies and indicators

used to measure the impacts of SBEFs was addressed by re-examining the 42 articles relevant for first and second research questions. The relevant articles are presented and discussed in the Findings section.

As a next step, we linked our findings from the international literature review with relevant empirical studies concerning public policies, support programs, and SBEFs in Norway. This search covered a broader range of publication types because much empirical and policy-oriented research is not published in scientific journals, but disseminated through for example reports, working papers, and conference papers (Bolkesjø and Vareide, 2004a; Borlaug et al., 2009a; Hervik et al., 1997a; Rasmussen et al., 2007b). This search was made in the BIBSYS-database which covers all content in Norwegian libraries. To make sure we covered sources that where SBEFs were only a sub-theme, the search terms were rather broad compared to the previous search in the international literature. We searched for the following keywords in Norwegian:

“kommersialisering forskning” OR “universitet bedrift” OR “universitet kommersialisering” OR “FORNY” OR “spin-off”

The field used for the searches was of the type “utvalgte felt”, while the searches covered e-journals, printed journals, internet resources, e-books, paper books, articles and book chapters as well as PhD theses. This search returned 102 publications that after a manual check were reduced to 14 publications relevant to this study. In addition we searched for the same keywords in English as used in the previous journal search:

“academic entrepreneur” OR “faculty entrepreneur*” OR “scientist entrepreneur*” OR science based entrepreneur*” OR “university spin*” OR “academic spin*”*

This search returned 116 publications that after a manual check were reduced to 3 publications that included data from Norway. After removing duplicates between the two searches, we were left with 15 publications containing data from Norway relevant to this study. Based on the retrieved Norwegian publications we extended the literature database and made comparisons with the international data.

3. FINDINGS

3.1 OVERVIEW OF THE INTERNATIONAL LITERATURE ON SBEFS

The literature related to SBEFs has grown exponentially in recent years. As illustrated in Figure 3.1, our sample contains four or less articles each year prior to 2003. From 2003 the number of articles increased significantly to more than 10 articles annually and reached 29 articles in 2010. The literature search was made during summer 2011, so the final number of articles for 2011 will be higher than the 13 included in this review. This shows that SBEFs has become a well established arena for empirical studies aiming at investigating this particular type of new ventures and as an empirical context for studies with more general aims of theory building or theory testing.

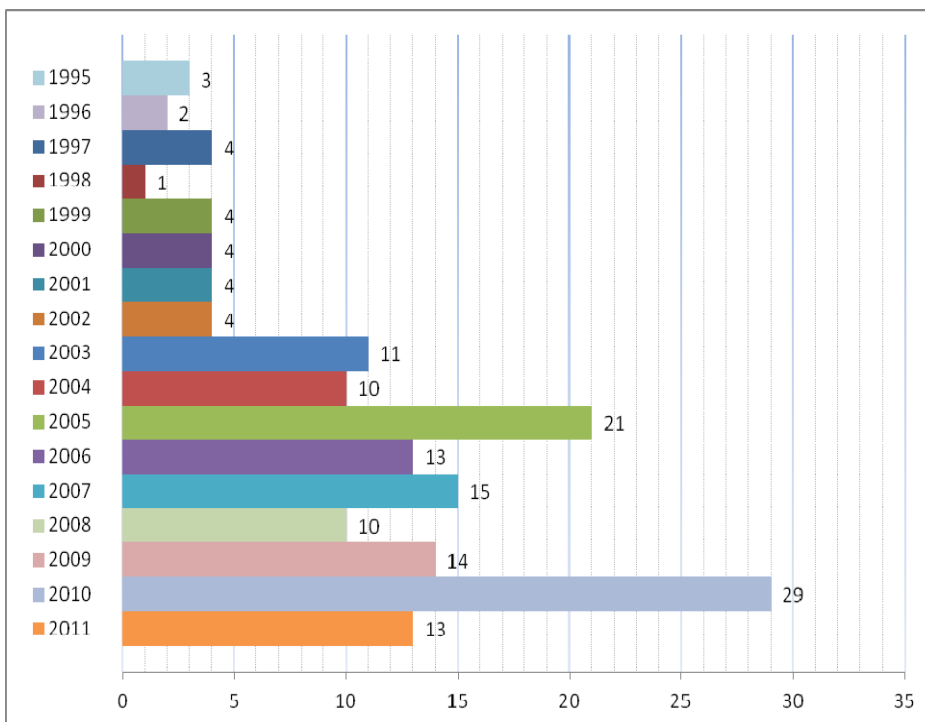


Figure 3.1 - Number of publications ranked by year (ascending) (Note that 2011 does not include a full year)

While 12 journals have published three or more articles (see Figure 3.2), five journals stand out as key outlets for publications in this area with 10 or more articles each. Research Policy has the highest number of articles (35), followed by Journal of Technology Transfer (26), Technovation (16), Journal of Business Venturing (11), and R&D Management (10). Thus, more than 60% of the articles are published in these five journals and more than one of five articles appear in one journal, Research Policy. The remaining articles are spread in many different journals and the 162 articles in this review appear in 38 different journals. More than half of these journals have published only one article. It should also be noted that several articles have been published in highly ranked management journals such as Management Science (5), Organization Science (2), and Journal of Management Studies (2). Thus, the context of SBEFs is regarded as appropriate for developing and testing theory of interest to a broader audience.

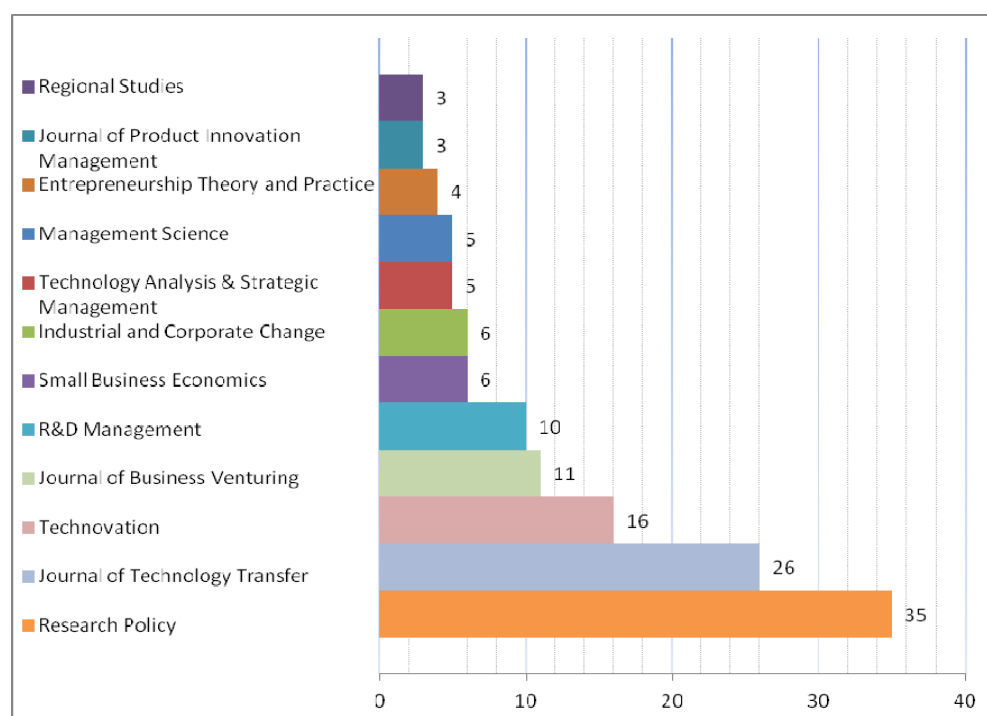


Figure 3.2 - Overview over journals with the highest publication frequency

The majority of the empirical studies (115) have data from a single country while some studies (30) combine data from several countries. Two countries stand out with empirical data in many studies (see Figure 3.3); US with 51 articles and UK with 36 articles. The empirical data is dominated by studies from Western Europe and North America. Outside these countries, China is included in most studies with three articles.

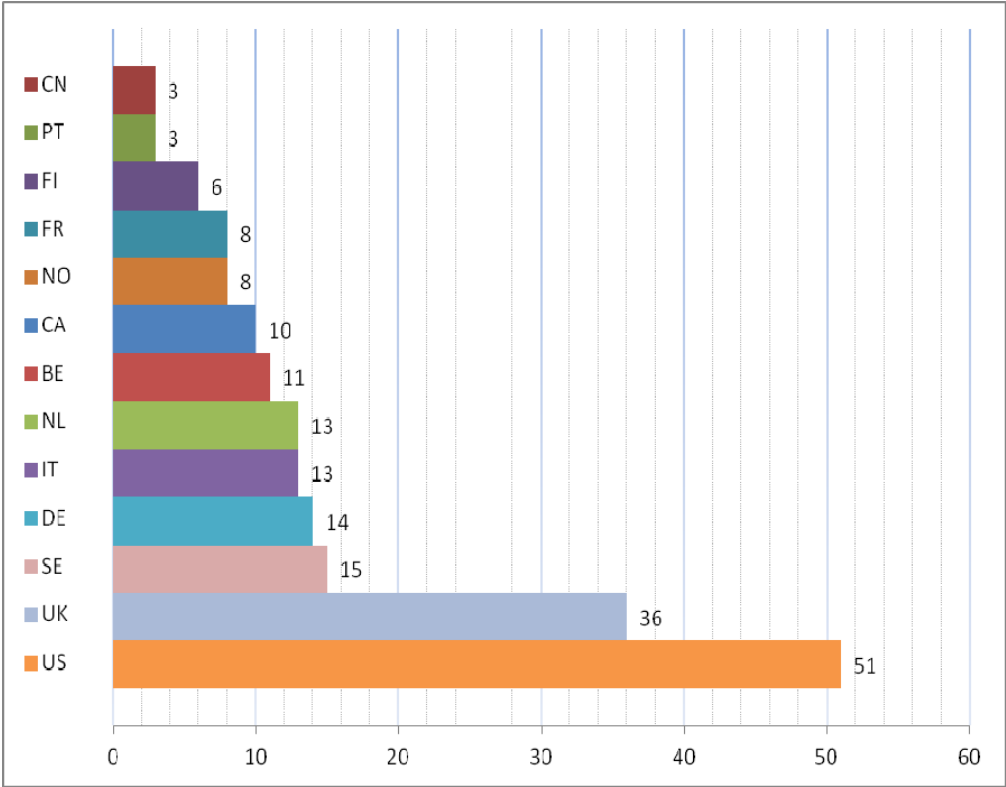


Figure 3.3 – Data sources by country

By looking at the author affiliation we can observe that some countries have more active researchers within this area (see Figure ??). US authors are represented on 52 articles, while authors from UK and Belgium are overrepresented compared to the number of empirical studies from these countries with 49 and 23 articles, respectively. Again, almost all articles are written by authors affiliated with institutions in Western Europe and North America.

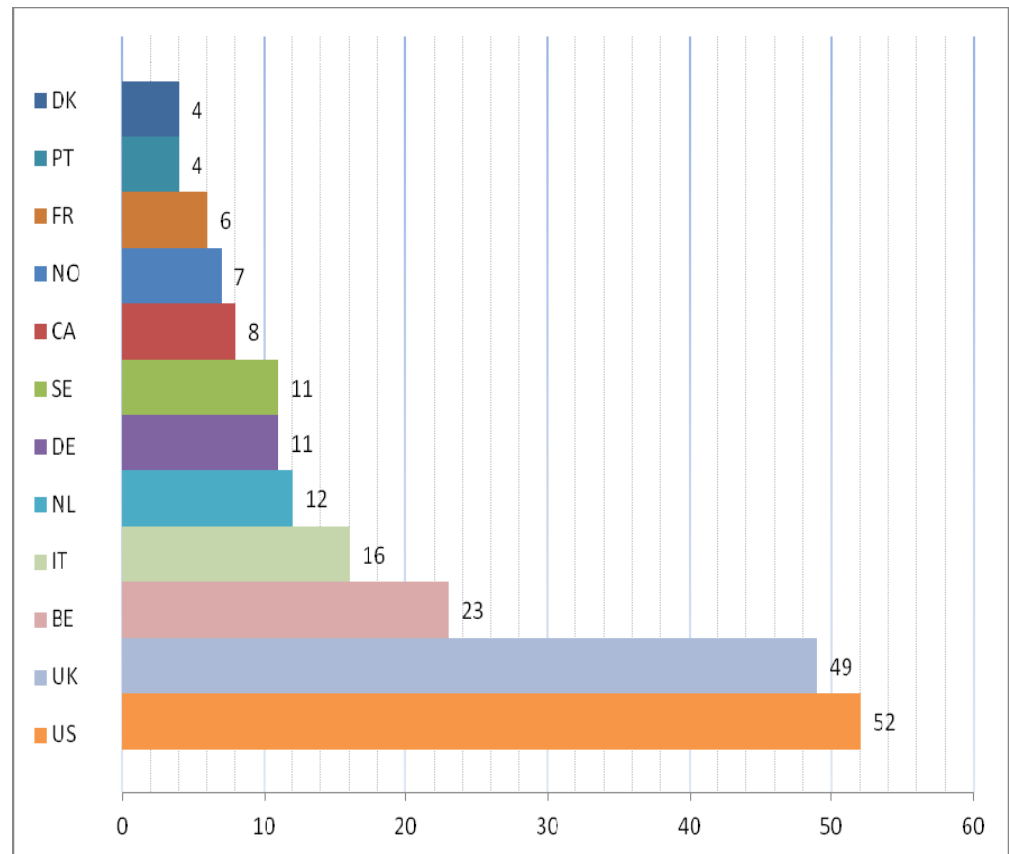


Figure 3.4 - Authors by country

An overview of the most productive authors (see Figure 3.5) reveals that a group of European authors have a strong position in this area. Mike Wright (UK) has the highest number of articles with 21, followed by Andy Lockett (UK) with 15 and Bart Clarysse (BE and UK) with 14.

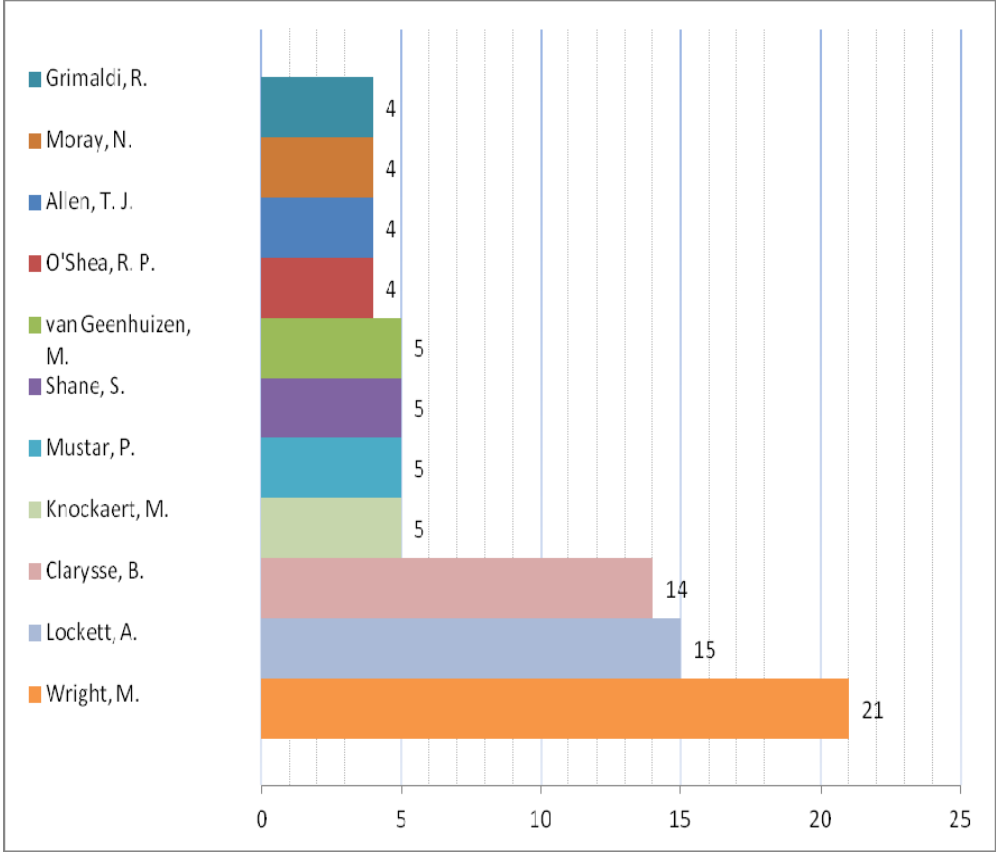


Figure 3.5 - Number of articles by authors

More than half of the articles (see Figure 3.6), a total of 86, relied on empirical data of a quantitative nature, while 45 relied on qualitative data. 16 articles used a mix of quantitative and qualitative, while the remaining 15 articles were conceptual of review articles that did not include any empirical data.

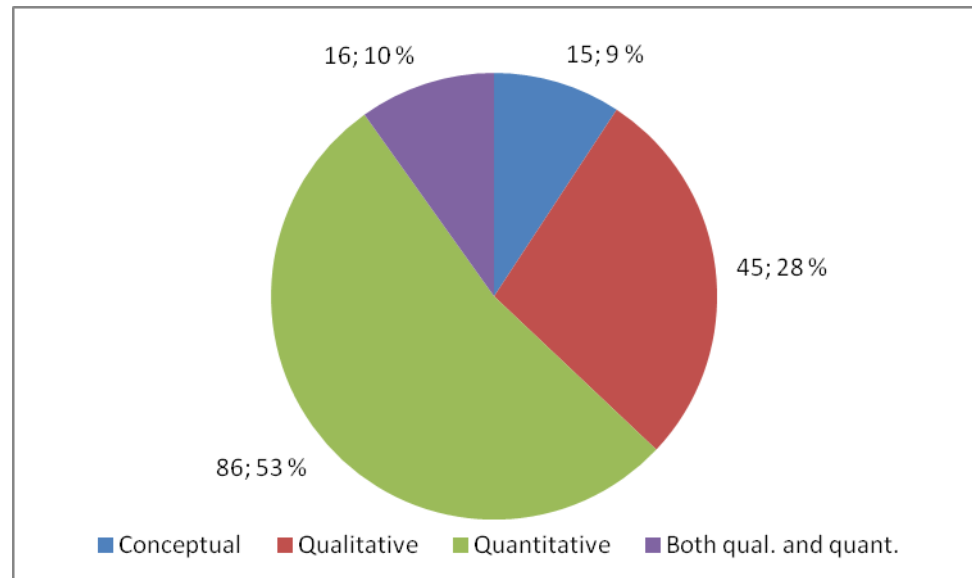


Figure 3.6 - Methodology used in the different articles

3.2 TYPES AND EXTENT OF IMPACTS GENERATED BY SBEFS

Very few articles in our sample explicitly discussed the impact generated by SBEFs. Among the 162 articles, we were able to identify only 14 empirical studies that included impact as a substantial theme. An overview of the approach, data and key findings of these studies are provided in Table 3.2.1. Most of these articles use data from a single university or region to discuss the impacts generated by SBEFs. Two different views on the impact of SBEFs related to their direct economic impact versus their impact as technology transfer agents.

Only one study has looked at the impacts of SBEFs at national level. This study by Vincett (2010) estimated the economic impacts of companies spun-off directly

from academic research in Canada from 1960 to 1998 and concluded that the impacts exceeded government research funding by a substantial margin. A study by Wallmark (1997) looked at patents from a single Swedish university from 1943 to 1994 and found that spin-off companies using these patents generated 70 new jobs each year.

A number of studies have examined the impacts of SBEFs at regional level, usually by considering firms spun-off from a single university. Among the most comprehensive is the study by Smith and Ho (2006) which identifies 114 spin-off firms in Oxfordshire established between 1950 and 2004 that currently employs 9000 people, while Chrisman et al. (1995) identified nearly 100 new ventures and 723 new jobs created by University of Calgary spin-offs. Moreover, Garnsey and Heffernan (2005) maps the development in the Cambridge area and shows that SBEFs can transform local economic activity. Berggren and Dahlstrand (2009) as well as Benneworth and Charles (2005) emphasizes the importance of SBEFs for the regional innovation system, but these studies rely mainly on anecdotal evidence. Leitch and Harrison (2005a) emphasizes that the impact of second order spin-outs is an important effect of university spin-out activity. In another study, Harrison and Leitch (2010) concludes that spin-off from UK universities appear to start and remain small. This article is the only that express general skepticism about the impacts of SBEFs and concludes that the prominence given to spin-offs in the analysis of technology transfer and in discussions of the economic impacts of universities is misplaced.

Also Rogers et al. (2001) discuss the regional impact of high-technology spin-offs based on research in New Mexico and concludes that high technology spin-offs are particularly effective means of technology transfer. Several studies points at the indirect effects of SBEFs as agents for technology transfer. For instance, Fontes (2005) concludes that biotechnology spin-offs play a valuable agency role in the access, application and dissemination of knowledge produced by research organizations. Along the same lines, Libaers et al. (2006) asserts that university spin-offs are important contributors to technological change in specific subfields of nanotechnology, but that other actors, notably, large firms and non-university affiliated new technology-based firms are even more significant agents of technological change. The study by Autio (1997) provides the most sophisticated assessment of the systemic impact of SBEFs to date. The study concludes that the most important economic impact delivered by new, technology-based firms may be a catalyzing one, delivered through technology interactions between the firms and their operating environment.

It seems clear that the evidence about the impacts generated by SBEFs is fragmented and partly contradicting. The majority of studies are based on anecdotal evidence and more than half the studies deals with a single university. The explanation for this lack of studies on the impact of SBEFs may be related to the need for consistent data over a long period of time (Smith and Ho, 2006). Studies considering impacts generated over a long period of time, such as Vincett's study including firms established from 1960 onwards and estimation of future impacts, establish a much more positive view of the economic impacts of SBEFs than studies considering the impact over shorter time periods (Harrison and Leitch, 2010). Moreover, there are many different perspectives on what can be considered as impact. All studies are, at least implicitly, discussing economic impacts in terms of economic activities that come as a direct or indirect result of the creation of SBEFs.

Table 3.2.1: Articles relevant for RQ1: 3.2. The types and extent of impacts generated by SBEFs

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings	Impact
			Quant.	Qual.	Long.	Cross	Data coll.	Sample size	Type of analysis		
(Autio, 1997)	Develop and empirically test a model to depict possible niches for new, technology-based firms, using a systemic view of the technological innovation process.	Systemic view of the technological innovation process	1	0	0	1	Survey of spin-off firms from Stanford, US; Cambridge, UK; and VTT, Finland	130 usable replies from spin-off firms	Descriptive statistics; student t-test; Mann-Whitney U test for unpaired groups	The most important economic impact delivered by new, technology-based firms may be a catalyzing one, delivered through technology interactions between the firms and their operating environment.	Technology transfer
(Benneworth and Charles, 2005)	Whether USOs bring economic benefits to less successful regions.	Case studies of two regions (Newcastle, UK and Twente, the Netherlands)	0	1	1	0	Anecdotal evidence from two peripheral regions	Two peripheral regions: Newcastle, UK and Twente, the Netherlands	Mapping of the literature; modeling	Case study highlight a conceptual model for understanding how spin-off companies can contribute to regional development through relationships and networking as well as by creating a regional knowledge pool that is actively used, and relevant to other firms.	Regional: Building territorial knowledge pool
(Berggren and Dahlstrand, 2009)	Regional effects of academic spin-offs	Exploratory case study of Halmstad University, Sweden	0	1	0	1	Case, face-to-face interviews	15 academic spin-offs from one university	Case, descriptive stories	Two waves of academic entrepreneurship contribute to the strengthening of the regional entrepreneurship en the attractiveness of the region.	Regional innovation system

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings	Impact
			Quant.	Qual.	Long.	Cross	Data coll.	Sample size	Type of analysis		
(Chrisman et al., 1995)	Determine the extent and impact of entrepreneurial activities of university faculty.	Descriptive case study of the University of Calgary	1	1	1	1	Multi-stage data: questionnaire, interviews, secondary data	374 scientists	Descriptive statistics	The economic benefits of the entrepreneurial activities of the faculty are substantial. A minimum of 180 ventures and 723 jobs have been created by the entrepreneurial activities of faculty over the years.	Economic/ regional impact
(Fontes, 2005)	What role do academic spin-offs play in transformation of knowledge into productive technologies, services and products?	Exploratory case studies of biotechnology firms in Portugal	0	1	0	1	Cases	18 academic spin-offs: 11 product-oriented and 7 service-oriented	Investigation , categorizing	Spin-offs play a valuable agency role in the access, application and dissemination of knowledge produced by research organisations.	Technology transfer
(Garnsey and Heffernan, 2005)	This study aims to describe the clustering at Cambridge through spin-outs.	Case study of Cambridge region. Human and social capital theory	1	1	1	0	Number of firms, jobs, turnover, survival rate, distribution by sector and more.	One region, longitudinal data	Descriptive statistics	Endogenous developments in Cambridge encompass the founding of companies by current and former members of the university, clustering stimulated by serial spin-outs from originator firms, the rise of local suppliers and, especially significant, the emergence of specialist labour markets.	Regional, transform local economy

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings	Impact
			Quant.	Qual.	Long.	Cross	Data coll.	Sample size	Type of analysis		
(Harrison and Leitch, 2010)	The role and dynamics of spin-offs development in the entrepreneurial system is defined.	Entrepreneurial system framework	1	1	0	1	Annual higher education-business and community interaction survey; interviews	Considers trend in spin-off activity in the UK and cases of 15 spin-off companies	Discussion based on descriptive statistics and cases	Spin-off companies are technology lifestyle businesses not dynamic high-growth potential start-ups. The prominence given to spin-offs in the analysis of technology transfer and in the economic impacts of universities is misplaced.	Economic (employment, turnover)
(Leitch and Harrison, 2005a)	What are the efficacy and appropriateness of the university technology transfer office becoming involved in second-order spin-out activities?	Longitudinal case study of Queens University, Belfast.	0	1	1	0	In-depth, multiple, semi-structured interviews	Single university	Discussion	The original parent/incubator organization can continue to play a significant role in channeling resources into start-up ventures and providing legitimation and credibility for them. Just considering the spin-offs as an extra revenue stream is not economically sound, but the effects of second order effects might change this.	Second order spin-out, regional impact

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings	Impact
			Quant.	Qual.	Long.	Cross	Data coll.	Sample size	Type of analysis		
(Libaers et al., 2006)	Examine the role of university spin-out in an emerging field - nanotechnology.	Explorative	1	1	1	0	Different databases on patents, from nanotech firms, 10 mini case studies	107 unique inventions; 70 co-publications; 121 firms	Descriptive statistics	University spin-offs are important contributors to technological change in specific subfields of nanotechnology, but other actors, notably, large firms and non-university affiliated new technology based firms are even more significant agents for technological change	Technology transfer
(Perez and Sanchez, 2003)	Is there any relationship between early networks development and knowledge creation and technology transfer in university spinoffs?	Exploratory study of spin-off from the university of Aragón, Spain	1	1	0	1	Structured interviews with a detailed questionnaire; survey	10 spin-offs	Descriptive	Technology transfer and networking at university spin-off decreased after their early years but at the same time the relationships with customers increased.	Technology transfer
(Rogers et al., 2001)	Lessons learned about effective technology transfer from research on the technology transfer process in New Mexico over the past several years.	Empirical study of the New Mexico case	1	1	1	0	Previous studies and snowball method to obtain data about	70 spin-offs; 55 research centers in New Mexico and cases from other regions	Descriptive statistics and anecdotal examples	High technology spin-offs are a particularly effective means of technology transfer.	Technology transfer

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings	Impact
			Quant.	Qual.	Long.	Cross	Data coll.	Sample size	Type of analysis		
(Smith and Ho, 2006)	Examine the number and performance of spin-offs of Oxford University and of the spin-offs from Oxfordshire's two other universities.	Empirical study of the Oxfordshire case	1	0	1	0	Employment , turnover, market cap. and patent and licensing activity from secondary sources	114 firms spun-out from three universities	Descriptive statistics	The survival rate of spin-off companies tends to be high but also, that the acceleration of growth takes up to 10 years to start. This illustrates that spin-outs are not a 'quick fix' for government economic development strategies.	Economic (regional level)
(Vincett, 2010),	Estimate the lifetime impacts of companies spun-off directly from academic research and compare the impacts with all government funding.	Empirical study of Canadian spin-offs	1	0	1	0	Government funding 1955-1998 and companies which spun-off 1960-1998.	111 companies	Descriptive statistics; estimates	The impacts exceed government funding by a substantial margin. Estimated discounted impacts for the whole non-medical natural sciences and engineering was about 3.3 times the discounted government funding.	Economic (national level)
(Wallmark, 1997)	University results in the form of patents. What is the impact of the inventions?	Exploratory case of Chalmers University of Technology, Sweden	1	0	1	0	Various statistics and archival sources	400 patents, 1943-1994	Descriptive statistics	About 50% of the university patents have been used for start-up of new spin-off companies and supporting their growth. Direct spin-off manufacturing firms with products protected by patents contribute with 70 new jobs each year.	Economic (employment)

3.3 LINKS BETWEEN THE START-UP CONDITIONS AND THE SUBSEQUENT PERFORMANS AND IMPACTS GENERATED BY SBEFS

After a critical assessment of all 162 articles, we identified 28 articles that included empirical data regarding the links between the start-up conditions and the performance of SBEFs. Because our focus was on venture performance subsequent to establishing the new venture, our analysis does not include a significant number of articles that were looking at factors associated with the event of starting-up SBEFs. Rather, we selected articles considering the performance of already established SBEFs. An overview of the 28 articles is provided in Table 3.3.1.

A number of factors that might be related to the development and performance of SBEFs had been explored by these articles. In the following we summarize the findings related to individual level factors, university level factors, and external factors. Moreover, we summarize some studies that have a more process oriented approach and a number of studies that compared academic and non-academic spin-offs.

Table 3.3.1: What are the links between the start-up conditions and the subsequent performance and impacts generated by SBEFs?

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Quant.	Qual.	Long	Cross	Data collection	Sample size	Type of analysis	
(Ambos and Birkinshaw , 2010)	What organizational archetypes can we identify in new ventures? What is the process through which new ventures transition from on archetype to another?	Venture archetypes; new venture growth theory; builds on contingency theory.	0	1	1	0	56 semi-structured interviews with all major stakeholders involved in the ventures, undertaken over 24 months.	9 firms.	Iterative process of theory develop-ment and analysis.	Identifies three distinct "venture archetypes," which typically emphasize one focal area of a business, and it sheds light on the sequencing of these archetypes. Show how the case ventures go through inter-archetype transitions, which are triggered by collective cognitive dissonance between the venture leaders' understanding of the old interpretive scheme and the emerging reality and are resolved through internal negotiations.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Bonardo et al., 2010)	What are the M&A (merger and acquisitions) dynamics of European science-based entrepreneurial firms (SBEFs).	Matching theory of ownership change; Q-theory of mergers. Analyse the M&A activity of innovative firms that went public in Europe in the period from 1995 to 2003.	1	0	0	0	List of Initial Public Offering (IPO) firms in Germany, the UK, France and Italy. Coded IPO prospectuses.	131 SBEFs.	Poisson regression; Cox proportional hazard regression.	The market for control of these firms was active, with most of the sample firms being acquired after their IPO, usually by companies within the same industry. Floated SBEFs showed a higher propensity to be acquired than independent firms: this distinction persisted after controlling for intellectual capital and other determinants. While university affiliation enhanced attractiveness in the eyes of other companies, it negatively affected the propensity for acquisition.
(Buenstorf, 2007)	Study 40 years of evolution in the German laser industry (1960s to 2003). Study entry and exit patterns as well as entrants' origins and performance, including spin-offs.	Constructed an original dataset to study the evolution of an industry.	1	0	1	0	A range of secondary sources and contact with firms.	143 German producers of laser sources, among them 28 academic startups.	Gompertz specification with proportional hazards; semi-parametric Cox regressions.	Germany and US laser industry have similar characteristics. Spin-offs from existing laser firms are more long-lived than academic startups. Technological capabilities were not as important for firm success as knowledge about market opportunities and customer needs. The strong international competition faced by the German laser industry did not fundamentally alter its evolutionary dynamics and did not preclude domestic entry.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Clarysse et al., 2007)	Examine the influence of formal technology transfer from a public research organization (PRO) on the amount of capital a spin-off raises at start-up and the increase in capital post start-up.	Valuation theory. Survey of academic spin-offs from PRO in five European countries.	1	0	0	1	Face-to-face interviews to collect the data.	97 firms.	Regression analysis.	Spin-offs involving a formal transfer of technology from their PRO start with a larger amount of capital than those without a formal transfer, but do not subsequently raise more capital. In those countries where the TTO offices are most developed and institutionalized, their influence on the way which spin-offs start up their business is highest.
(Clarysse et al., 2011)	How different characteristics in the technological knowledge base at start-up influence spin-off performance.	Study technological knowledge characteristics endowed at start-up to predict growth, controlling whether the technology is transferred from a corporation or university.	1	0	1	1	Personal interviews and archival data.	48 corporate spin-offs (CSOs) and 73 university spin-offs (USOs).	Multiple regression analysis.	CSOs grow most if they start with a specific narrow-focused technology sufficiently distinct from the technical knowledge base of the parent company and which is tacit. USOs benefit from a broad technology which is transferred to the spin-off. Novelty of the technical knowledge does not play a role in CSOs, but has a negative impact in USOs unless universities have an experienced technology transfer office to support the spin-off.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Gr	Data collection	Sample size	Type of analysis	
(Colombo et al., 2010)	Examine the effects of local universities on the growth rates of academic start-ups (ASUs) and compare with the effects on the growth of other NTBFs.	Absorptive capacity theory.	1	0	1	0	Longitudinal dataset of Italian NTBFs (1994 to 2003).	487 firms, 48 of these are ASUs.	Econometric methods; Gibrat law panel data model.	Universities do affect growth rates of local ASUs, while the effects on the growth rates of other NTBFs are negligible. Scientific quality has a positive effect, while commercial orientation has a negative effect on ASU growth.
(Ensley and Hmieleski, 2005)	A comparative study of new venture top management team (TMT) composition, dynamics and performance between university-based and independent start-ups.	Institutional isomorphism.	1	0	0	1	Survey to managers of high technology firms in the US.	102 university-based start-ups and matched sample of 154 independent new ventures	A combination of discriminant analysis, multiple regressions, and <i>t</i> -tests.	University-based start-ups are comprised of more homogenous TMTs with less developed dynamics than their independent counterparts. University-based ventures, while perhaps being mature from a technology perspective, appear to be somewhat immature in regard to their TMT dynamics.
(Grandi and Grimaldi, 2005)	Organizational factors affecting the process through which new ventures are established by academics and are likely to affect their performance	Organizational theory	1	0	0	1	Nonrandom sample of academic spin-off founders. Structured face-to-face interviews using a questionnaire.	42 Italian spin-off companies	Factor analysis, correlation and regression analysis	Company performance is linked with combining different knowledge sets which reside outside firms' boundaries. Prior joint experience positively influences business idea articulation.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Gurdon and Samsom, 2010)	Explore the personal and organizational dynamics which drive scientists to become involved in creation high-tech ventures and how these firms attain competitive advantage.	Exploratory follow up study in 2001 of scientists first studied in 1989 who had commercialized their inventions.	0	1	1	0	Multiple case study approach of biomedical start-ups.	17 ventures	Case comparison	An effective combination of management team processes and access to capital was observed among the successful ventures. Personal motives expressed by scientists in 1989, especially the single-minded focus on financial outcomes, appear correlated with ultimate success. Those who failed experienced a more intense conflict between business and science values. Frames of reference are dramatically different between scientists and business people.
(Hayter, 2011)	What are the motivations and definitions of success among nascent academic entrepreneurs?	Entrepreneurial motivations, growth aspirations and success	1	0	0	1	Interviews	74 nascent academic entrepreneurs	Coding of interviews, descriptive statistics	Academic entrepreneurs define success in a number of complex, interrelated ways including technology diffusion, technology development, financial gain, public service and peer motivations, among others. A large percentage of the respondents have little immediate interest in growth and have instead established their firms to pursue other sources of development funding.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Heirman and Clarysse, 2007)	How can research-based start-ups speed up innovation?	Resource-based view of the firm and new product development (NPD) literature.	1	1	1	0	structured questionnaire; face-to-face interviews with the founder	99 cases	Event history analysis. Cox proportional hazard models; probability model	The stage in the NPD process and assets at founding explain innovation speed in RBSUs, but differs considerably between software and other companies. Employing people who previously worked together leads to faster innovation speed, except for the software start-ups. Alliances with other companies do not significantly influence the time it takes to develop the first product.
(Lindelof and Lofsten, 2005)	Research proposition: University spin-offs (USOs) will use Science Park resources regarding business networks and financing issues to a larger extent than Corporate spin-offs (CSOs).	Empirical study of USOs and CSOs in Science parks.	1	0	0	1	Survey of new technology-based firms in Sweden.	134 firms: 74 USOs and 60 CSOs.	Descriptive statistics and correlation matrix.	There is a direct relationship between Science Park importance for attracting external capital and financing issues (USOs). There is also some evidence that professional businesses benefit from a Science Park location. The general levels of advice (Advice related to park: Banking institutions and Chamber of Commerce) by those CSOs located on a Science Park was considerably high.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Moray and Clarysse, 2005)	Whether the resource endowments of SBEFs are influenced by the way technology transfer is organized at the parent organization.	Longitudinal case study of one public research organization in Belgium	1	1	1	0	Data from different levels. Combination of quantitative and qualitative data.	Single case; 40 interviews	Historical process analysis	Establishing an incubator structure for spin-offs seems to be a learning process during which little decision making can be exerted over senior management's social network in the financial and business community for securing the financial, technological and human resources for the SBEFs.
(Munari and Toschi, 2011)	Do venture capitalists have a bias against investment in academic spin-offs?	Agency theory (information asymmetry etc) Evidence from the micro- and nanotechnology sector in the UK.	1	0	0	1	Secondary data sources.	247 firms (123 academic spin-offs and 124 other firms).	Descriptive statistics; cross-tabulation; Pearson chi-square; regression; correlation.	The results reject the presence of bias in this type of science-based business. They also highlight intellectual property rights (IPRs), type of business model and the university's scientific prestige as important factors in the academic spin-off's ability to access VC financing.
(Nerkar and Shane, 2003)	Why does the exploitation of radical technology only appear to help new firms survive in certain industries?	Use a data set of new technology ventures originating at Massachusetts Institute of Technology (MIT).	1	0	1	0	Data from the MIT technology licensing office. Unstructured interviews and secondary sources.	128 firms.	Weibull model of failure rates for MIT start-ups; instantaneous hazard function of failure.	Technological radicalness and patent scope reduce new firm failure only in the context of fragmented markets.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Rasmusse n et al., 2011)	Which entrepreneurial competencies are needed for nascent spin-off ventures within a university context to reach the credibility threshold? Who provides these competencies? How are they developed?	Evolutionary perspective; competency theory. Longitudinal multiple case study approach.	0	1	1	0	Secondary and primary data from spin-off projects, including 54 face-to-face interviews conducted at regular intervals throughout a 12-18 month period.	4 cases.	Classification into the three distinct competencies	The three competencies of opportunity refinement, leveraging, and championing are need to successfully launch a university spin-off venture. In some instances these competencies are built within the venture over time, while in other cases the competencies are acquired from sources outside the venture. Offer propositions regarding the intricacies of how these competencies evolve in different ways.
(Salvador, 2011)	Whether science parks and incubators can be considered as good 'brand names' for research spin-off firms.	Case study of Turin, including two science parks and two incubators.	1	0	0	1	Two samples; survey and comparison using secondary data.	30 spin-offs in survey; compare 91 start-ups and 20 spin-offs.	Descriptive statistics.	Turin spin-offs are micro firms rather than SMEs but dealing on the international market and in the most important sectors for the regional development plan. Spin-offs had lower performance than start-ups. The role as 'brand names' of science parks and incubators should be enhanced.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Shane and Stuart, 2002)	How do initial resource endowments affect the performance of new ventures?	Social capital theory. Data archive describing life history of university start-ups.	1	0	1	0	Firms founded to exploit inventions assigned to the Massachusetts Institute of Technology, 1980 to 1996.	134 firms	Event history analysis.	New ventures with founders having direct and indirect relationships with venture investors are most likely to receive venture funding and are less likely to fail. Receiving venture funding is the single most important determinant of the likelihood of IPO.
(Soetanto and van Geenhuizen, 2010)	What are the characteristics of social networks employed by university spin-off firms to gain knowledge? What is the influence of these characteristics on spin-offs' growth? What is the role of proximity in shaping the influence of social networks on growth?	Empirical study of university spin-off firms to explore differences in social networks between two development stages and to estimate the influence of network characteristics on growth in these stages.	1	0	0	1	Survey of university spin-offs of TU Delft, the Netherlands, and NTNU, Norway.	100 firms.	Descriptive statistics; OLS regression.	Early stage spin-offs tend to employ networks dominated by tightness, strong relationships, more homogeneous partners and local partners, whereas networks of spin-offs in later stages tend to face clearly contrasting features. Furthermore, network characteristics tend to influence growth mainly in years following the early stage, with a positive influence of social capital in networks that are relatively open to new knowledge and information.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Soetanto and Van Geenhuizen, 2009)	(1) What are the characteristics of social networks employed by university spin-off firms to gain knowledge in a large metropolitan region contrasted with a single, isolated city? (2) What is the influence of these characteristics on spin-offs' growth? (3) What is the role of proximity in shaping the influence of social networks on growth?	Agglomeration theory; social network. Examine social networks employed by university spin-off firms in contrasting urban environments, namely, Delft (NL) and Trondheim (NO).	1	0	0	1	The study draws on a survey of university spin-offs of TU Delft and NTNU. Data were collected using a semi-structured questionnaire in face-to-face interviews with entrepreneurs.	100 firms.	Regression modeling.	The networks appear to differ in various respects, except for a positive influence on growth of heterogeneity in the social background of partners. The largest difference is observed in strength of relationships: an increase in strength tends to hamper growth in Delft, while it tends to enhance growth in Trondheim.
(Toole and Czarnitzki, 2007)	Considers the U.S. Small Business Innovation Research (SBIR) program as a policy fostering academic entrepreneurship.	Traces academic entrepreneurship through the SBIR program and examine the impact these scientists have on the performance of the SBIR firms they found or join.	1	0	1	0	Database of firms that participated in the NIH SBIR program 1983 – 1996 and database of biomedical scientists.	2855 firms. Academic entrepreneurs associated with 240 of these firms.	Various regression models.	The SBIR program is used as a commercialization channel by biomedical academic scientists. The SBIR firms associated with these scientists perform significantly better than other SBIR firms in terms of follow-on venture capital funding, SBIR program completion, and patenting.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Toole and Czarnitzki, 2009)	To what extent does academic human capital contribute to firm performance?	Analyzes how the depth of academic entrepreneur's scientifically and commercially oriented academic human capital contributes to firm performance.	1	0	1	0	Construct two databases: 1) individual scientists performing biomedical research 2) firms participating in SBIR program.	2727 firms. Academic entrepreneurs associated with 169 of these.	Various regression models; cross-sectional probit-model.	Scientist-linked SBIR firms have a higher probability of follow-on venture capital investment, program completion and better innovative performance. The NIH stars within this group of entrepreneurs only increase the chances of follow-on venture capital investment. Firms that complete the SBIR program are more likely to receive follow-on venture capital funding.
(Valentin et al., 2007)	Analyse the research strategies of DBFs (dedicated biotech firms) and their link to financial valuation.	Resource based view;	1	0	1	0	Data extracted from the Scandinavian Biotech database (SCANBIT), developed by the authors to cover Scandinavian biotech firms.	43 Swedish and 49 Danish discovery DBFs.	Descriptive statistics; regression analysis (OLS).	Knowledge assets were shaped with distinct differences between two different approaches to drug discovery as part of the early activities of the firm. Firms emerge as strategizers also in the sense that inventions, subsequent to the initial composition of knowledge architectures, reveal a systematic pattern of reversing the balance of problem solving and knowledge creation established initially. Firms vary significantly in their ability to meet this challenge. Strategizing precisely in this respect significantly affects evaluation of firms and hence their ability to attract further capital at attractive rates.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Vohora et al., 2004)	What phases do do university spinout companies (USOs) go through in their development? What are the key challenges these ventures face in their development?	Inductive research; stage-based models; resource-based view	0	1	1	0	USO cases from top 10 elite list of UK-Universities.	9 USOs	Cross case analysis.	The article identifies several critical junctures and stages of development that spin-off companies go through. The different phases are critical as these ventures cannot develop into the next phase without overcoming each of the junctures.
(Walter et al., 2006)	What impact does network capability (NC) and entrepreneurial orientation (EO) have on spin-off performance?	Network capability theory; entrepreneurial orientation.	1	0	0	1	Mailed questionnaires.	149 university spin-offs.	Regression analysis.	A spin-off's organizational propensities and processes that enhance innovation, constructive risk taking, and proactiveness in dealing with competitors per se do not enhance growth and secure long-term survival. However, we found that NC moderates the relationship between EO and organizational performance.
(Wright et al., 2004b)	Explore the joint venture route to commercializing university owned intellectual property.	Compare two spinouts formed as joint ventures between universities and industrial partners and two spinouts with venture capital backing.	0	1	0	1	Multiple case study design.	4 cases; 36 interviews .	Inductive approach; cross-case analysis.	Creating a spinout company as a joint venture with an industrial partner, may be a means of overcoming some of the potential problems associated with managing resource weaknesses and inadequate capabilities that may be difficult to achieve as a freestanding spin-out company with or without venture capital backing.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Zahra et al., 2007)	Do corporate spin-offs (CSOs) and university spin-offs (USOs) differ in their knowledge conversion activities and if so, how? How do such differences influence the performance of CSOs versus USOs?	Knowledge based theory;	1	0	0	1	Mail survey to firms in 4 US states and secondary sources.	91 corporate and 78 university spin-offs (169 in total)	T-tests; χ^2 test; multi-analysis of covariance (MANCOVA); Scheffe test;	Corporate and university spin-offs transform their inventions into new products, goods and services that create value. This transformation requires a "knowledge conversion capability" that has three components: conceptualization and visioning of applications of that knowledge; configuration and design of potential products and other applications; and the embodiment and integration of knowledge into products. We find that CSOs and USOs differ in their emphasis on the three knowledge conversion capability components, benefit differently from these components in terms of their performance, and vary significantly in their performance.

Author(s)	Research questions/ theme	Approach	Type of study (method)							Key findings
			Qu	Qu	Lo	Cr	Data collection	Sample size	Type of analysis	
(Zhang, 2009)	Does university spin-offs perform better than other firms?	Database of venture-backed start-ups in the US	1	0	1	0	Data from VentureOne, a VC research company.	22479 rounds of VC financing involving 11029 venture-backed firms	Multivariate regression analyses; Pearson's X ² test; student t-test; OLS and logit regressions	Venture-backed university spin-offs are concentrated in certain industries. Technology transfer through university spin-offs is a local phenomenon. University spin-offs have a higher survival rate but exhibit no significant difference from other venture-backed firms in terms of the amount of VC money raised per round, total amount of VC raised, the possibility of completing an IPO, the probability of making a profit, or employment size.

3.3.1 Individual level

At the individual scientist level, many studies have looked at the propensity of academics to start new ventures (Bercovitz and Feldman, 2008; Fini et al., 2009). Still, only a few studies that look into the influence of the founders or the academic entrepreneurs on the performance of SBEFs. Two papers by Toole and Czarnitzki building on similar data from biomedical scientists and firms supported by the SBIR program in the US show that firms associated with scientists perform better (Toole and Czarnitzki, 2007). The contributions from the biomedical academic entrepreneurs, however, depend on the match between their specialized human capital and specific tasks within the firm (Toole and Czarnitzki, 2009). More specifically, the study by Shane and Stuart (2002) show that the social capital of the new venture founders in terms of relationships with venture investors increases the likelihood of receiving venture funding which in turn determines the likelihood of IPO. Moreover, the prior joint experience of the academic founders is found to influence business idea articulation that is seen as a precursor for firm success (Grandi and Grimaldi, 2005). Another study that focused on new venture top management team composition found that the top management teams of university-based start-ups were more homogenous than in independent start-ups and appeared less dynamic, which again hampered performance (Ensley and Hmieleski, 2005). Gurdon and Samsom (2010) asserted that scientists that were more motivated by financial outcomes were associated with successful spin-offs and that conflicts between business and science values could hamper spin-off development.

The most common measures of performance are related to the financial performance and the growth of the new venture, but performance is not clearly defined and may be assessed differently by different stakeholders. Although the vast majority of the studies has a one dimensional focus on economic performance, the study by Hayter (2011) shows that the performance of SBEFs can be assessed on many dimensions. Academic entrepreneurs define success in a range of different ways including technology diffusion, technology development, financial gain, public service and peer motivations. Hence, SBEFs that do not grow and have weak financial performance may still be viewed as highly successful by the academic entrepreneurs, for instance if the venture contributes to technology development that are seen as exciting by the academics. Thus, the link between start-up conditions and the performance and impacts of SBEFs is highly dependent on the perspective taken.

3.3.2 University-level

Another set of articles examine the research organization or the university-level influence on the performance of SBEFs. Moray and Clarysse (2005) followed the creation of spin-offs from one research organization over a 16 year period and find that the strategic choices of the research organization were highly influential for the type of spin-offs created. In particular, a more focused effort on spin-off creation resulted in new ventures that were able to attract more venture capital. Formal transfer of technology from the parent research institution was related to higher amounts of start-up capital, but not to subsequent capital raising (Clarysse et al., 2007). Another study found that collaborations with universities are associated with longer development times for research-based start-ups (Heirman and Clarysse, 2007).

The local university characteristics may be of particular importance for the growth rate of academic start-ups compared to other firms in the region as shown by Colombo et al. (2010). They found that the scientific quality of the research performed by universities has a positive effect on the growth rates of academic start-ups, while the commercial orientation of research has a negative effect. The latter finding is interesting because studies at the individual level indicate that commercial orientation is positive for venture performance (Grandi and Grimaldi, 2005). At a later stage of firm development, Bonardo et al. (2010) found that university affiliation enhanced the attractiveness of publicly listed SBEFs in terms of making them more likely to be acquired by other companies.

The link between start-up conditions and performance is obviously related to what time period in the new venture development that is considered. For instance, the university context may be much more influential in the earliest stages of venture development than for older and larger SBEFs. Still, some argue that initial start-up conditions may have a long term imprinting effect that may facilitate or hamper firm performance in the long run. For instance, the motives expressed by scientists early in the venturing process appears correlated with ultimate success (Gurdon and Samsom, 2010), the characteristics of the technological knowledge base at start-up influence spin-off firm performance (Clarysse et al., 2011), specific capabilities acquired at the parent firm influence the long term survival (Buenstorf, 2007).

3.3.3 External context

Few studies have looked at how specific industry environments may influence the success of SBEFs. A novel study by Nerkar and Shane (2003) shows that SBEFs

exploiting radical technologies with broad patent scope are more likely to survive in fragmented industries than in concentrated industries. Industry difference is also evident in the study by Heirman and Clarysse (2007), who found that the impact of starting conditions on innovation speed differs between software SBEFs compared to SBEFs in other industries. The complexity of environment influence on spin-off development were illustrated by Soetanto and van Geenhuizen (2010) who found that stronger networks enhance growth in one region and hamper growth in another region.

A subset of studies deals with science parks and their impact on SBEF performance. For instance Lindelof and Lofsten (2005) found that university spin-off gained more from their relationship with science parks than corporate spin-offs in terms of attracting external capital. Moreover, Salvador (2011) argues that science parks and incubators serves as important brand names for spin-offs.

3.3.4 New venture start-up process

Some studies have looked into the intricacies of the start-up process in SBEFs. It has been suggested that these ventures go through different critical junctures (Vohora et al., 2004) or archetype changes (Ambos and Birkinshaw, 2010) that are crucial for their development into successful firms. These critical junctures may be seen as obstacles to growth that the firm has to overcome in order to achieve sustainable growth. One way of overcoming such obstacles may be to create the spinout company as a joint venture with an industrial partner (Wright et al., 2004b). Furthermore, Rasmussen et al. (2011) suggest that the evolution of entrepreneurial competencies is critical for making SBEFs overcoming their earliest stages of development and that many different actors can contribute to the development of these competencies. Moreover, Zahra et al. (2007) discuss the knowledge conversion capabilities of university spin-offs and find that the emphasis on these capabilities is different compared to corporate spin-offs. It has also been argued that the firms' network capability is important for performance (Walter et al., 2006), and that firm strategy effects the evaluation of science-based biotech firms (Valentin et al., 2007). Soetanto and van Geenhuizen (2010) asserts that the social networks of university spin-offs differs between early stage and later stage spin-offs, and that in later stages there is a positive relationship between networks open to new knowledge and information, and firm growth.

3.3.5 Comparing academic and non-academic technology ventures

One way of assessing the performance and impacts of SBEFs is to compare these firms with a control group of firms with a non-academic origin. Nine of the 28

articles included data on both academic and non-academic technology ventures and compared the performance of these two groups. This approach shows whether SBEFs are different from other technology ventures and the performance implications of these differences. A summary of these comparisons are provided in Table 3.3.2. All nine studies looked at the firm survival and economic performance of SBEFs, while other impacts have not been compared by any study. The study by Ensley and Hmieleski (2005) concludes that university-based start-ups perform significantly lower than independent new ventures in terms of revenue growth and net cash flow. Munari and Toschi (2011) concludes that venture capitalists do not have a bias against investment in academic spin-offs in the micro- and nanotechnology sector, indicating that SBEFs perform as well as other firms in terms of obtaining venture capital investment. This finding was supported by another study (Zhang, 2009). It was also found that spin-offs from existing laser firms have been more long-lived than have been academic startups (Buenstorf, 2007). However Zhang (2009) finds that university start-ups have higher survival rates than other start-ups. It seems likely that differences in survival rates are contingent on contextual factors related to the type of industry, regional conditions, and factors associated with the university and surrounding support system (e.g. TTO and incubators).

Table 3.3.2 Studies comparing academic and non academic spin-offs.

Author	Sample	Key findings
(Buenstorf, 2007)	143 confirmed German producers of laser sources between 1964 and 2003 (among them 28 academic startups).	Spin-offs from existing laser firms have been more long-lived than have been academic startups.
(Clarysse et al., 2011)	48 corporate spin-offs; 73 university spin-offs	Platform technology can be beneficial to use by firm founders. However it has positive effect while target market is unknown, and can have negative effect on growth if the market is known; due to founders spread their resources too thin.
(Colombo et al., 2010)	487 Italian NTBFs 48 of which are ASUs	The paper suggests that universities do affect growth rates of local ASUs, while other NTBFs are barely effected. The authors conclude that this is due to the lacking ability of other NTBFs to absorb and take advantage of research done at the universities.
(Ensley and Hmieleski, 2005)	102 high-technology university-based start-ups an otherwise equivalently matched sample of 154 independent	(1)"university-based start-ups are comprised of more homogenous TMTs with less developed dynamics than their independent

Author	Sample	Key findings
	high-technology new ventures	counterparts. Further, university-based start-ups are found to be significantly lower performing in terms of net cash flow and revenue growth than independent new ventures."(2)"Our findings demonstrate that university-based ventures, while perhaps being mature from a technology perspective, appear to be somewhat immature in regard to their TMT dynamics.
(Lindelof and Lofsten, 2005)	134 new technology-based firms in Sweden: 74 NTBFs from academy, 60 NTBFs from private sector	"The study indicates that there is a direct relationship between Science Park importance for attracting external capital and financing issues (USOs).There is also some evidence that professional businesses benefit from a Science Park location. The general levels of advice (Advice related to park: Banking institutions and Chamber of Commerce) by those CSOs located on a Science Park was considerably high."
(Munari and Toschi, 2011)	247 companies (123 academic spin-offs and 124 other companies)	The results reject the presence of bias in this type of science-based business. They also highlight intellectual property rights (IPRs), type of business model and the university's scientific prestige as important factors in the academic spin-off's ability to access VC financing.
(Salvador, 2011)	30 spin-offs answered the questionnaire; 91 spin-offs	The analysis from the spin-offs reveals that the firms are micro firms rather than SMEs but dealing on the international market and in the most important sectors for the regional development plan. The author also agrees with Autio (Autio 1997) that the companies suffer from "growth myopia" but "they show great aspirations for the future". The main difficulties for these companies are lack of managerial experience and lack of funding support.
(Zahra et al., 2007)	91 corporate and 78 university spin-offs (169 in total)	The results underscore the importance of the KCC in explaining the relative performance of CSOs and USOs, contributing to the knowledge-based theory of the firms. The analyses also show that both CSOs and USOs have performance advantages of their own.

Author	Sample	Key findings
(Zhang, 2009)	22479 rounds of VC financing involving 11029 venture backed firms; a total of 10530 individual founders whereof 903 individuals have been affiliated with an academic institution.	After controlling for industry and other relevant factors, university spin-offs have a higher survival rate but exhibit no significant difference from other venture-backed firms in terms of the amount of VC money raised per round, total amount of VC raised, the possibility of completing an IPO, the probability of making a profit, or employment size.

3.4 STRENGTHS AND WEAKNESS OF THE DIFFERENT METHODOLOGIES AND INDICATORS USED TO MEASURE THE IMPACTS OF SBEFS

To answer the third research question regarding the use of methodologies and indicators we examined all articles that were relevant for the two first research questions, 42 in total. Detailed overviews of each article were presented in Table 3.2.1 and Table 3.3.1, while Table 3.4.1 provides an overview of the measures and indicators used in each article.

Table 3.4.1 Studies comparing academic and non academic spin-offs.

Author(s)	Which measures/indicators of impact or performance is used	Key indicators
(Ambos and Birkinshaw, 2010)	Performance not directly measured, but the process of venture development is analyzed. Comprehensive organizational transitions are necessary for ventures to evolve.	Process of venture development.
(Autio, 1997)	Impact measured as the firms' technology interactions with the operating environment.	Technology transfer.
(Benneworth and Charles, 2005)	Discusses impact in terms of university spin-off companies' contribution to building territorial knowledge pool.	Regional development.
(Berggren and Dahlstrand, 2009)	Measure impact in number of employees and turnover. Discusses the impact on regional innovation system.	Regional development.
(Bonardo et al., 2010)	Performance measured as probability of being acquired after IPO.	Venture acquisition.
(Buenstorf, 2007)	Time period of presence in the laser industry is taken as a measure of firm performance.	Firm survival.

Author(s)	Which measures/indicators of impact or performance is used	Key indicators
(Chrisman et al., 1995)	Impact measured as venture creation and employment growth.	Economic impact (technology transfer).
(Clarysse et al., 2007)	Start-up capital raised within 18 months of start-up. Average capital increase (total capital divided on firm age).	Obtaining external financing.
(Clarysse et al., 2011)	Performance measured as sales growth and employment growth.	Sales growth and employment growth.
(Colombo et al., 2010)	Performance measured as growth in number of employees. The contribution of university research to the growth of academic start-ups (number of employees).	Employment growth.
(Ensley and Hmieleski, 2005)	Performance measured as net cash flow and revenue growth. University-based start-ups are found to be significantly lower performing in terms of net cash flow and revenue growth than independent new ventures.	Financial firm performance.
(Fontes, 2005)	Discusses impact in terms of three technology transfer functions: 1) Bring to market research results or technologies, 2) Improve accessibility of under-exploited industry-oriented knowledge, 3) Active intermediation in knowledge transfer and absorption by specific users.	Technology transfer.
(Garnsey and Heffernan, 2005)	Impact measured as survival, employment, and turnover. Discusses impact from clustering at regional level.	Survival, employment, financial.
(Grandi and Grimaldi, 2005)	Performance linked to successful business idea generation. It is assumed that a high level of the two dependent variables (business idea articulation and business idea market attractiveness) leads to success.	Venture success.
(Gurdon and Samsom, 2010)	Performance linked to successful venture development over time and the start of additional ventures by the academics. Personal interest and motivation important for survival and growth.	Venture success
(Harrison and Leitch, 2010)	Impact measured as employment and turnover. Impact on the entrepreneurial system is discussed.	Employment, financial.
(Hayter, 2011)	Performance related to what academic entrepreneurs define as success. For academic entrepreneurs, successful performance is more linked to technological than financial outcomes.	Success as defined by academic entrepreneurs.
(Heirman and Clarysse, 2007)	Performance measured as the time from starting a company to the first product is launched. Speed to market. Starting conditions influence speed to market.	Speed to market.
(Leitch and Harrison, 2005a)	Discussing impact measures such as survival rate, turnover, employment, and second order spin-offs.	Regional development.
(Libaers et al.,	Impact measured in terms of patenting and co-publishing	Technology

Author(s)	Which measures/indicators of impact or performance is used	Key indicators
2006)	of scientific papers.	transfer
(Lindelof and Lofsten, 2005)	Performance measured as sales growth and profitability There is no evidence that USOs exhibit slower growth (sales) than CSOs – they are also equally profitable.	Financial.
(Moray and Clarysse, 2005)	Performance measured as financial measures and employment growth. The research institution significantly impacts the starting configuration of its SBEFs.	Financial, employment growth.
(Munari and Toschi, 2011)	Performance measured as firms ability to attract VC funding. Venture Capitalists do not have a bias against investment in academic spin-offs.	Attract VC funding
(Nerkar and Shane, 2003)	Performance measured as firm survival (acquired firms included). Authors test several factors that influence on survival and success of a new start-up firm.	Firm survival.
(Perez and Sanchez, 2003)	Impact measured as number of employees. Explores technology transfer by looking at networking activities.	Technology transfer.
(Rasmussen et al., 2011)	Performance defined as reaching the credibility threshold (adding new team members beyond the original inventor(s) and early stage investment from a private sector investor).	Process of venture start-up.
(Rogers et al., 2001)	The number of start-ups is discussed as an effective means of technology transfer. No measure of impact used.	Technology transfer.
(Salvador, 2011)	It uses the term "added value" which is the increase in value form being affiliated with the science park. Added value measured as total assets and time.	Financial
(Shane and Stuart, 2002)	Analyses three dimensions of performance: the ability to attract venture capital, experience IPOs and failing. Also consider the time it takes to achieve each of these outcomes.	Resource acquisition, financial, survival.
(Smith and Ho, 2006)	Impact measured as employment, turnover, market capitalization and patent and licensing activity. Discusses the contribution to the economy.	Employment, financial, innovation. Regional impact.
(Soetanto and Van Geenhuizen, 2009)	Performance measured as annual average job growth.	Employment growth.
(Soetanto and van Geenhuizen, 2010)	Performance measured as annual average job growth.	Employment growth.
(Toole and Czarnitzki, 2007)	Performance measured as completing SBIR program, patents granted and follow up private venture capital backing.	Start-up process, attract VC funding.
(Toole and Czarnitzki, 2009)	Performance measured as successful completion of Phase I of the SBIR program, patents granted and venture	Resource acquisition,

Author(s)	Which measures/indicators of impact or performance is used	Key indicators
	capital backing.	innovation, attract VC funding.
(Valentin et al., 2007)	Performance measured as financial performance, number of patents.	Financial, innovation.
(Vincett, 2010)	Impact is measured as the present value of past and future sales. Discusses the contribution to Gross Domestic Product.	Financial.
(Vohora et al., 2004)	Performance modeled as several "critical junctures" that have to be overcome for the venture to succeed.	Process of venture start-up.
(Wallmark, 1997)	Measure impact in terms of employment.	Employment.
(Walter et al., 2006)	Performance measured as sales growth, sales per employee, profit attainment, perceived customer relationship quality, realized competitive advantages, and long-term survival.	Financial.
(Wright et al., 2004b)	Performance analyzed as success in overcoming critical junctures during the start-up process.	Process of venture start-up.
(Zahra et al., 2007)	Performance measured as productivity, profitability (ROA), and revenue growth.	Financial.
(Zhang, 2009)	Performance measured as firm survival.	Survival.

The variety of measures and indicators is striking and reflects the different objectives of the studies and the high share of explorative studies. The most common measure to analyze the impact or performance of SBEFs is related to firm level performance derived from commonly available indicators such as firm size (turnover, employment) or financial performance. Moreover, some studies consider their impact in terms of technology transfer and the impact of SBEFs at regional level. Except of one study that looked at success from the perspective of academic scientists (Hayter, 2011), all articles dealt with either the firm level, technology transfer, or regional level of SBEF outcomes.

3.4.1 Firm level performance

The studies ranged from measuring the performance of SBEFs during their initial start-up process to study the performance of firms after IPO. To study the performance during the start-up process is challenging because it is difficult to identify samples of firms at this early stage of development and because SBEFs often have long development paths before they start to grow and become profitable. Some studies have looked at the initial development process and suggested that SBEFs initially have to overcome several critical junctures (Vohora et al., 2004; Wright et al., 2004b) or go through comprehensive organizational

transitions to progress into a successful venture (Ambos and Birkinshaw, 2010). One measure of success in the early stages of venture development is to overcome the credibility threshold, defined as gaining external equity investment and additional team members to the new venture (Rasmussen et al., 2011).

Many studies rely on proxies and intermediary measures of success instead of direct performance measures. For instance Grandi and Grimaldi (2005) use Business Idea Market Attractiveness and Business Idea Articulation as dependent variables and assumed that firms with these characteristics would be successful over time. Another example is Heirman and Clarysse (2007) who assumed that a shorter time between launching a company and getting the first product to market is preferable. Because SBEFs typically need a significant amount of financing to develop their product or services, successful acquisition of external financing have also been used a proxy for success (Clarysse et al., 2007; Munari and Toschi, 2011; Toole and Czarnitzki, 2009). Several studies use the ability to attract external financing (Clarysse et al., 2007), particularly VC financing (Munari and Toschi, 2011; Shane and Stuart, 2002; Toole and Czarnitzki, 2007, 2009) as a measure of successful venture development. The logic is that external financiers make an independent assessment of the venture's potential for success and they establish a market value of the venture based on its expected future potential. Thus, attracting external financing and other resources can be seen as an intermediary measure of venture success. Some studies used other intermediary measures that are assumed to be associated with higher subsequent performance, such as speed to market (Heirman and Clarysse, 2007) and business idea generation (Grandi and Grimaldi, 2005).

A number of studies look at the survival of SBEFs either as a single measure or in combination with other measures (Buenstorf, 2007; Garnsey and Heffernan, 2005; Nerkar and Shane, 2003; Shane and Stuart, 2002; Zhang, 2009). Survival is a very simple measure that are easily available, but surviving firms may stay small and lead to very limited impact. Thus, survival is a shallow measure that reveals little about the development patterns of the surviving firms. This measure may also be biased if the destinies of the non-surviving firms are unknown. For instance, for many SBEFs the preferred outcome is to be acquired by another firm. One study actually uses the probability of being acquired after IPO as the dependent variable (Bonardo et al., 2010).

Absolute employment numbers (Garnsey and Heffernan, 2005; Leitch and Harrison, 2005a; Smith and Ho, 2006; Wallmark, 1997) or employment growth is a

common measure of SBEF performance (Clarysse et al., 2011; Colombo et al., 2010; Moray and Clarysse, 2005; Soetanto and van Geenhuizen, 2010). This measure may be particularly relevant when considering the impact at regional level.

A relatively large share of the studies measure different types of financial success such as net cash flow and revenue growth (Ensley and Hmieleski, 2005), turnover (Garnsey and Heffernan, 2005; Harrison and Leitch, 2010; Smith and Ho, 2006), profitability (Zahra et al., 2007), sales growth and profitability (Lindelof and Lofsten, 2005), and added value (Salvador, 2011).

3.4.2 Technology transfer impact

The impact in terms of technology transfer from SBEFs is discussed by several of the studies. Although not all studies have operationalized how impacts are created (Fontes, 2005; Rogers et al., 2001), studies use diverse measures such as networking (Perez and Sanchez, 2003), patenting and co publishing of papers (Libaers et al., 2006), and technology interactions with environment (Autio, 1997).

3.4.3 Regional impact

The regional impact of SBEFs is of course closely linked to the firm level performance and technology transfer impact. In addition, some studies explicitly discuss the role that SBEFs play in developing the regional innovation system (Berggren and Dahlstrand, 2009) and building a territorial knowledge pool (Benneworth and Charles, 2005). In this perspective, the SBEF provides more to a region than its direct economic impact and technological contributions. SBEFs are seen as firms that can increase the attractiveness of a region and contribute to more entrepreneurial activity, for instance through second order spin-offs as suggested by Leitch and Harrison (2005a).

To investigate the long term effect of start-up conditions there is a need for longitudinal datasets, preferably over long time periods. Creating datasets by using historical data is labour intensive and restricted to issues covered by historical documentations. One example is the study of the evolution of the German laser industry over 40 years (Buenstorf, 2007), which relied on historical data from a number of different sources. The recent increase in studies on SBEFs, however, makes a fertile ground for more follow-up studies on existing datasets to explore the mechanisms behind long term performance and impacts of SBEFs.

3.5 THE NORWEGIAN LITERATURE ON SBEFS

From the original sample of 162 articles, we identified 8 articles that contain data from Norway. Three articles use the same dataset of SBEFs in Trondheim and Delft (The Netherlands) with particular emphasis on the role of social capital and networking in these firms (Soetanto and Van Geenhuizen, 2009, 2010; Taheri and van Geenhuizen, 2011). The study by Gulbrandsen and Smeby (2005) found neither a positive nor negative relationship between academic publishing and entrepreneurial outputs in a study of university professors in Norway. Rasmussen and Borch (2010) examined the development of four Norwegian spin-offs to explore the university capabilities that facilitate the creation of SBEFs. Based on data from a scholarship program, Reitan (1997) examined how universities can act as an incubator for new technology based firms. Bjørnåli and Gulbrandsen (2010) explored the board formation and evolution of board composition in 11 US and Norwegian academic spin-offs. Finally, Rasmussen et al. (2011) studied the evolution of entrepreneurial competencies in four university spin-off from the UK and Norway. Except of one study (Reitan, 1997), the articles with Norwegian data are published recently.

As an extension of the international literature search we searched for additional Norwegian sources of literature related to SBEFs. An overview of the 15 additional publications is provided in Table 3.5.1. Most of these publications are commissioned by policy makers and government support agencies and deals with the implementation of policies and the organization of support programs rather than the impact and performance of SBEFs. Three of the publications were evaluations of the FORNY-programme which is the main support initiative for the commercialization of research in Norway (Bolkesjø and Vareide, 2004b; Borlaug et al., 2009a; Hervik et al., 1997b). Moreover, the FORNY-programme has commissioned one evaluation of its infrastructure funds (Borlaug et al., 2008) and one international benchmarking study of similar programmes in other countries (Rasmussen et al., 2006a). The FORNY-programme has also supported several projects in areas of interest to its operation (Bjørnåli, 2010; Branstad, 2009; Sætre et al., 2006). The Norwegian publications also included one Official Norwegian Report (Bernt, 2001) and one report commissioned by the Norwegian government (Rasmussen et al., 2007a). Moreover, the documents included two PhD thesis (Bjørnåli, 2009; Rasmussen, 2006a) and three other reports stemming from different projects (Bugge et al., 2003; Gulbrandsen, 2003; Waagø, 2006).

Most of these publications were dealing with the commercialization of research more in general where the creation of SBEFs is considered as one of several mechanisms alongside licensing and different forms of industry interaction. Thus, only some of the studies included original data about Norwegian SBEFs. The 2009 evaluation of the FORNY-programme included an analysis of Norwegian SBEFs based on a survey and secondary data (Borlaug et al., 2009a). These analyses show that the FORNY grant-supported project portfolio from 1996-2007 counts 295 new companies started on the basis of technology that had been developed in Norwegian research institutions. In 2008, about 200 of these firms still existed with a total turnover of about NOK 900 million and 700 employees. Most of these firms are small, and only about 5% display patterns that make them likely to become high-growth firms (Borlaug et al., 2009a).

Tabell 3.5.1: The Norwegian literature related to SBEFs

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Bernt, 2001) Fra innsikt til industri: kommersialisering av forskningsresultater ved universiteter og høyskoler: innstilling fra et utvalg oppnevnt ved kongelig resolusjon 28. januar 2000: avgitt til Kirke-, utdannings- og forskningsdepartementet mars 2001. Oslo, Statens forvaltningstjeneste. Informasjonsforvaltning.	Official Norwegian Report "1) Gjøre rede for hvordan systemet for kommersialisering av forskningsresultater er i dag i Norge og i de andre nordiske landene. 2) Vurdere om det bør gjøres endringer for å oppnå økt kommersialisering 3) Gjøre rede for hvilke konsekvenser disse endringene vil få."	"Utvalget peker på at institusjonene i framtida i større grad enn i dag må se kommersialisering av forskningsresultater som del av sin virksomhet og sine samfunnsmessige forpliktelser. Denne kommersielt rettede virksomheten må samordnes med og integreres i institusjonens øvrige virksomhet på en måte som sikrer et fruktbart samspill mellom kommersialiseringsrettet virksomhet og grunnforskning." Rapporten legger vekt på at overføring av kunnskap fra forskning til samfunnet for øvrig er særdeles viktig.	N/A	N/A	N/A

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Bjørnåli, 2010). The role of the top management team and board in academic spin-offs. Trondheim, Høgskolen i Sør-Trøndelag, Avdeling for teknologi.	"This report attempts to ascertain the significance of the top management team and board of directors in the development of academic spin-offs." Project supported by the Research Council of Norway (FORNY).	"1) The findings show that boards in successful academic spin-off firms add value by bringing in necessary resources that the management team lacks. Additions of outside directors to the board are associated with a positive firm development. 2) Larger and more active networking boards facilitate the recruitment of new people to the top management team. 3) The board chair's personal networks are important when finding new potential board members. 4) Effective teams have members with diverse functional experience and industrial backgrounds. This diversity is associated with the firm's ability to recruit new members to the management team and attract venture capital financing. 5) The probability of attracting venture capital financing is also higher when an academic spin-off has previously received seed and industry capital financing."	The only (remotely) societal impacts mentioned in the article are the level of satisfaction with the companies' products, and their market share growth.	A linkage between the top-management competency and success is found.	

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Bjørnåli, 2009) Board of directors, top management team and the development of academic spin-off companies. Trondheim, Norges teknisk-naturvitenskapelige universitet. 2009:144: 153 s.	PhD dissertation. This dissertation addresses the under-studied area of the role of the top management team (TMT) and board of directors in the development of academic spin-off companies (ASOs) originating from public research institutes.	"The dynamics of the development stages in an ASO is related to the dynamics of its board. In successful ASOs the board contribution is dynamic. The board chair's social networks seem to be essential when attracting key members to the board of an ASO. Key board members bring in needed resources that the TMT lacks, ranging from finance and industry experience in earlier stages to executive and marketing/sales experience in later development stages. Thus, they help an ASO to provide a venture's viability and approach a stage of sustainable returns. Board size and networking appear to be important when recruiting new TMT members with necessary competences who open for new growth opportunities. ASOs that have value adding boards and TMT members with diverse functional and industry backgrounds succeeded in recruiting new team members and acquiring venture capital. The likelihood of attracting venture capital increases if ASOs have previously managed to receive seed capital and support from industrial partners."	N/A	The likelihood of attracting venture capital increases if ASOs have previously managed to receive seed capital and support from industrial partners.	Attracting venture capital used as performance measure.

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Bolkesjø and Vareide, 2004b). Evaluering av kommersialiseringsenheter i FORNY-programmet: hovedrapport. Bø, Telemarksforskning.	Evaluation of commercialization units connected to the FORNY program. Project commissioned by the Research Council of Norway (FORNY).	"The enterprise of the Commercialising Units ("kommersialiseringsenheter", KE) has a high additionality in regard to the completed commercialisations, and it has contributed to a compensation for market failure of different kinds. The value added is greater than the public means that are put into the program. The value added and the employment that grows out of the program are increased each year. While the program has many positive sides, there are also sides with clear potential for improvements."	The only impacts mentioned in the report is the employment growth that seems to have been stimulated as an effect of the work of the evaluated institutions (ch-7.3)"	N/A	Value added and employment measures used.
(Borlaug et al., 2008) Evaluering av bruken av infrastrukturmidlene i FORNY-programmet. Oslo, NIFU STEP.	Evaluation of the infrastructure funds awarded by the FORNY programme. Project commissioned by the Research Council of Norway (FORNY).	"Gjennomgående vurderes betydningen av infrastrukturmidlene som relativt høy, og dette er diskutert i forhold til tre typer av addisjonalitet..." (Are: innsatsaddisjonalitet, prosessaddisjonalitet og resultataddisjonalitet. De to første har høy addisjonalitet, og det tyder på at den siste også har det, men den har større usikkerhet knyttet til seg)	N/A	Lite fokus på bedriftene selv, men heller på FORNY-programmet rundt dem	N/A

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Borlaug et al., 2009a) Between entrepreneurship and technology transfer: Evaluation of the FORNY programme. Oslo, NIFU STEP.	Evaluation of the FORNY programme commissioned by the Research Council of Norway. The background for the evaluation is that the current programme period will be terminated by the end of 2009, and the results of the evaluation will be an important basis for designing the future programme."	"The general conclusion of the evaluation of FORNY is that despite the positive additionality and the successful targeting of high technology commercialisation projects, the overall results of FORNY are not very impressive. It should be mentioned that comparisons are extremely difficult and there may be indirect results and a positive dynamics taking place. Still, we worry about the lack of firms that have grown large and the generally poor growth rate compared to international cases."	Despite the positive additionality and the successful targeting of high technology commercialisation projects, the overall results of FORNY are not very impressive.	N/A	Financial and employment measures used.
(Branstad, 2009) Ulike kompetanseformers betydning for kommersialisering av forskning: en studie av fire norske Technology Transfer Offices (TTO). Tønsberg, Høgskolen i Vestfold.	"Denne rapporten redegjør for resultatene av en case-basert undersøkelse i fire ulike TTOer. Arbeidet er gjort underveis i min doktorgradsavhandling om støttestruktur for innovasjon og entreprenørskap i Norge." "Problemstillingen for denne undersøkelsen gjelder hvilken betydning ulike typer kompetanse har for TTOenes funksjoner."	"Det generelle bildet av kompetansebehovet i de fire TTOene er at ansatte bør ha kommersiell forståelse, kunnskaper om intellektuelle rettigheter, patentering og administrasjon, samt prosjektlederevner. Alle ser på fagspesifikk kompetanse som en ressurs, men de aller fleste mener enten at de ikke har behov for interne ansatte med høy forskningskompetanse da det går an å skaffe nok fagkompetanse ved behov gjennom organisatoriske grep, for eksempel eksterne engasjement eller styrerepresentasjon."	N/A	Fokus er på andre områder enn selve selskapene. I denne rapporten er det TTOene som står i fokus.	N/A

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Bugge et al., 2003). Kommersialisering av forskningsresultater: viktige forutsetninger, hvordan disse er håndtert ved noen amerikanske universiteter og anbefalinger for norske forhold. [S.l.], [s.n.].	Utgitt av Norges Eksportråd. Rapporten drøfter i første rekke kommersialisering slik det foregår ved såkalte "Offices of Technology Licensing" (OTL) i USA.	Rapporten inneholder en rekke anbefalinger for hvordan kommersialisering av forskningsresultater bør organiseres i Norge.	N/A	N/A	N/A
(Gulbrandsen, 2003) "Jeg gjør jo ikke dette for å bli rik av det": kommersialisering av norsk universitetsforskning - en intervjustudie. Oslo, NIFU.	"Denne publikasjonen omhandler kommersialisering av universitetsforskning med spesielt fokus på patentering og etablering av ny forskningsbasert virksomhet. Rapporten presenterer erfaringer fra norske universitetsforskere med kjennskap til slike aktiviteter, og den gjennomgår funn fra andre land."	"Et hovedinntrykk fra litteraturen og intervjuene er at kommersialisering både er arbeids- og kapitalintensivt..." "Ikke bare synes det å være få spenningsforhold mellom kommersialisering og grunnforskning, de to aktivitetene kan i en del tilfeller berike hverandre og spinne ut av samme interesse for faget..." "Forskerne antyder, som i en del andre undersøkelser, at det er en mangel på ekspertise i støtteapparatet for kommersialisering ved og i randsonen til de enkelte lærestedene."	N/A	Denne rapporten har lite konkret å gjøre med bedriftene, men heller mye med kommersialiseringsprosessen.	N/A

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Hervik et al., 1997b) Evaluering av FORNY-programmet: tilrådinger og endringsforslag. Molde, Møreforskning.	"Hovedformålet for NFR og SND med å sette i gang en evaluering har vært å få vurdert FORNY som konsept, organisering, gjennomføring samt foreløpige resultat og resultatpotensialet som grunnlag for beslutning om eventuell videreføring og/eller reorganisering og for å identifisere forbedringsbehov."	Antall nye ideer er tilfredsstillende, og det samme er kommersialiseringene. Få har gitt inntekter så langt. Infrastruktur-utviklingen tar tid, spesielt rundt holdninger på universitetene. Selvfinansiering ligger også langt framme. Noen "gull-fugler" er identifisert, men på grunn av en lang kommersialiseringsprosess, vil det ta noe tid før dette er sikkert.	N/A	Vurderingen her var opp mot hvordan FORNY stimulerte kommersialisering av NTBfer.	N/A

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Rasmussen, 2006a). Facilitating university spin-off ventures: an entrepreneurship process perspective. Bodø, HHB. no 8-2006: XIII, 273 s.	PhD dissertation.	The practical implications of this thesis assert that the spin-off activity is to a large degree embedded with 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 allow 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 in 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.	N/A	N/A	N/A

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Rasmussen et al., 2006a) Government initiatives to support the commercialization of research: an international benchmarking study. [Bodø], Handelshøgskolen i Bodø.	"This study was commissioned by the Research Council of Norway to improve their FORNY program. The study has benchmarked government initiatives aimed at increasing commercialization from public research institutions."	(1) There are different needs in different stages of national development of research commercialization. (2) Countries with weak cooperation between industry and research institutions tend to establish more comprehensive programs to facilitate commercialization in form of spin-offs or licenses. (3) There is a wide-spread recognition that a lack of seed capital finance has been a major obstacle. To remedy this, a more proactive stance has been taken.	N/A	This is a benchmarking of commercialization initiatives, and not the impacts of the SBEFs.	N/A
(Rasmussen et al., 2007a) Gjennomgang av virkemidler for kommersialisering av forskningsresultater. [Bodø], Handelshøgskolen i Bodø, (SIB AS).	Rapport utarbeidet på oppdrag fra Nærings- og handelsdepartementet (NHD) og Kunnskapsdepartementet (KD).	(1) Forskningsinstitusjonene bør i enda større grad se på teknologioverføring og kommersialisering som en primæroppgave. (2) Det er mangel på kompetanse innenfor kommersialisering av forskning ved mange institusjoner (3) Det er for lite helhetlige virkemidler rettet mot kommersialiseringsobjekter (4) Utydelige roller og sammenhenger mellom virkemidler.	N/A	Rapporten inneholder en analyse av offentlige virkemidler for kommersialisering og sier lite om SBEFs og deres impacts".	N/A
(Sætre et al., 2006). University spin-offs as technology commercialization: a comparative study between Norway, Sweden and the United States. Trondheim, NTNU, Dep. of Ind. Economics and Tech. Management.	"The purpose of this report is to survey university spin-offs as a mechanism for commercializing the results of academic entrepreneurship." Project supported by the Research Council of Norway (FORNY).	Rapporten fant at myndighetenes monetære støtte er essensiell for spin-offenes oppstartsfase. Dette gjaldt for alle landene i undersøkelsen. Amerikanske spin-offs får mer VC og annen kapital ved oppstart, i tillegg til å få denne ved et tidligere stadi enn i de skandinaviske landene. Investorer i USA, har også sterkere bånd til den relevante industrien, enn i Norge og Sverige. NTNU var også dårligere på å gjennomføre spin-off policyen deres.	N/A	Studie av kommersialiseringssprosessen og ikke noe om "impact".	N/A

Reference (BIBSYS)	Mission of the study	General findings	Findings of relevance to RQ1	Findings of relevance to RQ2	Findings of relevance to RQ3
(Waagø, 2006) Kommersialisering av forskning og utvikling (FoU): en undersøkelse av vilkårene for kommersialisering av FoU med spesielt fokus på Midt-Norge regionen. [Trondheim], Høgskolen i Nord-Trøndelag.	I bestilling		N/A	N/A	N/A

4. IMPLICATIONS FOR NORWEGIAN POLICY AND RESEARCH

By answering the three research questions outlined in the introduction, we seek to provide implications for Norwegian policy and research related to three areas. First, exploring evidence regarding the impacts created by SBEFs could inform debates about whether the creation of SBEFs is an efficient mechanism to create impacts from investments in research and how Norway compares to other countries in this respect. Second, to map the literature regarding what influences the performance of SBEFs would be important for the design of efficient policies and support schemes to promote SBEFs. Third, to explore the relevant methods and indicators to measure the impact of SBEFs is important for the evaluation of policies and support schemes, as well as further research. We will discuss these issues in turn. Finally, implications and suggestions for further research are provided.

4.1 THE IMPACTS OF SBEFS

Given the prominence of SBEFs in government policies to promote economic growth, the empirical evidence on the impact provided by this particular type of firms is limited. Some of the success stories that have created high attention towards the role of universities in the creation of new firms are based on very broad definitions where any venture started by faculty or students are included (Bank of Boston, 1989). Moreover, a small share of universities stands for a high proportion of the SBEFs created (O'Shea et al., 2005; Wright et al., 2008), and the literature often use empirical data from the most successful examples (Garnsey and Heffernan, 2005; O'Shea et al., 2007; Smith and Ho, 2006). Most studies in this area rely on anecdotal evidence or case studies of a single university or a single region. These studies typically conclude that SBEFs has a substantial positive impact related to for instance job creation and innovation, but whether this conclusion can be transferred to other contexts is not clear.

Although most studies portray a very positive image of SBEFs, there have been some critical voices questioning the prominence given to spin-offs in the analysis of economic impact from universities (Harrison and Leitch, 2010). Critics points to the fact that most SBEFs are small firms which often use long time to grow, if they grow at all. Moreover, the majority of the SBEFs created are associated with a

limited number of research institutions, while this is a neglectable activity at most institutions. In addition, almost all studies are done in North America and Western Europe, primarily the US and the UK. Based on the currently available studies it seems too early to conclude on the overall impact of SBEFs, but some indications can be made depending on the perspective taken.

Two distinct perspectives regarding the impact of SBEFs are evident in the literature. One set of studies focus on the direct economic impact in terms of for instance firm performance and job creation in the SBEFs themselves. Another approach emphasis the role of SBEFs as technology transfer agents that contribute to the dissemination of scientific knowledge into use in society. In the first perspective, it seems like SBEFs perform poorly relative to other technology-based firms, although this conclusion is not unambiguous. A comparison between corporate and university spin-offs might not be relevant due to the different starting conditions and purposes of these firms.

Studies that examined the impact of SBEFs using a long time-frame have provided more promising results. For instance, it was calculated that the impacts exceeded government research funding by a substantial margin for Canadian SBEFs established in the period 1960 to 1998 (Vincett, 2010). Thus, a challenge for most studies seeking to uncover the impact of SBEFs is to have data that covers a time period long enough for the impacts to be materialized. For instance, the evaluation of the FORNY program in Norway found that most firms in the portfolio of FORNY supported SBEFs were small (Borlaug et al., 2009a). However, this study mainly included firms that were 10 years or younger, while a study of SBEFs from the UK concluded that it takes up to 10 years before the acceleration of growth tends to start in this type of firms (Smith and Ho, 2006). Hence, it might be too early to expect that the impacts from the FORNY supported SBEFs has materialized only a little more than a decade after the first firms were established. It seems clear that the creation of SBEFs is not a short-term strategy to create high-growth firms, so called gazelles. Other types of firms tend to grow faster, but whether this is a relevant comparison might be discussed. SBEFs are seen to create attractive jobs and are often R&D intensive firms in emerging industries and therefore perceived as an important type of firms by policy-makers world-wide. Thus, the indirect impacts of SBEFs may be even more interesting than their direct impacts in terms of firm performance and direct employment.

From the technology transfer perspective, the indirect impacts are considered. However, these impacts are much harder to identify because they do not occur in

the SBEF itself. Based on anecdotal evidence and case studies, there is little doubt that SBEFs potentially can contribute to the transfer of new knowledge and technology into application in society. This view has been supported by a survey leading to the conclusion that the most important economic impact delivered by SBEFs may be delivered through technology interactions with their operating environment (Autio, 1997). The question is whether SBEFs can be seen as a generally important mechanism for technology transfer and whether this role has a substantial impact. Studies show that the creation of SBEFs is a relatively marginal channel of interaction between academics and industry (D'Este and Patel, 2007), and both governments and universities are spending significant amounts of resources to promote the creation of SBEFs (Harrison and Leitch, 2010; Rasmussen, 2008; Rasmussen et al., 2006b). Thus, in addition to the challenge of identifying and measuring the impacts generated, two questions need to be explored. First, do the creation of SBEFs maximise the impacts or are there other channels of technology transfer that may lead to higher impacts or more efficient processes? Second, does the impact exceed the substantial cost and potential negative side effects associated with promoting the creation of SBEF in universities? The latter is related to the additionality of government support. So far, these questions have not been paid much attention to in the literature.

Several studies in our sample adopted a regional or university case design to capture the contributions to economic development over time, but the direct impact of SBEFs are difficult to isolate from other factors contributing to successful regional development. Most studies in our review are discussing the direct economic impacts generated by SBEFs, but other types of impacts may be an important contribution from these firms. For instance, academic entrepreneurs pay relatively little attention to economic performance, but define success in terms of technology diffusion, technology development, public service, and peer motivations, among others (Hayter, 2011). Moreover, the goal of research commercialization also includes terms like social wellbeing (Langford et al., 2006). For example, the research council for health research in Canada defines the role of commercialization as benefiting Canadians through “improved health, more effective services and products, and a strengthened health care system” (Rasmussen, 2008). US programs supporting innovation, for example the partnership for innovation grants from the National Science Foundation, include social as well as economic objectives and metrics (Rasmussen and Rice, 2012). The Norwegian policy to increase the commercialization of research is mainly based on a rationale to foster industry development. The impacts from SBEFs in terms of social and societal benefits has not been empirically explored by any of the

studies in this review, but from anecdotal evidence and increased policy interest this is a promising area for further research.

To conclude, the majority of studies portray a very positive image of the impacts generated by SBEF. The number of studies that have examined this issue with empirical data is very limited and the findings remain open to criticism. SBEFs seem to be a special type of firms that have other purposes than other start-ups in terms of technology transfer and other societal benefits. However, many potential types of impacts have not been sufficiently explored by empirical data. Much work remains before any general conclusions can be made whether and under which conditions SBEFs creates an impact that exceeds the alternatives.

4.2 POLICIES AND SUPPORT SCHEMES TO PROMOTE SBEFS

By exploring the antecedents of firm performance and impacts, this review seek to provide some implications for policy and support that can strengthen these outcomes. It seems clear from reviewing the literature that SBEFs have some distinct characteristics from other new technology-based firms, such as higher survival rate and slower growth rate. In particular, SBEFs may experience particular challenges in their earliest phases of development that warrants special attention from policy makers and support schemes.

This literature review included several studies that linked the performance of SBEFs to individual level factors. Moreover, there is no doubt that the parent research institution has an impact on the development of SBEFs and that universities can develop capabilities that promotes the success of SBEFs (Clarysse et al., 2007; Rasmussen and Borch, 2010). Still, there is a need for a more fine grained understanding of how this relationship works and whether policies and support schemes can enhance the performance and impacts of SBEFs.

The external environment is likely to influence the development and performance of SBEFs, for instance in terms of industry differences (Nerkar and Shane, 2003) and regional differences (Soetanto and Van Geenhuizen, 2009). Still, our knowledge about how regional conditions and industry characteristics influence the subsequent success of SBEFs is fragmented. More knowledge would be vital to be able to create policies and support targeted to the particular challenges of industry sectors and regions.

Studies that follow the development of SBEFs at firm level and over time are scarce and they often face limited availability of historical data that are specific enough to reveal firm-level characteristics that have an impact on subsequent success. Moreover, studies related to firm performance are generally concerned with financial performance, venture growth, or intermediary measures assumed to be associated with these outcomes. Although many studies asserts that SBEFs play an important role for technology transfer or regional development, very few studies provide insights about what leads to successful outcomes on these dimensions. There are no large sample studies that have studied the links between start-up conditions and the societal impact of SBEFs.

To conclude, a number of factors have been found to influence the performance of SBEFs in different contexts, but how these factors interrelates remains scarcely studied. There is no doubt that policies and support can promote the performance and impacts of SBEFs, but the mechanisms leading to successful outcomes appears to be highly context specific. Thus, policy actions need to be differentiated according to the particular regional and institutional context, the phase of development, and the business model chosen by the SBEFs, as well as the type of impacts sought.

4.3 METHODS AND INDICATORS TO MEASURE THE IMPACTS OF SBEFS

A number of different methods and indicators have been used to empirically examine the impacts of SBEFs. It seems fair to say, however, that most studies rely on rather simple measures, often selected on the basis of data availability. SBEFs have long development paths and successful firms typically remain small for a rather long time period before they start to grow. To be able to capture this development the preferred option is to measure the impact over a long period of time, but such data are not readily available. Historical data is limited because attention to the creation of SBEFs is relatively new in many countries and the number of firms established has increased substantially in recent years (Wright et al., 2007).

Because it takes a long time before the impacts of SBEFs have materialized and can be measured directly, an alternative is to use intermediary measures that are associated with higher performance and impact at a later point in time. For instance, the FORNY-program in Norway has experimented with incentive

schemes that promote the creation of SBEFs that are able to attract private financing because such firms are perceived to have a higher value creation potential. The same logic is used in many of the studies reviewed in this report where obtaining external financing, particularly venture capital, is used as a performance measure. Other examples of intermediary measures are speed to market, business idea generation, patenting, IPO, and achieving 'milestones' perceived to be important for venture development. To use such intermediary measures is risky because new ventures follow different development paths. Not all SBEFs need venture capital and patenting is relevant in some industries, but not others. Thus, a thorough understanding of the venture creation process in different contexts is needed to develop appropriate measures and the use of multi-dimensional measures is preferred.

When it comes to methods and indicators to measure the impacts of SBEFs in terms of technology transfer, it becomes even more challenging. Measures such as patenting, co-publishing, and networking have been used, but these will only uncover some aspects of technology transfer.

To conclude, we observed that a broad range of indicators were used. Most studies were looking at firm level performance using indicators such as survival, employment, resource acquisition, financial indicators and growth measures. Although indicators to measure impact at regional level and in terms of technology transfer were discussed in several studies, it seems very difficult to measure this type of outcomes. None of the studies explored the non-economic and societal impacts generated by SBEFs in any detail. Hence, methods and indicators to measure technology transfer are very underdeveloped in the literature on SBEFs.

4.4 IMPLICATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The number of studies on SBEFs has grown rapidly over the last decade and has contributed to a better understanding of the particular challenges faced by this type of new ventures. The creation of SBEFs is a young but vibrant research theme that also encompasses high quality research that appears in top ranked entrepreneurship, innovation, and management journals. The studies covered by this literature review span a broad array of issues and few studies explore the same issues or use comparable data. As a result, it seems fair to say that the

current literature is rather fragmented. Hence, there are ample opportunities for further research that can lead to a better understanding of SBEFs and more informed policy and support.

There are few simple answers to the questions asked about the impact and development of SBEFs in the studies we have reviewed. The creation of SBEFs may be seen as an extreme version of new venture creation because of their resource demanding and complex development paths. University spin-offs are characterized by dynamic interactions between different individuals throughout the start-up process (Rasmussen et al., 2011). Business models are modified as the entrepreneurs improve their knowledge of available opportunities and resources (Druilhe and Garnsey, 2004). The entrepreneurial team of an academic spin-off evolves and changes in composition over time (Clarysse and Moray, 2004; Vanaelst et al., 2006), and its resource configurations may need to be modified as the spin-off develops (Vohora et al., 2004). Moreover, academic entrepreneurs are embedded in a university context, which both facilitates and constrains the venturing process (Kenney and Goe, 2004; Rasmussen and Borch, 2010). The complexity of the university spin-off process is evident from the many actors involved at different levels and their often different and unclear objectives (Mustar et al., 2006a).

Studying the complex and dynamic process of venture creation is challenging, and many have noted the atheoretical nature of spin-off research (Nicolaou and Birley, 2003; O'Shea et al., 2005; Shane, 2004). Most spin-off studies rely on data derived only from successful spin-offs which have survived the initial phases of development. There are frequent calls for more multilevel and process-oriented research into the university spin-off phenomenon (Lockett and Wright, 2005; Mustar et al., 2006b; Wright et al., 2004a). Hence, there seems to be a need to go beyond studies of the factors and conditions influencing the process by conducting more detailed investigations of the process as it unfolds over time.

Most studies included in our review suffer from survival biases because they only include SBEFs that have survived as an independent organization over the time of study. Although the survival rates of SBEFs are higher than other new firms, a large share of the firms that are established will discontinue after some years. Thus, a question that remains open is whether the firms that exit the databases and registers should be considered as having no impact. Most likely, the technology and activities of many of the SBEFs that discontinue will be continued in different forms. Many firms are bought or merged, which means that another

firm may continue and further develop the technology and business activity. In other cases, a new venture is established to continue the business or technology development. To be acquired by another firm would often be the preferred outcome for SBEFs, but relatively few studies have access to data that can separate these successful outcomes from firms that fail completely. For instance, the evaluation of the FORNY program included data only from firms that still existed in the Norwegian Business Register, which mean that the destiny of more than 100 firms (one third of all FORNY supported firms at that time) is unknown. Thus, it is likely that many successful acquisitions and other possible impacts have not been identified. To study the development of a full cohort of SBEFs and track the history of the firms that exit the registers would yield important new insights about the development patterns and impacts of SBEFs.

The literature is dominated by studies of SBEFs originating from university research, while in Norway and many other countries the research institute sector performs a significant share of the publicly financed research. Many research institutes generate a significant amount of spin-offs, such as IMEC in Belgium that established 20 SBEFS between 1991 and 2002 (Moray and Clarysse, 2005). Research institutes have a different purpose than universities, but whether and how this influence the creation and performance of spin-offs is under-explored.

It seems clear that there are significant variations in the extent and the development process of SBEF creation between different scientific disciplines and in different industries. Typically, the samples used in current research are not discipline or industry specific and the discipline specific samples are most often from the biotechnology area. Seen from a Norwegian perspective there is a lack of knowledge related to the importance of SBEFs in industries where Norway has a prominent position, such as offshore oil and gas technology. Thus, more industry specific studies of the role and impacts of SBEFs would be important. Moreover, there is a lack of comparative studies of SBEFs across different countries. 80% of all empirical studies reviewed in this report had data from a single country. Comparative studies can provide important insights into the influence of context upon the development of SBEFs.

Because of the long development paths of SBEFs, opportunities for studying their development over time are highly welcomed. Studies following the development of a cohort of SBEFs or university technologies over an extensive period of time, where different economic and societal outcomes are considered, would yield important new insights.

Finally, it seems like the most important impacts generated from SBEFs may be related to technology transfer and more societal benefits, rather than direct economic impacts at the firm level. There are, however, few studies of these impacts and the methods and indicators to measure technology transfer and societal benefits are underdeveloped. Thus, studies that explore these issues are highly welcomed.

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APPENDIX

The references and abstracts of all 162 articles that were identified in this literature review are listed in alphabetical order below.

Aldridge, T. and D. B. Audretsch (2010). "Does policy influence the commercialization route? Evidence from National Institutes of Health funded scientists." Research Policy **39**(5): 583-588.

The purpose of this paper is to provide an empirical test of the commercialization route chosen by university scientists funded by the National Cancer Institute (NCI) at the NIH and how their chosen commercialization path is influenced by whether or not the university technology transfer office is involved. In particular, the paper identifies two routes for scientific commercialization. Scientists who select the TTO route by commercializing their research through assigning all patents to their university TTO account for 70% of NCI patenting scientists. Scientists who choose the backdoor route to commercialize their research, in that they do not assign patents to their university TTO, comprise 30% of patenting NCI scientists. The findings show a clear link between the commercialization mode and the commercialization route. Scientists choosing the backdoor route for commercialization, by not assigning patents to their university to commercialize research, tend to rely on the commercialization mode of starting a new firm. By contrast, scientists who select the TTO route by assigning their patents to the university tend to rely on the commercialization mode of licensing. (C) 2010 Elsevier B.V. All rights reserved.

Ambos, T. C. and J. Birkinshaw (2010). "How Do New Ventures Evolve? An Inductive Study of Archetype Changes in Science-Based Ventures." Organization Science **21**(6): 1125-1140.

This paper presents a process study on the evolution of new ventures. We adopt the theoretical lens of "archetypes," which allows us to take a holistic perspective on new venture evolution and to provide rich insights into the interdependencies between the multiple contributory factors that shape the evolutionary process. Our analysis identifies three distinct "venture archetypes," which typically emphasize one focal area of a business, and it sheds light on the sequencing of these archetypes. We show how the case ventures go through interarchetype transitions, which are triggered by collective cognitive dissonance between the venture leaders' understanding of the old interpretive scheme and the emerging reality and are resolved through internal negotiations. The research provides insights into new venture evolution, the theory of organizational archetypes, and punctuated equilibrium perspectives on organizational change.

Audretsch, D. B., T. T. Aldridge and M. Sanders (2011). "Social capital building and new business formation: A case study in Silicon Valley." International Small Business Journal **29**(2): 152-169.

The article tracks potential employees (team members), university scientists (advisors) and venture capitalists (investors) who participated in a two-day workshop at Stanford University. The three groups are identified as either having preexisting professional interactions with the other two groups prior to attending the initial workshop, or having met for the first time at the workshop. The groups are then tracked over time for entrepreneurial activity. Positive relationships are found for groups who had preexisting professional interactions for founding a firm after the workshop. The article argues that innovation accelerators, such as the Stanford University workshop, offer invaluable social capital building opportunities to accelerate needed trust and tacit knowledge requisite for new firm formation.

Autio, E. (1997). "New, technology-based firms in innovation networks symplectic and generative impacts." Research Policy **26**(3): 263-281.

The traditional body of research on new, technology-based firms reflects the linear sequential view of the technological innovation process. The 'modern' innovation theory views the innovation process as a complex, iterative process, that is essentially systemic in character. The systemic view of the technological innovation process largely remains to be implemented in research on new, technology-based firms. The present study represents an attempt to bridge this gap, by applying a systemic approach to research on new, technology-based firms. The empirical part of the present study develops and empirically tests a model that classifies new, technology-based firms into science-based firms and engineering-based firms. The two categories are defined in terms of the functional relationship between the new, technology-based firm and the articulation process of basic technologies. In the model, new, technology-based firms are analyzed in terms of the systemic knowledge conversion process to which they are attached. The model receives support in three empirical databases, compiled among new, technology-based firms in Finland, the United Kingdom, and Silicon Valley. The analysis of the Silicon Valley database is the first ever systematic survey of the spin-off firms of Stanford University. (C) 1997 Elsevier Science B.V.

Baldini, N. (2010). "University spin-offs and their environment." Technology Analysis & Strategic Management **22**(8): 859-876.

Using nine university-level variables (including publications, patents, and spin-offs) and ten regional indicators, I show that the regional economy clearly differentiates Italian universities according to four distinct types, corresponding to four productivity levels. The typology stemming from multiple correspondence analysis suggests that a fertile context is important to successful universities;

however, where the environment is extremely rich, individuals seem to strongly self-select at the beginning of their careers, thus dividing entrepreneurs from professors; hence university activities in these regions are lower. A categorical regression specifically exploring success in university spin-off creation tends to reject that publications and spin-offs are substitutes, and confirms several US findings, albeit in a significantly different environment.

Baptista, R., F. Lima and J. Mendonça (2011). "Establishment of higher education institutions and new firm entry." *Research Policy* **40**(5): 751-760.

The presence of universities has generally been associated with technological entrepreneurship. But what is the real impact of new universities on the levels of firm creation in a region? The present paper uses policy evaluation methodologies and longitudinal data on the establishment of higher education institutions in Portuguese municipalities for the period 1992-2002 to examine its effect on entry rates of new firms in different sectors. We find that the establishment of a new university has a positive and significant effect on subsequent levels of knowledge based firm entry in municipalities, and a negative effect on the levels of entry in other sectors, such as low-tech manufacturing.

Bathelt, H., D. F. Kogler and A. K. Munro (2010). "A knowledge-based typology of university spin-offs in the context of regional economic development." *Technovation* **30**(9-10): 519-532.

Drawing on the literature pertaining to the role universities play in promoting technology transfer, this paper develops an insightful conceptualization of spin-off processes, and applies it to a current regional case study. The suggested typology of university spin-off/start-up firms is based on several variables, including the type of university sponsorship, university involvement in firm formation, the character of knowledge applied, and co-localization of the founders. The empirical case study is used to demonstrate the usefulness of this approach in analyzing spin-off firms, and then dynamics. The study is based on interviews conducted with university spin-offs/start-ups in the information technology (IT) sector located in the Kitchener and Guelph metropolitan areas. This region, which is home to the University of Waterloo - one of Canada's premier science and technology universities - has experienced an impetus of spin-off processes coming from university research dating back to the 1970s. The results of our analysis expose several trends. Sponsored spin-offs are largely the result of particular university research projects, and apply specific knowledge inputs in the development of their initial core technology. Unsponsored spin-offs, which find their foundation in decentralized idea development outside of the university setting, almost entirely rely on generic broad knowledge bases for the development of innovative products and services, which have enabled the firm-formation process. Overall, it is surprising that even firms that have received some form of university support described the role the University of Waterloo had in

their start-up process as marginal The dynamic research approach applied in this study, which outlines the university's changing role over time and the regional dynamics associated with spin-off firms, further demonstrates the potential of out typology As such, our typology of university-related start-up/spin-off firms is designed to support studies concerned with the wider impact of universities on technology transfer and regional development (C) 2010 Elsevier Ltd All rights reserved

Benneworth, P. and D. Charles (2005). "University spin-off policies and economic development in less successful regions: Learning from two decades of policy practice." European Planning Studies **13**(4): 537-557.

Although there is great interest in the new knowledge economy, less favoured regions seem permanently disadvantaged because they lack a critical mass of knowledge capital to initiate accumulation, growth and economic development processes. This is a problem for policy-makers seeking to promote economic growth and territorial cohesion in such regions. Despite this, examples from two such regions, Newcastle, UK and Twente, the Netherlands, suggests that such companies can be very successful. This paper seeks to develop a conceptual model of how university spin-off companies (USOs) can improve their regional economies. The economic benefits that such companies bring are explored, to identify those elements which can potentially upgrade regional economies through knowledge accumulation, which are termed 'building up territorial knowledge pools'. This paper concludes by developing a conceptual framework for the operation of the territorial knowledge pool; highlighting four different roles played by USOs in improving regional innovation environments and considering the conceptual and policy implications raised by the framework model.

Bercovitz, J. and M. Feldman (2008). "Academic entrepreneurs: Organizational change at the individual level." Organization Science **19**(1): 69-89.

This study explores the process of organizational change by examining localized social learning in organizational subunits. Specifically, we examine participation in university technology transfer, a new organizational initiative, by tracking 1,780 faculty members, examining their backgrounds and work environments, and following their engagement with academic entrepreneurship. We find that individual adoption of the new initiative may be either substantive or symbolic. Our results suggest that individual attributes, while important, are conditioned by the local work environment. In terms of personal attributes, individuals are more likely to participate if they trained at institutions that had accepted the new initiative and been active in technology transfer. In addition, we find that the longer the time that had elapsed since graduate training, the less likely the individual was to actively embrace the new commercialization norm. Considering the localized social environment, we find that when the chair of the department

is active in technology transfer, other members of the department are also likely to participate, if only for symbolic reasons. We also find that technology transfer behavior is calibrated by the experience of those in the relevant cohort. If an individual can observe others with whom they identify engaging in the new initiative, then they are more likely to follow with substantive compliance. Finally, when individuals face dissonance, a situation where their individual training norms are not congruent with the localized social norms in their work environment, they will conform to the local norms, rather than adhering to the norms from their prior experience.

Berggren, E. and A. L. Dahlstrand (2009). "Creating an Entrepreneurial Region: Two Waves of Academic Spin-offs from Halmstad University." European Planning Studies **17**(8): 1171-1189.

This article presents a Swedish case study of the regional effects of academic spin-offs. It is based on empirical data from Halmstad University and the Halmstad region, on the west coast of Sweden. The Halmstad case functions as an illustration of co-existing territorial and functional rationales, where a suburban lifestyle is combined with an increasingly academic knowledge. Spillover effects of university research (directly as well as indirectly) in the form of academic spin-offs have been traced over time. In doing so, we are able to identify two waves of academic entrepreneurship with direct and indirect regional effects. These waves contribute to the strengthening of the regional entrepreneurship and the attractiveness of the region. The establishment and (early) actions of the university can be seen as a stone that was thrown in the water, causing several waves to appear in the region. Whether these waves will be reinforced enough to create an entrepreneurial region, or just slowly disappear as rings on the water, also depends on the creation of an absorptive capacity and construction of the regional innovation system.

Bjornali, E. S. and M. Gulbrandsen (2010). "Exploring board formation and evolution of board composition in academic spin-offs." Journal of Technology Transfer **35**(1): 92-112.

An in-depth analysis of 11 cases is used to provide insight into the neglected area of the dynamics of boards in academic spin-offs. Drawing on stage-based, resource dependence, and social network theories, we explore board formation and changes in board composition occurring in Norwegian and US spin-offs. We find that these theories are important complements to earlier research on boards in technology-based new ventures. The process of board formation is mainly driven by social networks of the founders. Although we find differences in the initial board compositions in Norwegian and US spin-offs, there is convergence over time in subsequent board changes, which are mainly driven by the social networks of the board chair. Additions of key board members are associated with the progress of a spin-off developing from one stage to another. Several avenues for future research and implications are discussed.

Bonardo, D., S. Paleari and S. Vismara (2010). "The M&A dynamics of European science-based entrepreneurial firms." Journal of Technology Transfer **35**(1): 141-180.

This paper investigates the dynamics of a sample of 131 science-based entrepreneurial firms (SBEFs), selected out of 500 innovative small and medium enterprises (SMEs) that went public in Europe in the period 1995-2003. We found that the market for control of these firms was active, with most of our sample firms being acquired after their Initial Public Offering (IPO), usually by companies operating within the same industry. Floated SBEFs showed a higher propensity to be acquired than independent firms; this distinction persisted after controlling for intellectual capital and other possible determinants. While university affiliation enhanced attractiveness in the eyes of other companies, it negatively affected the propensity for acquisition. We argue that university-based firms do contribute to the technology transfer process, as evidenced by the widespread interest of the business world in investing in these firms. The creation of a SBEF is a first step in the process of commercial exploitation of university-research, while the subsequent step of going public is a sign of the success of this entrepreneurial venture. The take-over of SBEFs may be a final outcome of the process of knowledge diffusion.

Bower, D. J. (2003). "Business model fashion and the academic spinout firm." R & D Management **33**(2): 97-106.

Studies indicate that most European new, technology-based firms (NTBFs) have been founded by relatively senior, highly-educated personnel coming from existing companies. These founders already have strong, industry and market links. A relatively small proportion have spun out of university or other public research facilities. However, this latter group has attracted particular attention from several interested groups, including governments and the scientific establishment. For governments, this has appeared to offer a means whereby public policy could have a direct and significant impact on economic development. Hence substantial public resources are increasingly being committed to support these developments in most industrialised countries. The founders of HEI spinouts are often academics aiming to commercialise nascent technologies and they face challenges which are less likely to arise for the founder with an industry background. The emerging technologies often commercialised in academic spinouts may have many potential applications. At the outset founders must make critical strategic choices of applications to develop, if they are to attract the substantial resources often needed for the risky development process. Some of these choices need an understanding of changing fashions in business models and investors' current preferences for particular industries. It is a difficult challenge for academic founders with little prior market knowledge and linkages, and no previous experience of professional investors and their requirements, to select the applications and business models which will

support successful venture creation. This paper explores a number of key issues which surround these decisions and their relation to the changing business environment. It is concluded that the acceptability of novel technologies and products is mediated by systemic interactions which are ill-understood by industry and government.

Bray, M. J. and J. N. Lee (2000). "University revenues from technology transfer: Licensing fees vs. equity positions." *Journal of Business Venturing* **15**(5-6): 385-392.

This paper analyzes the financial return of universities' taking equity in their spin-off companies, and the prevailing attitudes toward taking equity. The reasons for taking equity include: the flexibility it gives licensing managers in structuring deals, the possibility that the university will still hold something of value if their technology is replaced and, the reduced time required to generate revenue compared to a traditional license. A traditional license is preferred when the technology is not suitable for a spin-off company, or when the technology is one of the rare jackpot licenses that bring in millions of dollars every year. The financial reward of taking equity was determined by comparing the value of equity sold in public spin-off companies to the return on an average license. A traditional license consists of a license issue fee between \$10,000 and \$250,000 and an annual royalty on sales. In 1996 the average annual income from a traditional license was \$63,832. The average value of equity sold in 14 university spin-off companies is \$1,384,242. If one assumes that half the spin-offs fail before they go public, the average value of equity is \$692,121. This is more than 10 times the average annual income from a traditional license, and is significantly higher than the amount usually received as a license issue fee. The high average value of equity depends on the presence of a few million-dollar equity sales. If those sales are excluded, the average value of equity is \$139,722, which is within the range that can be received as a license issue fee. There is a high correlation between million-dollar equity sales and the amount of venture capital spending in the region. The million-dollar sales in this study all occurred in the top 11 states in the country in terms of venture capital spending in 1997. From a financial viewpoint it makes sense for licensing managers to take equity in their start-up companies. Our data show that even if none of the start-ups produces a million-dollar equity sale, the financial return of equity will be within the range normally received as a license issue fee. Taking equity leaves the door open for the occasional jackpot, which will bring in significantly more money than a standard license. When combined with a strong program of traditional licensing, making equity in start-up companies maximizes the financial return that universities realize from their intellectual property. (C) 2000 Elsevier Science Inc.

Brunitz, S. M., R. P. O'Shea and T. J. Allen (2008). "University commercialization strategies in the development of regional bioclusters." Journal of Product Innovation Management **25**(2): 129-142.

To analyze university contribution to economic development, the present study examines universities' technology transfer policies and their associated economic development impact. The article examines how a university defines itself as part of a region as well as what activities, if any, do university commercialization strategies in context of their regional environment affect spin-off activity. Furthermore, this study explores the ways universities contribute to regional economic development by examining existing theories and analyzing universities' relationships with both government and industry in two regions. This study draws from Roberts and Malone's (1996) selectivity-support typology and highlights this article's argument by comparing the commercialization strategies of world-class universities strategies in the development of regional biotechnology clusters in Massachusetts and in Connecticut. This article investigates the notion of whether universities can differently influence the economic development processes of the while still having successful commercial outcomes. These findings build on previous research (Clarysse et al., 2005; Degroof and Roberts, 2004; Powers and McDougall, 2005), which argues that low support-low selectivity policies may be more suitable to entrepreneurially developed environments, whereas high support-high selectivity policies are more efficient in entrepreneurially underdeveloped environments. Massachusetts Institute of Technology (MIT) is located in a strong technopole region, whereby many of its support structures for spin-off formation are provided by the regional infrastructure of the Cambridge-Boston region. In contrast, Yale University, which has an underdeveloped entrepreneurial context, has had to take a more proactive role in providing incubation capabilities to their spin-off projects. This finding supports a contingent based perspective of academic entrepreneurship, whereby low support-low selectivity policies are more fitted to entrepreneurially developed environments, whereas high support. high selectivity policies are more efficient in entrepreneurially underdeveloped environments.

Buenstorf, G. (2007). "Evolution on the shoulders of giants: Entrepreneurship and firm survival in the German laser industry." Review of Industrial Organization **30**(3): 179-202.

This paper studies 40 years of evolution in the German laser industry, which developed in the context of strong foreign competition. Key characteristics found in the U.S. laser industry are also present in Germany. There is sustained entry into the industry, and neither a shakeout nor first-mover advantages of early entrants are observed. Similar to the U.S. industry, spin-offs from existing laser firms have been more long-lived than have been academic startups. An analysis of the spin-off process indicates the importance of specific capabilities acquired at the parent firm.

Caldera, A. and O. Debande (2010). "Performance of Spanish universities in technology transfer: An empirical analysis." Research Policy **39**(9): 1160-1173.

This paper investigates the performance of universities in the transfer of technology using a unique university-level dataset for Spain. The results suggest that universities with established policies and procedures for the management of technology transfer perform better. Universities with large and experienced technology transfer offices (TTOs) generate higher volumes of contract research, but the TTO characteristics appear to matter less for university performance in terms of licensing and creation of spin-offs. Furthermore, universities with a science park perform better than those without, which suggests that the agglomeration of knowledge close to universities has a positive effect on universities' technology transfer performance. (C) 2010 Elsevier B.V. All rights reserved.

Carayannis, E. G. and J. Alexander (1999). "Secrets of success and failure in commercializing US government R&D laboratory technologies: a structured case study approach." International Journal of Technology Management **18**(3-4): 246-269.

With the end of Cold War, the US government started encouraging defence conversion and commercialization activities. Although currently highly contested in the political arena for their tangible short-term economic benefits, these activities have fostered multiple high-tech government-university-industry partnerships and helped shape regions of emerging clusters of high-tech entrepreneurship, such as the Rio Grande Technology Corridor in the southwestern United States, where Sandia and Los Alamos National Laboratories are located, or the Austin, Texas technopolis. This paper studies, compares and contrasts case studies of high-tech strategic alliances, spin-offs, CRADAs, and other related modalities of technology transfer and commercialization, it aims to enhance the understanding of the role and potential of a case study to produce powerful new 'performance metrics' which could complement structured, quantitative metrics in a hybrid approach to assessing and reengineering technology transfer and commercialization efforts. It could further lead towards the formulation of an effective mid-range theory for technology transfer and commercialization combining micro-level with macro-level elements and concepts.

Carayannis, E. G., E. M. Rogers, K. Kurihara and M. M. Allbritton (1998). "High-technology spin-offs from government R&D laboratories and research universities." Technovation **18**(1): 1-11.

The present paper examines the high-tech spin-off process through which a new company is formed from a parent organization. Here we investigate spin-offs from three U.S. Federal R&D laboratories in New Mexico, and from Japanese government laboratories and universities. The spin-off process is one important means of transferring and commercializing technological innovations. Our study

of seven spin-off companies leads us to suggest a more complex definition than the conventional definition, which centers on (1) the technological innovation, and (2) the entrepreneurs who found the spin-off.

Carlsson, B. and A. C. Fridh (2002). "Technology transfer in United States universities - A survey and statistical analysis." *Journal of Evolutionary Economics* **12**(1-2): 199-232.

This paper examines the role of offices of technology transfer (OTT) in 12 U.S. universities in 1998 in commercializing research results in the form of patents, licenses, and start-ups of new companies. We study the organization and place of OTTs within the university structure, the process of technology transfer, and the staffing and funding of the office. Data were collected through a mail questionnaire followed up through telephone interviews. We also conducted a statistical analysis of data for 170 U.S. universities, hospitals, and research institutes for the period 1991-1996. Our findings suggest that technology transfer from universities to the commercial sector needs to be understood in its broader context. The primary purpose of a technology transfer program is for the university to assist its researchers in disseminating research results for the public good. Success in this endeavor is only partially reflected in income generated for the university or the number of business start-ups. The degree of success depends not only on the nature of the interface between the university and the business community but also on the receptivity in the surrounding community as well as the culture, organization, and incentives within the universities themselves.

Chang, Y. C., P. Y. Yang and M. H. Chen (2009). "The determinants of academic research commercial performance: Towards an organizational ambidexterity perspective." *Research Policy* **38**(6): 936-946.

This paper examined the relationship between organizational ambidexterity and research commercialization in universities. The paper develops two types of organizational ambidexterity: structural ambidexterity and contextual ambidexterity that influence research commercialization. Through a dataset of 474 academic patent inventors in Taiwan, the results revealed structural and contextual ambidexterity factors are patenting-, licensing- and start-up-specific. Despite both types of ambidexterity are complementary in patenting and licensing, contextual ambidexterity outperform structural ambidexterity in fostering university start-up equity participation. To promote academic research commercialization, it is necessary to build up a university as a dual structural organization that allows pursuing research excellence and research commercialization at the same time. (C) 2009 Published by Elsevier B.V.

Chiesa, V. and A. Piccaluga (2000). "Exploitation and diffusion of public research: the case of academic spin-off companies in Italy." R & D Management **30**(4): 329-339.

Scientific and technological knowledge is considered the most important raw material for economic growth. The attention on the exploitation of public research, undoubtedly one of the main sources of new scientific and technological knowledge, has increased in recent years. After reviewing some concepts regarding the exploitation of public research results, the paper focuses on the analysis of academic spinoff companies as one of the most promising ways to transfer research results to the market place. The phenomenon of academic spin-off companies is described using both international evidence and a recent survey regarding 48 Italian spin-off companies.

Chrisman, J. J., T. Hynes and S. Fraser (1995). "FACULTY ENTREPRENEURSHIP AND ECONOMIC-DEVELOPMENT - THE CASE OF THE UNIVERSITY-OF-CALGARY." Journal of Business Venturing **10**(4): 267-281.

The common perception of universities as merely institutions of higher learning is giving way to one where universities are viewed as engines of economic growth and development. This study documents the entrepreneurial activities of the faculty of the University of Calgary, as well as the impact the University has had and the impact its recent budgetary problems might have on such activities. Results indicate that nearly 100 new ventures with at least one full-time employee were started by faculty or were started as a consequence of significant faculty inputs. These ventures, in turn, have generated at least 723 new jobs in Alberta. Furthermore, our projections suggest that faculty entrepreneurs will create approximately 14 ventures per year in the near future. implications for the role universities and governments should play to encourage faculty entrepreneurship are discussed.

Clarysse, B., M. Knockaert and A. Lockett (2007). "Outside board members in high tech start-ups." Small Business Economics **29**(3): 243-259.

Board composition in large organizations has been subject to much empirical research, however, little attention has been focused on board composition in start-ups, and more specifically high tech start-ups. This lack of research is surprising given that many high tech start-ups have multiple equity stakeholders such as venture capitalists or public research organizations, such as universities. Given that high tech start-ups are commonly resource-poor these external stakeholders may play an important role in accessing critical external resources. Drawing on agency theory, resource dependence theory and social network theory we examine the tensions that exist between the founding team and external equity stakeholders in determining the presence of outside board members. In particular we focus on whether or not the outside board members have either complementary or substitute human capital to the founding team. We test our model on a sample of 140 high tech start-ups in Flanders. Our results

indicate that high tech start-ups with a public research organization as an external equity stakeholder are more likely to develop boards with outside board members with complementary skills to the founding team.

Clarysse, B. and N. Moray (2004). "A process study of entrepreneurial team formation: the case of a research-based spin-off." Journal of Business Venturing **19**(1): 55-79.

This paper describes how a team of entrepreneurs is formed in a high-tech start-up, how the team copes with crisis situations during the start-up phase, and how both the team as a whole and the team members individually learn from these crises. The progress of a high-tech university spin-off has been followed up from the idea phase until the post-start-up phase. Adopting a prospective, qualitative approach, the basic argument of this paper is that shocks in the founding team and the position of its champion co-evolve with shocks in the development of the business. (C) 2002 Elsevier Science Inc. All rights reserved.

Clarysse, B., M. Wright, A. Lockett, P. Mustar and M. Knockaert (2007). "Academic spin-offs, formal technology transfer and capital raising." Industrial and Corporate Change **16**(4): 609-640.

In this article we examine the influence of formal technology transfer from a public research organization (PRO) on the amount of capital a spin-off raises at start-up and the increase in capital post start-up. We examine these relationships using a unique sample of 135 spin-offs from PROs across five European countries. Our findings suggest that spin-offs with formal technology transfer start with a larger amount of capital but subsequently do not raise more capital than spin-offs without formal technology transfer.

Clarysse, B., M. Wright, A. Lockett, E. Van de Velde and A. Vohora (2005). "Spinning out new ventures: a typology of incubation strategies from European research institutions." Journal of Business Venturing **20**(2): 183-216.

This paper explores the different incubation strategies for spinning-out companies employed by European Research Institutions. More specifically, we focus on two central questions: (i) What differences or similarities are there in the goals and objectives of the Research Institutions for creating new spinout ventures? (ii) What different incubation strategies are employed to achieve these goals in terms of the resources utilized and activities undertaken? The study uses a two-stage approach. In the first stage, seven spin-out services in five European countries were selected for analysis. At the time of the study, each research institute under analysis had only one unique way to stimulate spin-outs. Therefore, the spin-out service and the particular Research Institution they are associated with are interchangeable as units of analysis. Based upon an in-depth analysis of these seven cases, we identified three distinct incubation models of managing the spin-out process: Low Selective, Supportive, and Incubator. The different incubation models have very different resource implications in

managing the process. In particular, we identify resource and competence differences relating to finance, organization, human resources, technology, network, and infrastructure. In the second stage, 43 cases were used to validate these incubation models in terms of resources and activities. This process identified two categories that departed from the normative models, namely, the Resource-Deficient group and the Competence-Deficient group.

Clarysse, B., M. Wright and E. Van de Velde (2011). "Entrepreneurial Origin, Technological Knowledge, and the Growth of Spin-Off Companies." Journal of Management Studies: no-no.

abstract We contribute to the literature on corporate spin-offs and university spin-offs by exploring how different characteristics in the technological knowledge base at start-up influence spin-off performance. We investigate how the technological knowledge characteristics endowed at start-up predict growth, taking into account whether the knowledge/technology is transferred from a corporation or university. We use a novel, hand-collected dataset involving 48 corporate and 73 university spin-offs, comprising the population of spin-offs in Flanders during 1991–2002. We find corporate spin-offs grow most if they start with a specific narrow-focused technology sufficiently distinct from the technical knowledge base of the parent company and which is tacit. University spin-offs benefit from a broad technology which is transferred to the spin-off. Novelty of the technical knowledge does not play a role in corporate spin-offs, but has a negative impact in university spin-offs unless universities have an experienced technology transfer office to support the spin-off.

Colombo, M., P. Mustar and M. Wright (2010). "Dynamics of Science-based entrepreneurship." Journal of Technology Transfer **35**(1): 1-15.

This article introduces the rationale for the special issue, summarizes the main themes covered by the papers presented and suggests areas for further research. Previous research has focused on the creation of Science-based entrepreneurial firms (SBEFs) but there is little research relating to their growth and the challenges in ensuring growth occurs. At the macro-level, there is a need to distinguish general versus specific policies and how these vary between different institutional environments. At the firm level, there is a need to consider the factors influencing the development of boards, the growth of SBEFs and their dynamics in terms of acquisitions and IPOs.

Colombo, M. G., D. D'Adda and E. Piva (2010). "The contribution of university research to the growth of academic start-ups: an empirical analysis." Journal of Technology Transfer **35**(1): 113-140.

The aim of this paper is to analyze empirically under which circumstances the universities located in a geographical area contribute to the growth of a special category of local new technology-based firms (NTBFs), those established by

academic personnel (academic start-ups, ASUs). We examine the effects of a series of characteristics of local universities on the growth rates of ASUs and we compare them with the effects of the same university characteristics on the growth of other (i.e., non-academic) NTBFs. In the empirical part of the paper, we estimate an augmented Gibrat law panel data model using a longitudinal dataset composed of 487 Italian NTBFs observed from 1994 to 2003. Out of these NTBFs 48 are ASUs. The results of the econometric estimates suggest that universities do influence the growth rates of local ASUs, while the effects on the growth rates of other NTBFs are negligible. In particular, the scientific quality of the research performed by universities has a positive effect on the growth rates of ASUs; conversely the commercial orientation of research has a negative effect. These results indicate that universities producing high-quality scientific research have a beneficial impact on the growth of local high-tech start-ups, but only if these firms are able to detect, absorb, and use this knowledge. In this perspective, a greater commercial orientation of university research leading to a reduction of the knowledge available for absorption by these companies, can be detrimental.

D'Este, P. and P. Patel (2007). "University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry?" *Research Policy* **36**(9): 1295-1313.

This paper examines the different channels through which academic researchers interact with industry and the factors that influence the researchers' engagement in a variety of interactions. This study is based on a large scale survey of UK academic researchers. The results show that university researchers interact with industry using a wide variety of channels, and engage more frequently in the majority of the channels examined-such as consultancy & contract research, joint research, or training - as compared to patenting or spin-out activities. In explaining the variety and frequency of interactions, we find that individual characteristics of researchers have a stronger impact than the characteristics of their departments or universities. Finally, we argue that by paying greater attention to the broad range of knowledge transfer mechanisms (in addition to patenting and spin-outs), policy initiatives could contribute to building the researchers' skills necessary to integrate the worlds of scientific research and application. (c) 2007 Elsevier B.V. All rights reserved.

Dahlstrand, A. L. (1999). "Technology-based SMEs in the Goteborg region: Their origin and interaction with universities and large firms." *Regional Studies* **33**(4): 379-389.

This paper investigates the local origins and continued regional interaction of a group of new technology-intensive Goteborg SMEs. The results are based on an original survey of 52 such firms. It finds that these Goteborg SMEs were almost exclusively established as spin-offs by founders who were previously working for another local firm or university. Local links and relationships - especially with the previous employer and with Chalmers University - were initially important for their development. With time, however, the importance of such links has tended

to decline, and instead wider national relationships are becoming more important.

De Coster, R. and C. Butler (2005). "Assessment of proposals for new technology ventures in the UK: characteristics of university spin-off companies." Technovation **25**(5): 535-543.

University "spin-off" companies are high technology ventures that originate from research work in a university, resulting in the generation of intellectual property and, usually, the subsequent involvement of key researchers. The analysis distinguishes between 14 new technology-based firms that are university "spin-off" companies and 14 community companies that had no connection with a university. The analysis described in this paper is based on a specially developed assessment methodology that comprises a structured decision-making model. This technology assessment methodology is based on the identification of key criteria for analysis. The study identified the most significant variable for university "spin-off" companies being that of protecting competitive advantage. This result can be attributed to the need for universities to protect their intellectual property, which is to be rewarded with an equity stake in the company. Two other significant variables were identified as the level of product innovation (compared to competitors) and market criteria (including the potential customer base). (c) 2003 Elsevier Ltd. All rights reserved.

Di Gregorio, D. and S. Shane (2003). "Why do some universities generate more start-ups than others?" Research Policy **32**(2): 209-227.

The results of this study provide insight into why some universities generate more new companies to exploit their intellectual property than do others. We compare four different explanations for cross-institutional variation in new firm formation rates from university technology licensing offices (TLOs) over the 1994-1998 period-the availability of venture capital in the university area; the commercial orientation of university research and development; intellectual eminence; and university policies. The results show that intellectual eminence, and the policies of making equity investments in TLO start-ups and maintaining a low inventor's share of royalties increase new firm formation. The paper discusses the implications of these results for university and public policy. (C) 2002 Elsevier Science B.V. All rights reserved.

Dill, D. D. (1995). "UNIVERSITY-INDUSTRY ENTREPRENEURSHIP - THE ORGANIZATION AND MANAGEMENT OF AMERICAN-UNIVERSITY TECHNOLOGY-TRANSFER UNITS." Higher Education **29**(4): 369-384.

Mechanisms for increasing technology transfer between universities and industry have proliferated rapidly in the United States as institutions of higher education have become much more entrepreneurial. The economic implications of these activities have received substantial attention and the sociological aspects of this process have been vigorously debated (e.g., the effect of university-industry

relationships on academic integrity). Much less consideration has been given to the successful organization and management of these emerging university 'service' units. The study presents results of a national survey of the organization, management, and perceived performance effectiveness of university technology transfer units. Units studied included: licensing and patenting offices (units seeking commercial applications for university research); small business development centers (units providing technical or managerial assistance to entrepreneurs or small businesses); research and technology centers (units operating or participating in facilities for the development of new technology); incubators (units managing facilities in support of new technology-based businesses); and investment/endowment offices (units utilizing the university's financial resources for equity in start-up businesses). The implications of the research for university management and government policy are explored.

Ding, W. and E. Choi (2011). "Divergent paths to commercial science: A comparison of scientists' founding and advising activities." *Research Policy* **40**(1): 69-80.

This paper investigates the difference in the profiles of university scientists who have founded or advised companies. We analyzed the commercial activities of a sample of 6138 university life scientists and found that the profiles of scientists who become academic entrepreneurs are different from those who become companies' scientific advisors. Founding activity occurs earlier during a scientist's career than advising. Factors such as gender, research productivity, social networks and employer characteristics also differ in their effects on the propensity for founding and advising. In addition, regression analysis shows that being a company's scientific advisor decreases the probability of becoming an academic founder. Overall, evidence from our analysis suggests that founding and advising are two divergent paths for commercially oriented university scientists. (C) 2010 Elsevier B.V. All rights reserved.

Djokovic, D. and V. Souitaris (2008). "Spinouts from academic institutions: a literature review with suggestions for further research." *Journal of Technology Transfer* **33**(3): 225-247.

This paper provides a comprehensive literature review of the phenomenon of spinouts from academic institutions. We systematically identified spinout papers in key management journals, categorised the literature and critically synthesised the findings. We present the findings of each literature stream in turn and also identify inconsistencies and directions for further research. We conclude that while the early literature has been mainly atheoretical and focused on describing the phenomenon, a core group of recent studies were theory-driven.

Druihlhe, C. and E. Garnsey (2004). "Do academic spin-outs differ and does it matter?" Journal of Technology Transfer **29**(3-4): 269-285.

This paper questions the widespread tendency to view academic spin-outs as an undifferentiated category and explores typologies of companies originating in universities, using a Penrosean conceptualization of entrepreneurial activity. We initially identified five main types of business activities pursued by academic entrepreneurs, which we revised after analyzing a database of Cambridge University spin-outs and real-time exemplars of emerging ventures. The refined typology takes into account the dynamic of the entrepreneurial process. As the business models of ventures evolve they may enter a different category of business activity. We conclude by discussing the academic and practical needs for a better understanding of the heterogeneity of spin-outs, the diversity of which has theoretical and policy implications. © 2004 Kluwer Academic Publishers.

Ebersberger, B. and C. Pirhofer (2011). "Gender, management education and the willingness for academic entrepreneurship." Applied Economics Letters **18**(9): 841-844.

This article explores the determinants of academic entrepreneurship. In particular, it investigates the effects of gender and supplementary management education on academics' willingness to start up a company. The analysis is based on a survey of academics. Controlling for academic achievement, field of science and perceived hampering factors, we find that female academics show a significantly lower propensity to have a high willingness to start up. Our results indicate that supplementary management education does not in general have a significant effect on the willingness to start up. Yet, for female academics supplementary management education exerts a significantly positive effect almost offsetting the gender effect.

Ensley, M. D. and K. A. Hmieleski (2005). "A comparative study of new venture top management team composition, dynamics and performance between university-based and independent start-ups." Research Policy **34**(7): 1091-1105.

The current study tests for differences in top management team (TMT) composition (education, functional expertise, industry experience, and skill), dynamics (shared strategic cognition, potency, cohesion, and conflict) and performance (net cash flow and revenue growth) between a sample of 102 high-technology university-based start-ups and an otherwise equivalently matched sample of 154 independent high-technology new ventures. The results find university-based start-ups to be comprised of more homogenous TMTs with less developed dynamics than their independent counterparts. Further, university-based start-ups are found to be significantly lower performing in terms of net cash flow and revenue growth than independent new ventures. (c) 2005 Published by Elsevier B.V.

Fini, R., R. Grimaldi and M. Sobrero (2009). "Factors fostering academics to start up new ventures: an assessment of Italian founders' incentives." Journal of Technology Transfer **34**(4): 380-402.

Why do university researchers decide to start-up a new venture? How can we distinguish between the different factors influencing such an important decision? To what extent are specific policies activated within universities relevant in the process of new venture creation? In this paper we try to answer these very significant questions, through an empirical analysis performed on a sample of 88 Italian academics involved in the creation of 47 spin-offs between 1999 and 2005. Our findings show that the availability of technologies with a potential for commercial exploitation, the possibility to access university infrastructures and the personal benefits are the most important incentives for academics. More generally, academics' involvement in creating new ventures is not driven by an entrepreneurial attitude, but rather by the expectation of generating results which will enhance their academic position. Additional investments and efforts made by some universities to create more mechanisms to support spin-offs are not perceived as additional incentives. These results hold after controlling for academic founders' institutional affiliation, status, and the companies' growth over their first two years of existence. Implications for public policy and organizational processes are discussed.

Fini, R., N. Lacetera and S. Shane (2010). "Inside or outside the IP system? Business creation in academia." Research Policy **39**(8): 1060-1069.

Research and public policy on academic entrepreneurship are largely based on the assumption that faculty members start businesses to commercialize inventions that have been disclosed to university administrators and have been patented. In this paper, we analyze a sample of 11,572 professors and find that much academic entrepreneurship occurs outside the university intellectual property system. Specifically, about 2/3 of businesses started by academics are not based on disclosed and patented inventions. Moreover, we show that individual characteristics, departmental and organizational affiliations, and time allocation of academics that have started business outside the IP system are different from those of academics that have started businesses to exploit disclosed and patented inventions. We discuss the implications for research on and the practice of academic entrepreneurship. (C) 2010 Elsevier BA/. All rights reserved.

Fontes, M. (2001). "Biotechnology entrepreneurs and technology transfer in an intermediate economy." Technological Forecasting and Social Change **66**(1): 59-74.

When a substantial part of the knowledge required for the development of a new field is generated at the university, new entrepreneurial firms can be a privileged vehicle for the transfer of research results to the market. This is particularly true in the case of "intermediate economies," where these firms can bridge the gap

between public research and an indifferent industry. Empirical research on the process of biotechnology firm creation in Portugal, confirmed that most biotechnology entrepreneurs are involved in the transfer/transformation of technological knowledge generated in public research organizations, playing a critical technological intermediary role. More specifically, the research identified three major knowledge transfer modes and revealed the role played in this process by a particular type of entrepreneur: highly qualified young people, who were found to be especially effective in achieving a match between scientific and technological knowledge and market needs by capitalizing on their technological competencies and "relational assets." But the research also highlighted the low incidence of firm creation in this field and the context-related difficulties experienced by their founders. This article addresses some of the obstacles and the entrepreneurs' adaptive responses to them, providing useful information for policy makers and would-be entrepreneurs. (C) 2001 Elsevier Science Inc.

Fontes, M. (2005). "The process of transformation of scientific and technological knowledge into economic value conducted by biotechnology spin-offs." Technovation **25**(4): 339-347.

This paper addresses the role played by academic spin-offs in the process of transformation of scientific and technological knowledge originating from research organisations (ROs) into viable technologies, products or services. It first discusses the need for such transformation; the reasons why, in some circumstances, spin-offs firms are particularly well positioned to conduct or orchestrate it, and subsequently looks in detail at the transformation process as it occurs in practice, in the biotechnology field. Three types of transformation functions are identified and described in detail, emphasising the outcomes that might not have taken place without the entrepreneurs' intervention. It is concluded that, in performing these functions, biotechnology spin-offs play a valuable agency role in the access, application and dissemination of knowledge produced by ROs, emerging as an alternative to 'technology transfer' organisations and mechanisms. (C) 2003 Elsevier Ltd. All rights reserved.

Franklin, S. J., M. Wright and A. Lockett (2001). "Academic and surrogate entrepreneurs in university spin-out companies." Journal of Technology Transfer **26**(1-2): 127-141.

Universities have two options when they formulate policies to develop new technology-based start-ups. One approach is to encourage faculty members to engage in this activity. Another avenue is to encourage surrogate (external) entrepreneurs to assume a leadership role. Based on a survey of technology transfer/business development officers at 57 U.K. universities, we examine perceptions regarding the advantages and disadvantages of each approach. We also analyze whether there are significant differences in these attitudes between universities that have launched many start-ups and those that have been less active in this arena. Our results imply that the most significant barriers to the

adoption of entrepreneurial-friendly policies are cultural and informational. We also find that universities that generate the most start-ups have more favorable attitudes towards surrogate entrepreneurs. It appears that a combination of academic and surrogate entrepreneurship might be the best approach for universities that wish to develop successful technology-transfer based start-up companies. © 2007 Kluwer Academic Publishers.

Garnsey, E. and P. Heffernan (2005). "High-technology clustering through spin-out and attraction: The Cambridge case." *Regional Studies* **39**(8): 1127-1144.

Co-determinants that have shaped developments in high-tech centres elsewhere are absent in Cambridge, UK, which thus provides a unique case demonstrating how technology enterprise around a science centre can transform local economic activity. But to capture dimensions of cumulative change requires a longitudinal approach. Here indicators that include rates of formation of new firms and their survival and growth over time are used to chart the transformation of collective capabilities. Emerging and growing areas of local competence are identified from data on the sectoral distribution of activity over time and on clusters of related activity in the Cambridge area that point to the emergence of specialized labour markets. The emergence of clusters of firms is related to serial spin-out from the university and local businesses. Channels of diffusion of knowledge and influence among local firms are mapped by graphics of spin-out clusters. Processes mobilizing social capital can be detected in the way technology-based firms evolved a collective response to local problems that could not be solved by individual enterprise.

Gilsing, V. A., E. van Burg and A. G. L. Romme (2010). "Policy principles for the creation and success of corporate and academic spin-offs." *Technovation* **30**(1): 12-23.

Following a design science approach, this paper develops a framework of policy design principles for fostering technology entrepreneurship in a region. These principles are grounded in research findings and describe the factors and causal mechanisms that explain the founding and success rates of both corporate and academic spin-offs. We differentiate between principles that serve the creation of spinoffs versus those focusing on their subsequent chances of success. We provide an in-depth empirical application of this framework to spin-off policy in the regions of Eindhoven and Leuven. This application of the framework serves to assess the extent to which standing spin-off policy in both regions is (1) up-to-date, (2) comprehensive as well as (3) sufficiently robust against 'policy fashions'. Several directions for redesigning spin-off policy follow from this assessment. (C) 2009 Elsevier Ltd. All rights reserved.

Grandi, A. and R. Grimaldi (2003). "Exploring the networking characteristics of new venture founding teams." *Small Business Economics* **21**(4): 329-341.

This paper deals with newly established ventures and their relations with external agents. The founding teams' intention to set up relations with external agents and their frequency of interaction with external agents are addressed as two features that are likely to lead to the success of academic spin-off companies. Empirical analysis is based on a data set of 40 Italian academic spin-offs. The external agents who are most likely to have interactions with academic spin-off companies are first identified. Two research hypotheses are then put forward: (a) that the intention of the founding teams to set up relations with external agents is influenced by the degree of articulation of roles and the completeness of the founding teams; (b) that the founding teams' frequency of interaction with external agents is influenced by the frequency of interaction with external agents of the research groups of origin and by their scientific and technological excellence. Some remarks are then made on the role that universities play in helping new ventures to set up relations with external agents.

Grandi, A. and R. Grimaldi (2005). "Academics' organizational characteristics and the generation of successful business ideas." *Journal of Business Venturing* **20**(6): 821-845.

This paper deals with the generation of Business Ideas (BI) by academics. It investigates organizational factors affecting the process through which new ventures are established by academics and are likely to affect their performance. The BI Market Attractiveness and the BI Articulation are addressed as two characteristics of academic spin-off companies which are likely to lead to their success. Two research hypotheses are formulated: (a) that the BI Market Attractiveness at the time of establishment of the new venture is positively influenced by the market orientation of the academic founders, and by their frequency of interaction with external agents; (b) that the BI Articulation at the time of establishment of the new venture is positively affected by the articulation of roles, and by the degree of prior joint experience of the academic founders. We test our hypotheses on a sample of 42 Italian academic start-ups. Implications for both universities and academic entrepreneurs are discussed. (c) 2004 Elsevier Inc. All rights reserved.

Gulbrandsen, M. and J. C. Smeby (2005). "Industry funding and university professors' research performance." *Research Policy* **34**(6): 932-950.

University research is to an increasing extent funded by industry, and the share of basic funding is decreasing. In the literature, there are optimistic and pessimistic views on the implication of this development. Based on data from a questionnaire study among all tenured university professors in Norway (N=1967) we find that there is a significant relationship between industry funding and research performance: professors with industrial funding describe their research as applied to a greater extent, they collaborate more with other researchers both

in academia and in industry, and they report more scientific publications as well as more frequent entrepreneurial results. There is neither a positive nor negative relationship between academic publishing and entrepreneurial outputs. (c) 2005 Elsevier B.V. All rights reserved.

Gurdon, M. A. and K. J. Samsom (2010). "A longitudinal study of success and failure among scientist-started ventures." Technovation **30**(3): 207-214.

We present the results from follow-up interviews in 2001 of scientists first studied in 1989 who had commercialized their inventions. Eleven of the original participating ventures had survived while six had failed outright. An effective combination of management team processes and access to capital was observed among the successful ventures. Additionally, personal motives expressed by scientists in 1989, especially the single-minded focus on financial outcomes, appear correlated with ultimate success. Those who failed experienced a more intense conflict between business and science values. Most of the latter did not repeat the experience whereas many of their commercially successful peers pursued further ventures.

Haeussler, C. and J. A. Colyvas (2011). "Breaking the Ivory Tower: Academic Entrepreneurship in the Life Sciences in UK and Germany." Research Policy **40**(1): 41-54.

We examine engagement in commercial activities (consulting, patenting, and founding) among more than 2200 German and UK life scientists. We test hypotheses that include attributes of individuals, their material and social resources, and perceptions about values and reputation. We find that characteristics reflecting professional security, advantage and productivity are strong predictors for a greater breadth of participation in academic entrepreneurship, but not for all forms of technology transfer that we are able to test. For such academics, science and commerce go hand in hand, as they are best poised to straddle the boundary between industry and academy. We find strong support, however, that scientists perceive the value of patenting differently, and the level of reputational importance placed on scientific compared to commercial achievements matters in shaping commercial involvement. (C) 2010 Elsevier B.V. All rights reserved.

Harmon, B., A. Ardishvili, R. Cardozo, T. Elder, J. Leuthold, J. Parshall, M. Raghian and D. Smith (1997). "Mapping the university technology transfer process." Journal of Business Venturing **12**(6): 423-434.

Transfer of technologies from the universities to the private sector is increasingly regarded as playing a significant role in new business starts, growth of existing businesses, and new job creation. Further, there are numerous models describing the process of technology transfer. Some of the existing models represent this process as a linear progression of steps: from idea generation and technology development at the university, to patenting the technology and then establishing

a university-private firm link through a formal search process. The process culminates in patent rights transfer. Other models describe technology transfer in terms of networking arrangements and emphasize not so much formal search as the role of long-term relationships between the two parties. Still other studies indicate that it is possible to combine the two approaches-formal search and informal networking arrangements-to ensure successful transfer. Business firms involved in transfer also may be classified into several groups. Transfer could occur between the University and an established firm, between the university and a recently created new venture, or transfer could result in the creation of a new company. Technology, for example, could be transferred to a large company that uses the transferred technology as a basis for just one of many product lines, or to a small firm in that makes the transferred technology a cornerstone of its product strategy. Are there any differences among the transfer processes used when large or small firms are involved, or when technology is transferred to an existing company or results in the creation of a new firm? To address these questions, we mapped the technology transfer processes of 23 different technologies developed at the University of Minnesota from 1983 to 1993. More than half of the technologies studied went to large companies and were used either to upgrade existing products or to extend existing product lines. In eight cases technologies were transferred to small firms. In three cases technologies were transferred to venture capital firms or intermediaries and had not been commercialized at the time the study was completed. In the rest of the cases new firms were created by the inventors/university scientists themselves and served as vehicles for marketing their inventions. None of the firms of the latter group have grown beyond a part-time employment opportunity for the inventors, and only one firm provided evidence that additional hiring would be necessary in the near future. Only four cases involved transfers of technologies that have been developed and patented by the university to firms that did not have any relationships, with the university prior to the transfer. In these four cases the firms used some form of search strategy to find a needed technology. However, there is no evidence that any of the firms had a well-developed formal search procedure. On the overwhelming majority of cases some form of relationship existed between the university (or individual inventors) and the private firm prior to the transfer. These relationships ranged from long-term friendships and/or cooperation to such less involved forms as interaction at research seminars and university-sponsored events. Further, in four cases, the technologies were initially developed by private companies, whereas the university's role was to assist in refinement or testing of the technology. The research yielded a number of additional findings that deserve further investigation and discussion. Specifically, the study did not provide any evidence that the successfully completed technology transfers made any substantial contribution to either new business creation or the generation of new jobs. This finding suggests that scholars and policy makers should proceed with caution before accepting a

notion that new or high technology firms will have any direct Economic impact. The study findings hold specific implications for entrepreneurial behavior and public policy. The "formal search and shopping" for a technology model suggests that both business and academic/government laboratories publicize, respectively, their requirements and offerings, and that opportunities for creative brokerage ought to exist. We found that in the majority of cases technology was transferred not through formal search, but through some prior relationships among individuals. This observation suggests that the ability to build extended networks of relationships not only within the business world but also with the university community is an important skill that owners and managers of the technology-based businesses need to possess. Entrepreneurs seeking to start businesses based on new technologies may need to reevaluate how much of their limited time to allocate to build and maintain networks and cooperative relationships, and how much time to shop for new technologies through formal channels. Further, public policy and the efforts of the university transfer agencies intended to facilitate transfer may need to shift their emphasis from facilitating "shopping" by organizing and/or paying for "publicity" (which is currently the major emphasis) to providing assistance in network building and relationship marketing efforts. (C) 1997 Elsevier Science Inc.

Harrison, R. T. and C. Leitch (2010). "Voodoo Institution or Entrepreneurial University? Spin-off Companies, the Entrepreneurial System and Regional Development in the UK." Regional Studies **44**(9): 1241-1262.

Harrison R. T. and Leitch C. Voodoo institution or entrepreneurial university? Spin-off companies, the entrepreneurial system and regional development in the UK, *Regional Studies*. University spin-off companies occupy a prominent position in both government and university policies and aspirations for the commercialization of university research for economic benefit at regional and national levels. However, most university spin-off companies start small and remain small, reflecting founder aspirations, capabilities, and resource endowments. Based on detailed analysis of university spin-offs in Northern Ireland, it is concluded that these companies are technology lifestyle businesses not dynamic high-growth potential start-ups, and it is suggested that the prominence given to spin-offs in the analysis of technology transfer and in discussions of the economic impacts of universities is misplaced. [image omitted]

Harrison R. T. et Leitch C. Une institution vaudou ou une université entrepreneuriale? La création d'entreprise, le système entrepreneurial et l'aménagement du territoire au R-U, *Regional Studies*. La création d'entreprise par les universités jouit d'une importance de premier plan pour ce qui est des politiques du gouvernement et des universités, et vu l'aspiration de commercialiser la recherche universitaire pour en tirer un profit économique au niveau régional et à l'échelle nationale. Cependant, la plupart des nouvelles entreprises créées par les universités sont de petite taille et continuent de l'être,

ce qui reflète l'aspiration, les capacités et la dotation en capital du créateur. À partir d'une analyse détaillée de la création d'entreprise par les universités situées en Irlande du Nord, on conclut que ces entreprises-là sont des entreprises technologiques par styles de vie et ne sont pas des créations d'entreprise dynamiques à croissance forte. On laisse supposer aussi que l'importance accordée à la création d'entreprise dans l'analyse du transfert technologique et le débat sur l'impact économique des universités s'avère déplacée. Transfert technologique Création d'entreprise Système entrepreneurial Aménagement du territoire Université entrepreneuriale Harrison R. T. und Leitch C. Voodoo-Institution oder Unternehmertum an Universitäten? Spin-off-Firmen, Unternehmenssysteme und Regionalentwicklung in Grossbritannien, Regional Studies. Spin-off-Firmen von Universitäten spielen in der Politik von Regierungen und Universitäten sowie bei den Bestrebungen zur Kommerzialisierung der universitären Forschung für einen wirtschaftlichen Nutzen auf regionaler und nationaler Ebene eine wichtige Rolle. Die meisten universitären Spin-off-Firmen sind jedoch zu Beginn und auch später von geringer Grösse und reflektieren die Bestrebungen, Fähigkeiten und Ressourcen der Gründer. Anhand einer detaillierten Analyse der Spin-off-Firmen von Universitäten in Nordirland ziehen wir den Schluss, dass es sich bei diesen Firmen weniger um dynamische Start-up-Firmen mit hohem Wachstumspotenzial als vielmehr um technologische Lifestyle-Unternehmen handelt und dass die starke Beachtung, die Spin-off-Firmen bei der Analyse von Technologietransfer und in den Diskussionen über die wirtschaftlichen Auswirkungen von Universitäten finden, fehl am Platze ist. Technologietransfer Spin-off-Firmen Unternehmenssystem Regionalentwicklung Unternehmertum an Universitäten Harrison R. T. y Leitch C. Institucion vudu o universidad empresarial? Empresas spin-off, el sistema empresarial y el desarrollo regional en el Reino Unido, Regional Studies. Las empresas spin-off universitarias ocupan un lugar destacado en las políticas gubernamentales y universitarias así como las aspiraciones para la comercialización de la investigación universitaria para el beneficio económico a nivel regional y nacional. Sin embargo, la mayoría de empresas spin-off universitarias comienzan como empresas pequeñas y siguen siendo pequeñas, lo que refleja las aspiraciones y capacidades de los fundadores y las dotaciones de recursos. Basándonos en un análisis detallado de las empresas spin-off universitarias en Irlanda del Norte, concluimos que estas sociedades no son empresas emergentes dinámicas con un alto potencial de crecimiento sino empresas de estilo de vida tecnológico, y sugerimos que la importancia que se otorga a las empresas spin-off en los análisis de transferencia tecnológica y en las charlas sobre las repercusiones económicas de las universidades queda fuera de lugar. Transferencia tecnológica Empresas spin-off Sistema empresarial Desarrollo regional Universidad empresarial.

Haug, P. (1995). "FORMATION OF BIOTECHNOLOGY FIRMS IN THE GREATER SEATTLE REGION - AN EMPIRICAL-INVESTIGATION OF ENTREPRENEURIAL, FINANCIAL, AND EDUCATIONAL PERSPECTIVES." *Environment and Planning A* **27**(2): 249-267.

The biotechnology sector is a revolutionary industrial sector and promises significant innovations in medicine, veterinary care, plant agriculture, food processing, and environmental industries. Within the United States, biotechnology firms have generally agglomerated in existing regional high-technology complexes. In this paper empirical evidence is presented on the formation, evolution, financial sources, and educational relationships of thirty-three commercial biotechnology firms in the Greater Seattle metropolitan region, a leading US biotechnology concentration. Data were collected through extensive personal interviews, and these biotechnology organizations are compared across the following organizational incubators of the founder(s): academic or other research institution, academic or other research institution and business, biotechnology firm spin-off, and nonbiotechnology firm spin-off. Findings show the significance of local universities, research institutions, and existing biotechnology organizations in developing and sustaining biotechnology investment and employment. Comparisons across the organizational origins of these firms indicate major differences in financial structure and in affiliations with educational institutions for resources and research collaborations. Results also highlight several issues concerning regional economic development and biotechnology enterprises.

Hayter, C. S. (2011). "In search of the profit-maximizing actor: motivations and definitions of success from nascent academic entrepreneurs." *Journal of Technology Transfer* **36**(3): 340-352.

Scholars have traditionally assumed the establishment and management of university spinoffs are guided by growth and the pursuit of profit. However, few studies have examined the motivations and post-establishment success definitions of entrepreneurs themselves. This paper seeks to contribute to our understanding of the mediating factors of academic entrepreneurship through an in-depth interview-based study of 74 nascent academic entrepreneurs. The results show that academic entrepreneurs define success in a number of complex, interrelated ways including technology diffusion, technology development, financial gain, public service and peer motivations, among others. Furthermore, a large percentage of the respondents have little immediate interest in growth and have instead established their firms to pursue other sources of development funding.

Heirman, A. and B. Clarysse (2007). "Which tangible and intangible assets matter for innovation speed in start-ups?" Journal of Product Innovation Management **24**(4): 303-315.

The launch of the first product is an important event for start-ups, because it takes the new venture closer to growth, profitability, and financial independence. The new, product development (NPD) literature mainly focuses its attention on NPD processes in large firms. In this article insights on the antecedents on innovation speed in large firms are combined with resource-based theory and insights from the entrepreneurship literature to develop hypotheses concerning the antecedents of innovation speed in start-ups. In particular, tangible assets such as starting capital and the stage of product development at founding and intangible assets such as team tenure, experience of founders, and collaborations with third parties are considered as important antecedents for innovation speed in start-ups. A unique data set on research-based start-ups (RBSUs) was collected, and event-history analyses were used to test the hypotheses. The rich qualitative data on the individual companies are used to explain the statistical findings. This article shows that RBSUs differ significantly in their starting conditions. The impact of starting conditions on innovation speed differs between software,are and other companies. Although intuition suggests that start-ups that are further in the product development cycle at founding launch their first product faster, our data indicate that software firms starting with a beta version experience slower product launch. The amount of initial financing has no significant affect on innovation speed. Next, it is shown that team tenure and experience of founders leads to faster product launch. Contrary to expectations, alliances with other firms do not significantly affect innovation speed, and collaborations with universities are associated with longer development times.

Jacobsson, S. and E. P. Vico (2010). "Towards a systemic framework for capturing and explaining the effects of academic RD." Technology Analysis & Strategic Management **22**(7): 765-787.

In the EU, it is believed that the potential benefits of academic RD are not fully reaped. Much attention is, therefore, given to enhancing commercialisation in the form of academic spin-offs, patents and licences. There are, however, a number of problems with this way of analysing the effects of academic RD. Its contribution must instead be captured by a systems approach and we go some way towards developing such an analytical framework. This enables us to capture, explain and assess the effects of academic RD on the dynamics of an innovation system. We apply this framework to the received literature which informs us of a great variety of impacts on such systems. Conventional indicators cover, therefore, just a small part of the full impact of academic RD.

Jain, S., G. George and M. Maltarich (2009). "Academics or entrepreneurs? Investigating role identity modification of university scientists involved in commercialization activity." Research Policy **38**(6): 922-935.

Establishing the microfoundations of academic entrepreneurship requires closer scrutiny of a key actor contributing to this phenomenon-the university scientist. We investigate the sense-making that scientists engage in as part of their participation in technology transfer and postulate that this process involves a potential modification in their role identity. We analyzed more than 70 h of interview data at a premier U.S. public research university. We observe that scientists invoke rationales for involvement that are congruent with their academic role identity. They typically adopt a hybrid role identity that comprises a focal academic self and a secondary commercial persona. We delineate two mechanisms - delegating and buffering - that these individuals deploy to facilitate such salience in their hybrid role identity. Overall, these patterns suggest that university scientists take active steps to preserve their academic role identity even as they participate in technology transfer. Our findings clarify the social psychological processes underlying scientist involvement in commercialization activity, and offer fresh insights to the academic entrepreneurship, science policy and role identity literatures. (C) 2009 Elsevier B.V. All rights reserved.

Johansson, M., M. Jacob and T. Hellström (2005). "The strength of strong ties: University spin-offs and the significance of historical relations." Journal of Technology Transfer **30**(3): 271-286.

This article investigates the relationship between universities and academic spin-offs, with special emphasis on the antecedent conditions of, and the nature of the linkages that the spin-offs form, as well as the means for sustaining them. The present research uses an instrumental case study approach, and is also an instance of a collective case study as four companies of various size and activities have been studied together. The preliminary results indicate that the network relations are characterized by a small number of strong ties to universities, with a high degree of trust and informality. Although fruitful for the transfer of complex knowledge, the strength of the ties also make them difficult to substitute, which may lead to problems as the spin-offs are highly dependent on continued basic research support. This may in turn lead to implications for policy at university, as well as higher levels. © 2005 Springer Science+Business Media, Inc.

Jong, S. (2006). "How organizational structures in science shape spin-off firms: the biochemistry departments of Berkeley, Stanford, and UCSF and the birth of the biotech industry." Industrial and Corporate Change **15**(2): 251-283.

This article examines how the organizational capabilities of academic spin-off firms in new industries are shaped by the organization of the research communities in universities from which these spin-off firms emerge. Contrasting the organization of research in the biochemistry departments of the University of

California at Berkeley (Berkeley), Stanford University (Stanford), and the University of California at San Francisco (UCSF) and key biotech firms spun-off from these departments, this article attempts to explain the central role UCSF scientists played in comparison with their Berkeley and Stanford counterparts, in the formation and development of the biotech industry in the San Francisco region during the late 1970s and early 1980s. It is demonstrated how the research environment at UCSF during this period positioned UCSF scientists comparatively well to identify in the context of their research new technological opportunities in therapeutic product markets and pursue these opportunities in the industrial research environment of the biotech industry. Finally, drawing parallels between this study on the role of UCSF in the formation of the San Francisco biotech industry and other studies on the role of Stanford in the formation of the Silicon Valley high-tech electronics industry, this article attempts to infer some general insights into the institutional dynamics that give rise to new science-based industries.

Karlsson, T. and C. Wigren (2010). "Start-ups among university employees: the influence of legitimacy, human capital and social capital." Journal of Technology Transfer: 1-16.

Using a sample of 7,260 university employees, we investigate how legitimacy, social and human capital influence the employees' start-up propensity. We find that scientific legitimacy, as measured by the number of recently published peer reviewed scientific articles, and conference papers accepted had no significant effect. Scientific legitimacy measured as publications in non-peer review journals even had a negative effect. Popular legitimacy showed mixed results. Measured as number of articles in popular science publications showed positive correlations and other public media appearances had a non significant effect on start-up propensity. Individuals who are older and have higher level of human capital, measured as level of education are less likely to start firms. We also found that, people with more social capital, such as contact with external product development teams are more likely to start new firms. Taken together, the findings suggest that activities spanning the university-business divide increase the start-up propensity, while within university activities had no, or negative effects on the propensity. Consequently, universities interested in encouraging their employees to start firms should focus their attention on creating spanning activities rather than improving conditions for within university tenure. © 2010 Springer Science+Business Media, LLC.

Kenney, M. and W. R. Goe (2004). "The role of social embeddedness in professorial entrepreneurship: a comparison of electrical engineering and computer science at UC Berkeley and Stanford." Research Policy **33**(5): 691-707.

Professorial entrepreneurship has recently attracted much attention. This paper draws upon historical research, a survey of faculty, and an Internet-based methodology for identifying professorial affiliations with entrepreneurial firms at

two of the premier electrical engineering and computer science departments in the US, The University of California, Berkeley and Stanford. We employ the concept of "nested embeddedness" to explain why the faculty members in these two institutions have different levels of entrepreneurship and corporate involvement. EE&CS faculty at both universities were found to be socially embedded in departments and disciplines that supported and placed value on entrepreneurial activities. However, while being embedded in a university environment with a history of success and high level of support for entrepreneurship, EE&CS faculty at Stanford had a significantly greater level of corporate involvement, including the founding of start-ups. Although significantly less than Stanford, the level of corporate involvement among EE&CS faculty at Berkeley was also substantial. This 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. (C) 2004 Elsevier B.V. All rights reserved.

Klofsten, M. and D. Jones-Evans (2000). "Comparing Academic Entrepreneurship in Europe -The Case of Sweden and Ireland." Small Business Economics **14**(4): 299-309.

One of the greatest challenges facing European economies is the comparatively limited capacity to convert scientific breakthroughs and technological achievements into industrial and commercial successes. As a result, there is growing awareness of the proactive approach being undertaken by academic institutions, with many adopting a direct entrepreneurial role in collaborating with industry. This paper examines the activities of those academics involved with industry within two small European countries, namely Sweden and Ireland. In particular, it discusses and contrasts the extent to which academic entrepreneurship (i.e. all commercialisation activities outside of the normal university duties of basic research and teaching) has developed. It examines the influence of gender, age, previous entrepreneurial experience, work experience and university environment on the entrepreneurship activities of a sample of academics in both countries. The results demonstrate that there is considerable entrepreneurial experience among academics in both countries, and that this translates into a high degree of involvement in "soft" activities such as consultancy and contract research, but not into organizational creation via technology spin-offs.

Knockaert, M., A. Spithoven and B. Clarysse (2010). "The knowledge paradox explored: what is impeding the creation of ICT spin-offs?" Technology Analysis & Strategic Management **22**(4): 479-493.

There has been an increased interest in technology transfer activities. This increased interest is inspired by the observation that not all generated knowledge gets translated into commercial products or processes, which is generally

referred to as the knowledge paradox. Many researchers have studied academic spin-offs. Within the resource based view of the firm the technological, human and financial starting resources of academic spin-offs have been studied. Little research has however studied the extent to which these resources are affecting spin-off establishment. This paper sheds light on the extent to which different resources were impeding ICT spin-off establishment. The results show that financial resources were hardly affecting ICT spin-off creation, whereas some human and technological resources had a high impact on the spin-off process. These findings call for an increased attention by policy makers and research institutes to provide support in bridging the gap between science and market.

Knockaert, M., M. Wright, B. Clarysse and A. Lockett (2010). "Agency and similarity effects and the VC's attitude towards academic spin-out investing." Journal of Technology Transfer **35**(6): 567-584.

Our research seeks to develop understanding of the factors explaining venture capital investment managers' attitudes towards investment in the unique context of academic spin-outs. We provide a novel integration of both VC fund characteristics and investment managers' human capital characteristics with a unique hand-collected dataset of 68 early stage VC investment managers in Europe. Attitudes toward academic spin-out investing are positively affected by the presence of public sector capital and by investment managers who are more intensively involved with the entrepreneur. Specific human capital in investment managers who had worked in an academic environment is more likely associated with investment in academic spin-outs. In terms of general human capital, financial experience is positively related while entrepreneurial experience is negatively associated with investment attitude towards academic spin-outs. There may be a need to facilitate the attraction of people from industry and investment banking into public VC funds in particular.

Krabel, S. and P. Mueller (2009). "What drives scientists to start their own company? An empirical investigation of Max Planck Society scientists." Research Policy **38**(6): 947-956.

Studies on academic spin-off companies have shown that the researchers' scientific potential, experience and established networks with other scientists or companies affect entrepreneurial activity. Most studies investigate official data such as patents and citations or qualitatively study a research group or spin-off formation. Only a few studies focus on the individual scientist. Our study fills this gap by analyzing survey interviews of 2604 scientists working for the Max Planck Society in Germany. Our empirical results indicate that the entrepreneurial activities of scientists heavily depend on patenting activity, entrepreneurial experience, and personal opinions about the benefits of commercializing research and close personal ties to industry. (C) 2009 Elsevier B.V. All rights reserved.

Krabel, S., D. S. Siegel and V. Slavtchev (2010). "The internationalization of science and its influence on academic entrepreneurship." Journal of Technology Transfer: 1-21.

We examine whether scientists employed in foreign countries and foreign-educated native researchers are more "entrepreneurial" than their "domestic" counterparts. We conjecture that foreign-born and foreign-educated scientists possess broader scientific skills and social capital, which increases their likelihood that they will start their own companies. To test this hypothesis we analyze comprehensive data from researchers at the Max Planck Society in Germany. Our findings provide strong support for the conjecture that academic entrepreneurship can be stimulated by facilitating the mobility of scientists across countries. © 2010 Springer Science+Business Media, LLC.

Kroll, H. and I. Liefner (2008). "Spin-off enterprises as a means of technology commercialisation in a transforming economy - Evidence from three universities in China." Technovation **28**(5): 298-313.

Recently, some university spin-off firms have begun to substantially contribute to the technological upgrading of China's economy. The corresponding academic literature, however, does not yet deal with spin-off activities of Chinese universities in a comprehensive and theoretically sound way. Currently, most articles on Chinese spin-offs focus on case studies of the most prominent government-sponsored enterprises in Beijing. This paper aims to contribute to the literature in a more comprehensive manner by providing a theoretical discussion of spin-off formation in a developing and transforming economy, and by presenting results from a comparative study based on data from 82 interviews with spin-off enterprises in three metropolitan regions in China. The study shows that under the initial framework conditions, government-driven spin-off formation has indeed proved an appropriate solution for technology transfer at Chinese universities. Many of the companies thus formed, however, suffer from defective incentive structures and lack of performance. Consequently, since lifting or easing restrictive regulations, the formerly unique model of Chinese spin-off formation has been complemented by a surge of entrepreneurial spin-off formation. (c) 2007 Elsevier Ltd. All rights reserved.

Landry, R., N. Amara and I. Rherrad (2006). "Why are some university researchers more likely to create spin-offs than others? Evidence from Canadian universities." Research Policy **35**(10): 1599-1615.

This paper addresses the following question: why are some university researchers more likely to create spin-off companies than others? In order to explain why university researchers create spin-offs, we draw on the resource-based theory of the firm. The study database consists of 1554 university researchers funded by the Natural Sciences and Engineering Research Council of Canada (NSERC). The logistic regression results suggest that the traditional and entrepreneurial visions

of university research complement each other when one looks at the resources mobilized by researchers to launch spin-offs. (c) 2006 Published by Elsevier B.V.

Landry, R., N. Amara and M. Saïhi (2007). "Patenting and spin-off creation by Canadian researchers in engineering and life sciences." Journal of Technology Transfer **32**(3): 217-249.

This paper examines the determinants of patenting and spin-off creation using survey data of 479 researchers in engineering and 449 researchers in life sciences funded by the Natural Sciences and Engineering Research Council of Canada (NSERC). The results show that research novelty and laboratory size are the only two variables significantly explaining patenting and spin-off formation in both engineering and life sciences. Network capital explains spin-off formation in engineering and in life sciences as well as patenting in life sciences, but not in engineering. Furthermore, the results suggest that many categories of resources explain patenting and spin-off formation in engineering and in life sciences, but that the combinations of resources required differ for patenting and spin-off formation and between engineering and life sciences. The results of this paper suggest that customized policies would be required to accommodate differences between spin-off formation and patenting as well as between engineering and life sciences. © Springer Science+Business Media, LLC 2006.

Landry, R., M. Saïhi, N. Amara and M. Ouimet (2010). "Evidence on how academics manage their portfolio of knowledge transfer activities." Research Policy **39**(10): 1387-1403.

The purpose of this paper is to explore whether six broad categories of knowledge transfer activities undertaken by academics: the creation and diffusion of knowledge through publications, transmission of knowledge through teaching, informal knowledge transfer, patenting, spin-off formation and consulting activities, are complementary, substitute, or independent, as well as the conditions under which complementarities, substitution and independence among these activities are likely to emerge. This investigation relied on data regarding 1554 researchers funded by the Natural Sciences and Engineering Research Council of Canada. Contrary to prior studies which have examined complementarities and the determinants of knowledge transfer activities in separate models, this study relied on a multivariate path model to reflect the fact that in practice, academics consider simultaneously whether or not to undertake multiple knowledge transfer activities. Overall, the results point to the existence of three very different types of knowledge transfer portfolios of activities: a first portfolio made up of complementary activities which are interdependent and reinforce each other. This portfolio includes publications, patenting, spin-off creation, consulting and informal knowledge transfer. A second portfolio includes teaching activities and publication outputs which are substitute for each other. A third portfolio comprises teaching activities and other activities independent

from teaching, namely, patenting, spin-off creation, consulting and informal knowledge transfer. Each of these three portfolios of knowledge transfer activities emerged under different conditions. Implications are derived for managerial practice and future research.

Leitch, C. M. and R. T. Harrison (2005). "Maximising the potential of university spin-outs: the development of second-order commercialisation activities." R & D Management **35**(3): 257-272.

This paper examines the dynamics of university spin-out company development, based on an in-depth, longitudinal case study of some of the spin-out activities of one of the longest established technology transfer organisations in the UK. The different types of resource flows between this organisation and some of the companies in which it has a stake are discussed. Specifically, the paper considers the efficacy and appropriateness of the university technology transfer office (TTO) becoming involved in what we term second-order spin-out activities. These are spin-out companies that have been formed on technology developed in a spin-out company, or by people working in that spin-out, but which have no substantive connection with the research or personnel base of the university. We argue that in a peripheral non-technology intensive regional economy, the role of the TTO may be more wideranging than has been commonly assumed and may include a focus on regional economic development as well as the commercialisation of university-based research.

Lerner, J. (2004). "The university and the start-up: Lessons from the past two decades." Journal of Technology Transfer **30**(1-2): 49-56.

This paper explores one of Edwin Mansfield's enduring interests: the interface between academia and industry. It highlights some key lessons regarding the management of university-based spin-outs, drawing on a variety of sources. I highlight the challenges that the spin-off process poses, the impracticality of directly financing firms through internal venture funds, and the ways in which universities can add value to faculty ventures. © Springer Science+Business Media, Inc. 2004.

Libaers, D., M. Meyer and A. Geuna (2006). "The role of university spinout companies in an emerging technology: The case of nanotechnology." Journal of Technology Transfer **31**(4): 443-450.

This study examines the role of university spin-out (USO) companies in the emergence of a new technology, in our case nanotechnology. Three unique data-sets based on patents, co-publications, and firm data pertaining to the unfolding field of nanotechnology in the UK were developed. Subsequent analysis suggests that USOs play an important though not a dominant role. Furthermore, the results indicate that USOs in certain subfields of nanotechnology do not have a strong and growing proprietary technology base, raising questions about the

commercial sustainability of these ventures. Overall, we observed that USOs are important contributors to technological change in specific subfields of nanotechnology, but that other actors, notably, large firms and (non-university affiliated) new technology-based firms are even more significant agents of technological change. © Springer Science+Business Media, LLC 2006.

Lindelof, P. and H. Lofsten (2005). "Academic versus corporate new technology-based firms in Swedish science parks: an analysis of performance, business networks and financing." International Journal of Technology Management **31**(3-4): 334-357.

This study is in the field of new technology-based firms and the role of Science Parks. The assessing of academic knowledge and expertise by businesses located on site is a key principle of Science Parks. Science Parks provide an important resource network for new technology-based firms (NTBFs). The independent new technology-based Science Park firms are analysed regarding their origin. The research proposition is empirically tested on the basis of 134 new technology-based firms in Sweden, NTBFs (University spin-offs; USOs) from the academy (74 firms) and NTBFs (Corporate spin-offs; CSOs) from the private sector (60 firms). These two categories of firms are assumed to need and acquire different types of resources due to their different background. The importance of Science Parks for the decision to start the firm: 66.7 percent (USOs) and 52.9 percent (CSOs). They would never have been established without the Science Park. The two groups tended to exhibit differences between advice from managers in the parks (USOs). The study indicates that there is a direct relationship between Science Park importance for attracting external capital and financing issues (USOs). There is also some evidence that professional businesses benefit from a Science Park location. The general levels of advice (Advice related to park: Banking institutions and Chamber of Commerce) by those CSOs located on a Science Park was considerably high.

Lindelof, P. and H. Lofsten (2006). "Environmental hostility and firm behavior - An empirical examination of new technology-based firms on science parks." Journal of Small Business Management **44**(3): 386-406.

Firms often respond to challenging environmental conditions, such as those in high-technology environments. Thus, in a hostile environment, the intensity of competition exerts more pressure on the firm and also a greater necessity for firm behavior. This study was conducted with empirical data collected in 1999 from 134 small firms on science parks in Sweden. The discussion in this paper is focused at the firm level. Analysis of firm behavior was conducted using a multivariate approach. The content of firm-level behavior is defined in terms of the firm's overall collection of business practices and competitive tactics. The investigation of customer preferences and competitors are the manifestations of the firm's more basic strategic direction and how the firm will reach the markets. Two different types of firms were analyzed: university spin-offs (USOs) and

corporate spin-offs (CSOs). The importance of the science park was included in the study as a control variable. The variable showed whether the firms had received support from a science park. This study indicated that the relations between change of marketing activities and long-term forecasting are strongest for both USOs and CSOs. The long-term forecasting, technology-importance of science park, was another key factor. This is exemplified by the two samples used in this study.

Link, A. N. and J. T. Scott (2005). "Opening the ivory tower's door: An analysis of the determinants of the formation of US university spin-off companies." Research Policy **34**(7): 1106-1112.

This paper presents findings from an analysis of the determinants of the formation of university spin-off companies within the university's research park. We find that university spin-off companies are a greater proportion of the companies in older parks and in parks that are associated with richer university research environments. We also find that university spin-off companies are a larger proportion of companies in parks that are geographically closer to their university and in parks that have a biotechnology focus. (c) 2005 Elsevier B.V. All rights reserved.

Lockett, A., D. Siegel, M. Wright and M. D. Ensley (2005). "The creation of spin-off firms at public research institutions: Managerial and policy implications." Research Policy **34**(7): 981-993.

We consider the managerial and policy implications of the rise of spin-offs at public research institutions (PRIs), based on a knowledge-based view (KBV) of the firm. This framework highlights the importance of knowledge in the creation and development of spin-offs. We argue that in order to understand the development of spin-offs, researchers should focus on "knowledge gaps" these new ventures encounter. Knowledge gaps can occur at different levels of aggregation, including the PRI, spin-off, team, individual, incubator, and at different stages of spin-off development. Based on this framework, we synthesize findings from previous studies and papers in the special issue and offer some suggestions for additional research on spin-offs from PRIs. (c) 2005 Elsevier B.V. All rights reserved.

Lockett, A. and M. Wright (2005). "Resources, capabilities, risk capital and the creation of university spin-out companies." Research Policy **34**(7): 1043-1057.

The commercialization of university research has become an increasingly important issue, given concerns regarding licensing and the university's desire to maximize the returns to intellectual property (IP). In this paper, we assess the impact of university resources and routines/capabilities on the creation of spin-out companies. We find that both the number of spin-out companies created and the number of spin-out companies created with equity investment are significantly positively associated with expenditure on intellectual property

protection, the business development capabilities of technology transfer offices and the royalty regime of the university. These results highlight the importance not just of resource stocks, but also of developing appropriate capabilities of technology transfer officers in spinning-out companies. The results suggest that universities and policy-makers need to devote attention to the training and recruitment of technology officers with the broad base of commercial skills. (c) 2005 Published by Elsevier B.V.

Lockett, A., M. Wright and S. Franklin (2003). "Technology Transfer and Universities' Spin-Out Strategies." Small Business Economics **20**(2): 185-200.

Universities may seek to transfer technology from the public to the private sector, and therefore capture the benefits of commercialization, through a number of different mechanisms. This paper examines the option of using technology-based spin-out companies. Based on a survey of technology transfer/business development officers at 57 U.K. universities, we examine their strategies to promote the creation of spin-out companies and how they then manage the development of these companies. Our analysis focuses on the difference between those universities that have been most active in the area and those that have been least active. The results indicate that the more successful universities have clearer strategies towards the spinning out of companies and the use of surrogate entrepreneurs in this process. In addition, the more successful universities were found to possess a greater expertise and networks that may be important in fostering spin-out companies. However, the role of the academic inventor was not found to differ between the more and less successful universities. Finally, equity ownership was found to be more widely distributed among the members of the spin-out company in the case of the more successful universities.

Lofsten, H. and P. Lindelof (2005). "R&D networks and product innovation patterns - academic and non-academic new technology-based firms on Science Parks." Technovation **25**(9): 1025-1037.

This research has explored the R&D networks and product innovation patterns made by the NTBFs (University spin offs, USOs and corporate spin-offs, CSOs) located on Science Parks. It seems reasonable to believe that firms established by those with an academic background might be expected both to perform differently and respond to different incentives from those founded by personnel from the industry. The two research propositions were empirically tested on the basis of 134 new technology-based firms (NTBFs) on Science Parks in Sweden, USOs from the academy (74 small firms) and CSOs from the private sector (60 small firms). There were no significant differences regarding growth (sales) and profitability (profit margin) between the two groups. In order to separate the performance due to the firms capability and the impact of the environment, a control variable was created. This paper, building on the resource-based theory

and empirical evidence, argues that NTBFs have an interest in co-operation between the university and the Science Park firms. The survey makes it clear that the proportion of USOs and CSOs on Science Parks with links with universities is comparatively high. Seventy percent of USOs cooperates with universities and 59 percent of the CSOs. This is surprisingly high percentages of the CSOs. One finding from this research is that USOs are not able to channel investments into greater R&D outputs (Patents) than comparable firms. (c) 2004 Elsevier Ltd. All rights reserved.

Macho-Stadler, I., D. Perez-Castrillo and R. Veugelers (2008). "Designing contracts for university spin-offs." Journal of Economics & Management Strategy **17**(1): 185-218.

We provide a theoretical model about how to design academic spin-off contracts between the university technology transfer office (TTO), the researcher, and the venture capitalist. The optimal contract entails the allocation of founder shares to the researcher to secure her participation in the venture. It may also require the researcher to be financially involved in the project to give her incentives to provide effort. We also show that when the TTO has better information than the other two participants concerning the likelihood of success of the spin-off, it will end up owning both founder and financial shares in the venture.

Markman, G. D., P. T. Gianiodis, P. H. Phan and D. B. Balkin (2005). "Innovation speed: Transferring university technology to market." Research Policy **34**(7): 1058-1075.

This study extends innovation speed theory by empirically linking the antecedents and outcomes of technology commercialization at universities. Assessing university technology transfer offices (UTTOs) in the U.S., we found that the faster UTTOs can commercialize patent-protected technologies, the greater their licensing revenues streams and the more new ventures they spin off. Furthermore, using commercialization time as a surrogate for innovation speed, we identify several determinants of speed. That is, UTTO resources and the competency in identifying licensees are related to commercialization time. Also, the participation of faculty-inventors in the licensing process is a critical determinant of commercialization time. Illustrating that innovation speed is an antecedent of performance as well as a desired outcome in and of itself, provides support for innovation speed theory. (c) 2005 Elsevier B.V. All rights reserved.

Markman, G. D., P. H. Phan, D. B. Balkin and P. T. Gianiodis (2005). "Entrepreneurship and university-based technology transfer." Journal of Business Venturing **20**(2): 241-263.

The success of business incubators and technology parks in university settings is often determined by how well technology is transferred from the labs to their startup firms. University technology transfer offices (UTTOs) function as "technology intermediaries" in fulfilling this role. Yet, entrepreneurship theory, and research on the role of the UTTO in business incubation and new venture formation is sparse. To move the research along, we use grounded theory to

build a framework to address two questions: (a) Which UTTOs' structures and licensing strategies are most conducive to new venture formation; and (b) how are the various UTTOs' structures and licensing strategies correlated with each other. Our findings reveal a complex set of relationships between UTTO structure and strategies, new venture formation, and business incubation. Based on interviews with 128 UTTO directors, we show that whereas for-profit UTTO structures are positively related to new venture formation, traditional university and nonprofit UTTO structures are more likely to correlate with the presence of university-based business incubators. Licensing-for-equity strategy is positively related to new venture formation while sponsored research licensing strategy is negatively related. Interestingly, the licensing-for-cash strategy, the most prevalent transfer strategy, is least correlated to new venture formation. A content analysis of UTTO mission statements also revealed an overemphasis on royalty income and an underemphasis on entrepreneurship. The paper concludes with a discussion that outlines some of the implications and limitations of our model. (C) 2004 Published by Elsevier Inc.

Markusen, A. and M. Oden (1996). "National laboratories as business incubators and region builders." *Journal of Technology Transfer* **21**(1-2): 93-108.

Public sector labs do not appear to have generated as much regional business spinoff as universities and research-intensive businesses. This difference may be explained in large part by the disparate capabilities for and attitudes toward new-firm incubation on the part of parent institutions and other anchor tenants. We believe that federal lab personnel systems, research cultures, geographical isolation, management preferences, and complex public interest issues are responsible. These phenomena are explored in an intensive case study of start-ups associated with Los Alamos and Sandia National Laboratories in New Mexico. Interviews conducted with 33 firms confirm many barriers to incubation, but also reveal some advantages offered by public labs and suggest that changes in attitude, culture, and policy can make a difference. We explore the difficult issues of property rights assignment, public employee conflict-of-interest rules, and the use of public sector equity in spinoffs, and we conclude that start-up efforts have been underfunded. Lab partnerships with large corporations in comparison are expensive, hoard labor, and are less effective at transferring technology. Recommendations for improvement of the incubation process include entrepreneurial leave and training, streamlining of conflict-of-interest, patent, and licensing procedures, and lab-based efforts to connect would-be entrepreneurs with sources of business assistance, space and capital.

McAdam, M., R. McAdam, B. Galbraith and K. Miller (2010). "An exploratory study of Principal Investigator roles in UK university Proof-of-Concept processes: an Absorptive Capacity perspective." *R & D Management* **40**(5): 455-473.

The increasing emphasis on academic entrepreneurship, technology transfer and research commercialisation within UK universities is predicated on basic research being developed by academics into commercial entities such as university spin-off companies or licensing arrangements. However, this process is fraught with challenges and risks, given the degree of uncertainty regarding future returns. In an attempt to minimise such risks, the Proof-of-Concept (PoC) process has been developed within University Science Park Incubators (USIs) to test the technological, business and market potential of embryonic technology. The key or the pivotal stakeholder within the PoC is the Principal Investigator (PI), who is usually the lead academic responsible for the embryonic technology. Within the current literature, there appears to be a lack of research pertaining to the role of the PI in the PoC process. Moreover, Absorptive Capacity (ACAP) has emerged within the literature as a theoretical framework or lens for exploring the development and application of new knowledge and technology, where the USI is the organisation considered in the current study. Therefore, the aim of this paper is to explore the role and influence of the PI in the PoC process within a USI setting using an ACAP perspective. The research involved a multiple case analysis of PoC applications within a UK university USI. The results demonstrate the role of the PI in developing practices and routines within the PoC process. These practices and processes were initially tacit and informal in nature but became more explicit and formal over time so that knowledge was retained within the USI after the PIs had completed the PoC process.

McAdam, R., M. McAdam and V. Brown (2009). "Proof of concept processes in UK university technology transfer: an absorptive capacity perspective." *R & D Management* **39**(2): 192-210.

Successful research commercialisation within the university domain is predicated upon basic research being developed into technology that will attract funding, ultimately resulting in entities such as University spin-out companies or licensing arrangements. This development process involves considerable risk and uncertainty and may require substantial resources to fund early stage operations while returns are uncertain. Hence there is a need to explore risk-minimisation approaches relating to proving the potential for development while concurrently allocating resources in an incremental manner. This paper focuses on the development of the Northern Ireland Proof of Concept (PoC) process within a University Science Park Incubator (USI) as a particular approach to addressing these challenges inherent in the United Kingdom University technology transfer. Furthermore, Absorptive Capacity has emerged in the literature as an appropriate theoretical framework or lens for exploring the development and application of new technology. Therefore, the aim of this paper is to explore the PoC process

within a USI as a means for improving the commercialisation of University technology transfer using an Absorptive Capacity perspective. A multiple case analysis of PoC applications within a UK university is described. From the findings it emerges that Absorptive Capacity influencing factors such as levels of R&D investment, prior knowledge base and integration of stakeholder and technology planning all impact on PoC outcomes. In addition a number of process improvement areas for PoC are identified in relation to the influencing factors within the Absorptive Capacity framework.

Mets, T., M. Leego, T. Talpsep and U. Varblane (2007). "The role of intellectual property protection in the business strategy of university spin-off biotech companies in a small transition economy." Review of Central and East European Law **32**(1): 19-40.

Spin-off biotech companies often have difficulties in creating competitive advantage through protection of their intellectual property, due to their limited human and financial resources. Having considered the value of the intellectual property and questions of enforceability, spin-off companies should use patenting only for inventions with a high market value and high patent enforceability; otherwise, publishing early or keeping the invention a trade secret should be preferred. This allows the inventor to benefit from operational freedom while maintaining low costs. The impact of the protected intellectual property on the success of the firm depends on its speed of entry into the market and when it reaches break-even point. In a transition country with a poorly developed entrepreneurial environment, patents may expire before the spin-off company has produced any profit from its expenditures on the protection of the intellectual property. It should also be remembered that their products may contain modules which are already protected by other inventors. Consequently, a strategically fundamental issue for the success of spin-off firms is the careful selection of the markets in which to operate, and the choice of the proper degree and method of intellectual property protection.

Meyer, M. (2003). "Academic entrepreneurs or entrepreneurial academics? Research-based ventures and public support mechanism." R & D Management **33**(2): 107-115.

The emergence of a new mode of knowledge production, the formation of a 'Triple Helix' of university-industry-government, and the advent of the academic entrepreneur-all these different developments point, in one way or another, to the increased attention that is being paid to the economic utilization of publicly funded research. One way to utilize academic research in a commercial manner is to set up university spin-off companies. We shall discuss the phenomenon of academic entrepreneurship in the context of public support mechanisms and incentive structures. One key finding is that support mechanisms do not necessarily promote academic entrepreneurship but further the development of a behavioural pattern that can be associated with the notion of the 'entrepreneurial academic'-scientists in public sector organizations who are not

necessarily interested in setting up a fast-growing company but looking for other avenues in which they can pursue their research interests. Badly targeted support mechanisms can have a negative impact on the growth-pattern of science-based SMEs by providing a distorted set of incentives. We shall discuss some of these support mechanisms in detail and illustrate effects they have had on the development of four research-based ventures.

Meyer, M. (2006). "Academic inventiveness and entrepreneurship: On the importance of start-up companies in commercializing academic patents." Journal of Technology Transfer **31**(4): 501-510.

This article presents research that places the academic start-up phenomenon in the broader technology transfer context. Drawing on data on Finnish academic inventions, the paper illustrates that a considerable share of university-related patents are utilized in start up companies but that still most academic patents are utilized in established and predominantly large firms. Differences in utilization patterns are explored for different fields of science and technology. © Springer Science+Business Media, LLC 2006.

Moray, N. and B. Clarysse (2005). "Institutional change and resource endowments to science-based entrepreneurial firms." Research Policy **34**(7): 1010-1027.

This paper considers the question of whether the resource endowments of science-based entrepreneurial firms are influenced by the way technology transfer is organised at the parent organisation. We studied one public research organisation in detail (IMEC, Belgium), by questioning all managers involved in technology transfer and the founders of all science-based entrepreneurial firms set up between 1986 and 2002. This research identifies three generations of companies at IMEC, mirroring the organisational changes in technology transfer policies and displaying distinct resource characteristics. Establishing an incubator structure for spin-offs seems to be a learning process during which little decision making can be exerted over senior management's social network in the financial and business community for securing the financial, technological and human resources for the science-based entrepreneurial firms. (c) 2005 Elsevier B.V. All rights reserved.

Mosey, S. and M. Wright (2007). "From human capital to social capital: A longitudinal study of technology-based academic entrepreneurs." Entrepreneurship Theory and Practice **31**(6): 909-935.

This article develops theory relating to how differences in the human capital of academic entrepreneurs influence their ability to develop social capital that can address the barriers to venture development. We examine the development of social capital by three types of academic entrepreneurs with differing levels of entrepreneurship experience: nascent, novice, and habitual entrepreneurs. Using a longitudinal study, critical differences are observed between the structure,

content, and governance of their social networks. We propose that entrepreneurs with prior business ownership experience have broader social networks and are more effective in developing network ties. Less experienced entrepreneurs likely encounter structural holes between their scientific research networks and industry networks. Support initiatives help attract industry partners for novice entrepreneurs from engineering and the material sciences but academics based within biological sciences encounter greater difficulties building such ties. Regardless of academic discipline, business ownership experience appears essential to learn to build relationships with experienced managers and potential equity investors.

Muller, K. (2010). "Academic spin-offs transfer speed-Analyzing the time from leaving university to venture." Research Policy **39**(2): 189-199.

For academic spin-offs I analyze the length of the time period between the founder's leaving of academia and the establishment of her firm. A duration analysis reveals that a longer time-lag is caused by the necessity of assembling complementary skills, either by acquisition by a single founder or by Searching for Suitable team members. Furthermore, new ventures are established faster if there has been high-level technology transfer, if the founders have access to university infrastructure, Or if they receive informal support by former colleagues. (C) 2009 Elsevier B.V. All rights reserved.

Munari, F. and L. Toschi (2011). "Do venture capitalists have a bias against investment in academic spin-offs? Evidence from the micro- and nanotechnology sector in the UK." Industrial and Corporate Change **20**(2): 397-432.

In this article, we analyze whether venture capital (VC) firms have a bias against investment in academic spin-offs based on empirical evidence from the micro- and nanotechnology sector in the UK. We also investigate the characteristics of academic spin-offs to capture the differences in their ability to attract VC funding. Finally, we examine whether the propensity to invest in such kinds of new ventures varies between private and public VC firms. The results of our regression analyses on a sample of 247 new ventures (123 academic spin-offs and 124 other companies) reject the presence of bias in this type of science-based business. They also highlight intellectual property rights, presence of academic-industrial collaborations, scientific reputation of the parent university and type of business model as important factors in the academic spin-off's ability to access VC financing. Furthermore, we show that private VCs devote a weaker attention than public VCs to the university's scientific reputation when deciding to finance academic spin-offs.

Murray, F. (2004). "The role of academic inventors in entrepreneurial firms: sharing the laboratory life." *Research Policy* **33**(4): 643-659.

While science-based entrepreneurial firms are a key feature of the modern economy, our insights into their organization and productivity remain limited. In particular, our understanding of the mechanisms through which academic inventors shape entrepreneurial firms established to commercialize their scientific ideas is based upon a traditional perspective that highlights the importance of human capital. Based on a study of biotechnology firms and their academic inventors, this paper examines the extent and mechanisms through which academic scientists contribute not only human capital but also social capital to entrepreneurial firms. The paper makes two contributions to our understanding of the academic-firm interface: First, it establishes that the social capital of academic scientists is critical to firms because it can be transformed into scientific networks that embed the firm in the scientific community through a variety of mechanisms. Second, the paper argues that an academic inventor's career plays a critical role in shaping his social capital, thus scientific careers mediate the networks and potential for embeddedness that an academic inventor brings to a firm. Specifically, the foundations of an academic's social capital can be traced to two sources: The first element that the firm may leverage is the academic's local laboratory network—a network to current and former students and advisors established by the inventor through his laboratory life. The second form of social capital is a wider, cosmopolitan network of colleagues and co-authors established through the social patterns of collaboration, collegiality and competition that exemplify scientific careers. These findings suggest that scientific careers are central in shaping an academic's social capital which can be translated into critical scientific networks in which entrepreneurial firms become embedded. (C) 2004 Elsevier B.V. All rights reserved.

Mustar, P., M. Renault, M. G. Colombo, E. Piva, M. Fontes, A. Lockett, M. Wright, B. Clarysse and N. Moray (2006). "Conceptualising the heterogeneity of research-based spin-offs: A multi-dimensional taxonomy." *Research Policy* **35**(2): 289-308.

Research-based spin-offs (RBSOs) have become an important aspect of the technology transfer process. Emanating from what is conventionally a non-commercial environment, RBSOs pose major challenges if they are to realise their potential to meet the objectives of their founders and the parent research organisations (PROs) from which they emerge. An important issue is to understand the heterogeneity of RBSOs. This paper reviews the literature on RBSO typologies to develop a taxonomy of RBSOs. We identify common themes in relation to these typologies in relation to (1) spin-off creation and (2) spin-off development. The dimensions that differentiate between firms are the type of resources, the business model and the institutional link. We identify gaps in current typologies in order to propose avenues for future conceptual and empirical research. (c) 2006 Elsevier B.V. All rights reserved.

Mustar, P. and M. Wright (2010). "Convergence or path dependency in policies to foster the creation of university spin-off firms? A comparison of France and the United Kingdom." *Journal of Technology Transfer* **35**(1): 42-65.

This paper examines attempts by French and UK governments to fill the gap between the US and Europe with respect to the creation of academic spin-offs. Analysis of the contrasting cases of the UK and France, shows that there is no convergence of national policies to foster the creation of firms by academics. Rather, the two countries demonstrate different rationales and approaches to policy in this area. In UK, the rationale for spin-off policy is mainly to develop a third stream of financing. Spin-offs are a part of a policy to commercialize technology and knowledge created by universities. Policy is at the university level, leading to the creation of diverse structures. Public schemes bring public money directly to universities. In France, the rationale for policy towards the creation of new ventures by academics is the development of high technology new ventures as part of a technological entrepreneurship policy. The notion of a third stream of financing for universities is an argument that is never advanced. The UK has placed the universities at the heart of policies aimed at the creation of spin-offs, this is not the case in France.

Mustar, P., M. Wright and B. Clarysse (2008). "University spin-off firms: Lessons from ten years of experience in Europe." *Science and Public Policy* **35**(2): 67-80.

This paper advances our understanding of university spin-off creation and development in environments outside the high-tech cluster of the USA. It adopts a multi-level approach in its examination of this phenomenon in diverse institutional environments. In particular, units of analysis involving universities, technology transfer offices, spin-off firms, finance providers and individual entrepreneurs and teams are analysed. Policy implications are analysed and recommendations are proposed for current policy on university spin-offs. © Beech Tree Publishing 2008.

Ndonzuau, F. N., F. Pirnay and B. Surlemont (2002). "A stage model of academic spin-off creation." *Technovation* **22**(5): 281-289.

The commercialisation of scientific and technological knowledge produced within publicly funded research institutions such as universities, laboratories, research centres, and so forth, is increasingly considered by policymakers as raw material for developing and sustaining regional economic growth. This paper focuses on one of the most promising ways to transfer research results to the market place, namely, the creation of academic spin-offs. Its main aim is to identify, understand, and distinguish the major issues raised by the creation of such companies from the point of view of both public and academic authorities. To achieve this, some well-known international spin-off support programmes have been benchmarked. We used these observations to build up a general model that

puts forward the major issues involved in the transformation of research results into the creation of economic value within the perimeter of universities. Based on inductive research, the model is composed of four successive stages interacting in a sequential manner. (C) 2002 Elsevier Science Ltd. All rights reserved.

Nerkar, A. and S. Shane (2003). "When do start-ups that exploit patented academic knowledge survive?" International Journal of Industrial Organization **21**(9): 1391-1410.

Researchers have generally suggested that new technology firms should exploit radical technologies with broad scope patents to compete with established firms, implying that new firms founded to exploit university inventions will be more likely to survive in all industries if they possess these attributes. However, the existing empirical evidence indicates that the effectiveness of these two dimensions of new firm strategy is contingent on the industry environment, specifically industry concentration. In this paper, we explain why this industry-specific relationship should exist and use a unique data set of new technology ventures originating at Massachusetts Institute of Technology to test our arguments. (C) 2003 Elsevier B.V. All rights reserved.

Nicolaou, N. and S. Birley (2003). "Academic networks in a trichotomous categorisation of university spinouts." Journal of Business Venturing **18**(3): 333-359.

The paper adopts a network perspective in an attempt to understand the underlying mechanisms generating the different university spinout structures. In this respect, we propose a trichotomous categorisation of university spinouts into orthodox, hybrid and technology spinouts and argue that the academic's embeddedness in a network of exoinstitutional and endo institutional ties influences the type of spinout initiated. We draw from some of the recent network research that has adopted a contingency approach in explaining the value of social networks. (C) 2002 Elsevier Science Inc. All rights reserved.

Nicolaou, N. and S. Birley (2003). "Social networks in organizational emergence: The university spinout phenomenon." Management Science **49**(12): 1702-1725.

This paper aims to ascertain the influence of social networks in the university spinout phenomenon. With respect to the instrumental role of social networks, it adopts a content contingency perspective pertaining to the role of closure and structural holes, and examines the interaction between relational and structural embeddedness in the academics' network structure. With respect to spinout outcomes, this paper distinguishes between academic exodus and stasis, and differentiates between types of spinouts based on the degree of involvement of the key academics. It also examines networks at the team level of analysis and submits that team-level structural differences exist between the different spinout structures.

Niosi, J. and M. Banik (2005). "The evolution and performance of biotechnology regional systems of innovation." Cambridge Journal of Economics **29**(3): 343-357.

The paper maintains that biotechnology regions develop as complex systems: they start with star scientists in research universities, generating knowledge spillovers, then move progressively towards regional technology markets. In the process they attract venture capital (or modify the behaviour of existing venture capital firms with the addition of biotechnology portfolios). The routines of universities are also modified with the addition of intellectual property and technology transfer offices intervening as sellers in the newly created knowledge markets. The paper also considers whether companies located in regional agglomerations grow faster than isolated ones, and whether companies spun-off from universities have a better performance than start-ups. The study is based on about 90 Canadian-based publicly quoted biotechnology companies.

Nosella, A. and R. Grimaldi (2009). "University-level mechanisms supporting the creation of new companies: an analysis of Italian academic spin-offs." Technology Analysis & Strategic Management **21**(6): 679-698.

In this paper we address the role of university policies in the creation of academic spin-offs. We focus on university technology transfer units (UTTs) in Italy and on the mechanisms they have implemented to support academic entrepreneurship. We gathered data relating to their strategies for technology transfer and to the mechanisms they had implemented to support new venture creation. Results show that the number of people dedicated to technology transfer activities, strong relationships that UTTs have with external organisations involved in technology transfer activities, and finally support services provided by universities and UTTs have a significant influence in fostering the generation of new ventures.

O'Gorman, C., O. Byrne and D. Pandya (2008). "How scientists commercialise new knowledge via entrepreneurship." Journal of Technology Transfer **33**(1): 23-43.

In this paper, we explore how university-based scientists overcome the barriers to appropriating the returns from new knowledge via entrepreneurship; and we examine how a university-based technology transfer office (TTO), with an incubation facility, can assist scientists in the commercialisation process. We identify how scientists overcome three barriers to commercialisation. First, we find that scientists take account of traditional academic rewards when considering the pay-offs of commercialisation activity. Second, scientists recognise the commercial value of new knowledge when market-related knowledge is embedded in their research context, and/or when they develop external contacts with those with market knowledge. Third, the deliberate efforts of scientists to acquire market information results in individuals or organisations with market knowledge learning of the new knowledge developed by the scientists; and intermediaries can help individuals or organisations with resources

learn of new knowledge developed by scientists. We find that the TTO, principally through an enterprise development programme (CCDP), played an important role in the commercialisation process. The principal benefit of the TTO is in the domain of putting external resource providers in contact with scientists committed to commercialisation. Our findings have important implications for scientists and for those interested in promoting commercialisation via entrepreneurship.

O'Shea, R. P., T. J. Allen, A. Chevalier and F. Roche (2005). "Entrepreneurial orientation, technology transfer and spinoff performance of US universities." Research Policy **34**(7): 994-1009.

This paper adopts a resource-based perspective to understand why some universities are more successful than others at generating technology-based spinoff companies. In this respect, we derive eight hypotheses that link attributes of resources and capabilities, institutional, financial, commercial and human capital, to university spinoff outcomes. Using panel data from 1980 to 2001, our econometric estimators reveal evidence of history dependence for successful technology transfer to occur although faculty quality, size and orientation of science and engineering funding and commercial capability were also found to be predictors of university spinoff activity. We conclude by drawing implications for policy makers and university heads. (c) 2005 Elsevier B.V. All rights reserved.

O'Shea, R. P., T. J. Allen, K. P. Morse, C. O'Gorman and F. Roche (2007). "Delineating the anatomy of an entrepreneurial university: the Massachusetts Institute of Technology experience." R&D Management **37**(1): 1-16.

In many universities, heads, administrators and faculty seek to increase the propensity to engage in commercialization of research activity through the spinoff of new companies. The highly complex mechanism of spinoff generation is typically considered the result of either the characteristics of individuals, organizational policies and structures, organizational culture, or the external environment. Explanations of spinoff activity have in the main focused on only one of these dimensions at a time. In this paper we integrate these four dimensions of academic entrepreneurship to develop a more systemic understanding of spinoff activity at the university level. Using the case of Massachusetts Institute of Technology (MIT), a top spinoff generator in the United States, a systemic analysis is presented. We identify the inter-related factors that have contributed to successful academic entrepreneurship in MIT. We argue that MIT's success is based on the science and engineering resource base at MIT; the quality of research faculty; supporting organizational mechanisms and policies such as MIT's Technology Licensing Office; and the culture within MIT faculty that encourages entrepreneurship. However, to understand why MIT has developed these resources and organizational mechanisms, it is necessary to understand the historical context and emergence

of MIT, and in particular the historical mission of the university, the role of key individuals and university leaders in supporting this mission, and the impact of past success at commercialization activity. Finally, we suggest that MIT's success needs to be understood in the context of the local regional environment. We argue that university administrators and academics can learn from the case of MIT, but that efforts at transposing or replicating single elements of MIT's model may only have limited success, given the inter-related nature of the drivers of spinoff activity.

O'Shea, R. P., H. Chugh and T. J. Allen (2008). "Determinants and consequences of university spinoff activity: a conceptual framework." Journal of Technology Transfer **33**(6): 653-666.

The characteristics and behavior of university spinoff activity is an important subject in economic and management studies literature. Such studies merit research because it is suggested that university innovations stimulate economies by spurring product development, by creating new industries, and by contributing to employment and wealth creation. For this reason, universities have come to be highly valued in terms of the economic potential of their research efforts. The aim of this paper is to offer a framework for the study of academic entrepreneurship that explains different aspects of university spinoff behavior in a coherent way. We suggest that the existing literature on this topic can be categorized into six separate streams and synthesized in a framework that captures the determinants and consequences of spinoff activity.

Patzelt, H. and D. A. Shepherd (2009). "Strategic Entrepreneurship at Universities: Academic Entrepreneurs' Assessment of Policy Programs." Entrepreneurship Theory and Practice **33**(1): 319-340.

In this article we draw on goal-setting theory to analyze how and why entrepreneurs perceive the usefulness of policy programs aimed at facilitating the development of academic ventures. Using a conjoint study and data on 3,136 assessments nested within 98 academic entrepreneurs, we find that access to finance offered by a policy program is central and enhances the entrepreneurs' perceived benefits of other policy measures such as providing access to nonfinancial resources (networks, business knowledge) and reducing administrative burdens, but diminishes the perceived benefits of offering tax incentives for new ventures. Our results extend the literature on academic entrepreneurship and entrepreneurs' assessments of government policy measures. For policy makers, our study suggests that the simultaneous launch of policy measures may be perceived by academic entrepreneurs as particularly beneficial for fostering the development of their young ventures.

Perez, M. P. and A. M. Sanchez (2003). "The development of university spin-offs: early dynamics of technology transfer and networking." *Technovation* **23**(10): 823-831.

Measuring the contributions of 'hi-tech' small firms by looking only at their product sales, innovation outputs and employment generation may understate their effectiveness. Another important contribution of entrepreneurship 'hi-tech' firms is their catalyzing role to knowledge creation and transfer in innovation networks. This paper addresses two exploratory research questions: how active in network development and technology transfer are university spin-offs during their early years to overcome initial disadvantages? Is there any relationship between early networks development and knowledge creation and technology transfer in university spin-offs? Using data from companies spun off from a Spanish university in the period 1990-2000, the empirical results suggest that technology transfer and networking at university spin-offs decreased after their early years but at the same time the relationships with customers increased. (C) 2002 Elsevier Science Ltd. All rights reserved.

Pfarrmann, O. (1999). "Neither soft nor hard - pattern of development of new technology based firms in biotechnology." *Technovation* **19**(11): 651-659.

Traditional theory states that small companies that emerge from a university environment follow a distinctive pattern of development. Due to this view the companies start as technical consultancies selling expert reports which incorporate a high degree of intellectual analysis and in which the scientist's original academic expertise is focused on the specific problem of a client. There then follows a gradual process of development during which this initial product is reduced, first to a more routine analytical package and then into a design technique, before eventually emerging as a distinct and standardized product which embodies in simplified form the original expertise, but which is now suitable for repetitive manufacture. This pattern can be described as a "hardening process" and is paralleled in the development of the company through a series of "soft" stages. Based on a sample of 35 biotechnology start-ups of a German region called Berlin-Brandenburg information about the services and products offered by these firms will be discussed. We found no clear evidence that follows the above mentioned development pattern. In contrast, several firms started exclusively with products. The majority, however, offers both products and services. The latter mainly in R&D. A large number of the start-ups already has their product launched on the market. There are individual factors of the entrepreneur/the entrepreneurial team, as well as the environment of the firms, for example the strong competition in biotechnology, that forces firms to market their product early. In several cases these products are not for final use, but can be regarded as intermediate products within the biotechnical value added chain. Several firms exhibit a broad network including research institutions, small and large firms that might also determine the development pattern. Finally, even the state-of-the-art of the specific technology itself allows for some tentative

conclusions to be drawn about product/service relationships within newly established firms. (C) 1999 Elsevier Science Ltd. All rights reserved.

Pilegaard, M., P. W. Moroz and H. Neergaard (2010). "An Auto-Ethnographic Perspective on Academic Entrepreneurship: Implications for Research in the Social Sciences and Humanities." Academy of Management Perspectives **24**(1): 46-61.

This paper employs a qualitative method to analyze a successful spin-off from a university's humanities department. We offer insight into (a) how sociospatial contexts may be structured to better evaluate the entrepreneurial facilitation process and (b) why academic entrepreneurship in the social sciences and humanities may differ from that in the hard sciences. Our findings illustrate the importance of bridging innovation using twin skills to balance research and commercial goals, and the need for codifying knowledge capacities and creating new or changing existing institutional structures to legitimize and facilitate entrepreneurial activity. The research also demonstrates the great value of auto-ethnographic techniques to bring fresh insight to the study of entrepreneurship. Directions for future research are offered.

Pirnay, F., B. Surlemont and F. Nlemvo (2003). "Toward a typology of university spin-offs." Small Business Economics **21**(4): 355-369.

This paper discusses existing definitions of USOs in order to reconcile them and to provide criteria for classifying and understanding the different facets of this multi-headed concept. Drawing the boundaries of this concept and elucidating its variety through a typology are therefore the two main objectives of this paper. USOs are defined as new firms created to exploit commercially some knowledge, technology or research results developed within a university. The proposed typology is based on two key discriminatory factors, namely (1) the status of individuals involved in the new business venturing process (researchers or students) and (2) the nature of knowledge transferred from university to the new venture (codified or tacit), inducing the nature of the USO activities (product or service-oriented).

Powers, J. B. and P. P. McDougall (2005). "University start-up formation and technology licensing with firms that go public: a resource-based view of academic entrepreneurship." Journal of Business Venturing **20**(3): 291-311.

Although academic entrepreneurship is a topic receiving some attention in the literature, higher education's appetite for expanding technology transfer activities suggests that more research is needed to inform practice. This study investigates the effects of particular resource sets on two university commercialization activities: the number of start-up companies formed and the number of initial public offering (IPO) firms to which a university had previously licensed a technology. Utilizing multisource data on 120 universities and a resource-based view of the firm framework, a set of university financial, human

capital, and organizational resources were found to be significant predictors of one or both outcomes. (c) 2004 Elsevier Inc. All rights reserved.

Prevezer, M. (2001). "Ingredients in the early development of the US biotechnology industry." *Small Business Economics* **17**(1-2): 17-29.

This paper explores the ingredients that stimulated the development of the biotechnology industry in the US and contrasts conditions with those in Europe. It examines relationships between established firms and new start-ups; the financing and managerial environment and the organizational environment, whereby firms were able to set up networks of alliances. Its main findings are that: 1) The funding of the medical science research base has been substantially more generous in the U.S. than Europe. It is the funding of the science base rather than of the biotechnology industry directly that has provided the foundations for start-ups to be created out of the science base. 2) It has been easier for U.S. academics to found start-ups, close to their research establishment, and to retain their academic posts and status as well as be involved in a commercial enterprise. In Europe, the scientific/academic and commercial worlds have a wider divide. 3) Start-ups have been concentrated in the therapeutics and agricultural fields, with strong scientific research inputs into their commercialization, in contrast to other sectors where downstream processing innovations have been more important, which have been undertaken in-house by the large incumbent companies. 4) Financing and managerial conditions have been significantly easier in the U.S. for start-ups, in terms of access to venture capital specialising in high technology, ability to use the stock market to raise capital, and access to people able to forge links between scientists and entrepreneurs, and to introduce managerial expertise into new companies. 5) There has been a greater facility in the U.S. than in Europe for alliances to be formed between incumbent companies and indigenous U.S. start-ups; European start-ups have not found similar backing from European incumbent companies.

Pries, F. and P. Guild (2007). "Commercial exploitation of new technologies arising from university research: start-ups and markets for technology." *R & D Management* **37**(4): 319-328.

The creation of start-up firms is an important method of commercializing new technologies arising from R&D at universities and other research institutions. Most research into start-ups presumes that these firms develop products or services. However, start-ups may operate through markets for technology by selling or licensing rights to use their technology to other firms - typically established firms - who develop and sell new products or services based on the technology. In this study of 57 public start-up firms created to commercialize the results of university research, we find evidence that (1) operating through markets for technology is a common approach to commercialization, (2) start-ups

that operate in markets for technology can be effectively distinguished in practice from start-ups operating through product markets, and (3) there are substantive differences in the business activities of firms depending on whether they operate through product markets or markets for technology.

Prodan, I. and M. Drnovsek "Conceptualizing academic-entrepreneurial intentions: An empirical test." Technovation **30**(5-6): 332-347.

Policy makers are increasingly recognizing the catalytic role of academics' spin-off companies in a national economy, which derives from their innovativeness that result in new value generation, and job creation. Although research on academics' spin-off companies has been increasing, knowledge gaps exist as to the specific determinants and processes that characterize the emergence of academics' entrepreneurial intentions that lead them to spin off companies. This research aims to fill this gap. Drawing from psychological and entrepreneurship research on intentionality, the authors propose a conceptual model of academics' entrepreneurial intentions. They empirically test the model using structural equation modeling and a robust data set collected in two European academic settings to guide future research on this important topic.

Rappert, B., A. Webster and D. Charles (1999). "Making sense of diversity and reluctance: academic-industrial relations and intellectual property." Research Policy **28**(8): 873-890.

The commercialisation of the public sector research base, and in particular academic research, has been a continuing preoccupation among policy makers around the world. Empirically, these issues are explored in the management of intellectual property in university spin-offs (USOs) that emerge through both informal and formal linkages with universities across three sectors. The paper utilises a recently developed methodology to map knowledge flows as well as linkages between organisations. This enables us to examine the exchange of knowledge in commercial and academic networks and the implications of changes in the sponsorship, ownership, and proprietary status of knowledge for these patterns of exchange. It is argued that some of the most important points of tension between universities and the firms studied derive from misconceptions in the value of intellectual property rights.

Rasmussen, E. and O. J. Borch (2010). "University capabilities in facilitating entrepreneurship: A longitudinal study of spin-off ventures at mid-range universities." Research Policy **39**(5): 602-612.

This paper investigated how universities facilitate the process of spin-off venture formation based on academic research. Building on a capability perspective, we add to the literature on university characteristics and resources by exploring how the university context impacts the entrepreneurial process. We based our study on two mid-range universities and followed the start-up process of four spin-off ventures. Based on the results of our longitudinal study, we propose a set of

three university capabilities that facilitate the venture-formation process: (1) creating new paths of action, (2) balancing both academic and commercial interests, and (3) integrating new resources. Each capability is particularly important for specific phases in the venturing process. Our findings suggest that these capabilities are dependent on prior spin-off experience and reside within several actors both inside and outside of the university. Furthermore, universities with weaknesses in the identified areas can take strategic action to develop these capabilities to some degree. (C) 2010 Elsevier B.V. All rights reserved.

Rasmussen, E., S. Mosey and M. Wright (2011). "The Evolution of Entrepreneurial Competencies: A Longitudinal Study of University Spin-Off Venture Emergence." Journal of Management Studies: no-no.

abstract This paper aims to better understand the development of entrepreneurial competencies to create new ventures within the non-commercial academic environment. We build upon the evolutionary perspective considering where resources come from to help define these competencies and explain their paths of development. The study follows the creation and early growth of four university spin-offs within the UK and Norway. We identified three competencies of opportunity refinement, leveraging, and championing that appeared crucial for the ventures to gain credibility. Although selected competencies were inherent within the academic founders, the specific competencies for venture creation had to be developed or acquired. This was achieved iteratively through entrepreneurial experience and accessing competencies from disparate actors such as industry partners and equity investors. Propositions are offered to guide future empirical research based upon our framework.

Reitan, B. (1997). "Fostering technical entrepreneurship in research communities: Granting scholarships to would-be entrepreneurs." Technovation 17(6): 287-296.

Experiences from a public measure with the aim of fostering technical entrepreneurship are presented. The measure -- a scholarship programme -- is positioned at the preparation stage of a new business formation process, with the aim of achieving high quality preparation. The target groups are scientists and academics who want to establish a new venture in a high-tech field. The programme has not been as huge a success as expected. It is not appropriate according to the criteria of realism, complementarity and compatibility. Assessing the success of the established new technology-based firms (NTBFs), we find that in quantitative terms the programme has to be categorized as a success. The start-up rate is 89%, the survival rate 73.7% and the '[]commercial utilization rate' 82.8%. However, in qualitative terms, the programme is not too successful. Most of the NTBFs do not contribute substantially to employment. Considering their turnover and net income before taxes, most of the firms are small and unprofitable. For the public fostering of technical entrepreneurship at universities and research institutions, the implications are that they have to attach great

importance to creating an environment supportive of technical entrepreneurship. The role of the incubator is very important for both the short-run and long-run success of NTBFs. The university or research institution as an incubator can, when playing a proper role, reduce some problems NTBFs experience later and thus strengthen their qualitative performance.

Renault, C. S. (2006). "Academic capitalism and university incentives for faculty entrepreneurship." Journal of Technology Transfer **31**(2): 227-239.

Entrepreneurial behavior by professors - including decisions about collaboration with industry, patenting and spinning off companies - can affect the productivity of top universities' technology transfer efforts. Interviews with 98 professors at 12 southeastern universities showed that the most significant influence on these aspects of entrepreneurial behavior is the beliefs of professors about the proper role of universities in the dissemination of knowledge. Some institutional policies, notably revenue splits with inventors, can affect aspects of this behavior. These findings suggest that both university incentive policies and ethical concerns about academic capitalism, by limiting the productivity of technology transfer efforts, have an effect on regional economic development. © Springer Science + Business Media, Inc. 2006.

Roberts, E. B. and D. E. Malon (1996). "Policies and structures for spinning off new companies from research and development organizations#." R&D Management **26**(1): 17-48.

Abstract This paper develops five alternative structural 'models' for formal efforts aimed at spinning off new companies from universities, government laboratories, and other research and development organizations. In various ways the models combine the roles of the technology originator, the entrepreneur, the R&D organization itself, and the venture investor. The paper also presents the policies and structures of technology commercialization operations from investigations at eight R&D organizations in the United States and the United Kingdom. The data indicate that a R&D organization operating in an environment where venture capital and entrepreneurs are readily available (e.g., MIT and Stanford) can appropriately: (1) exercise a low degree of selectivity in choosing technologies for spin-off creation, and (2) provide a low level of support during the spin-off process. The spin-off process is more difficult in environments where venture capital and entrepreneurs are scarce (e.g., ARCH) and mechanisms for high-selectivity and a high level of support must be in place by the R&D organization to compensate for this scarcity.

Rogers, E. M., S. Takegami and J. Yin (2001). "Lessons learned about technology transfer." Technovation **21**(4): 253-261.

The present paper derives lessons learned about effective technology transfer from research on the technology transfer process in New Mexico over the past

several years. Technology transfer from national R&D laboratories and from research universities provides the main basis for economic growth by metropolitan regions in the United States. New Mexico is (1) technology-rich because of Sandia National Laboratories, Los Alamos National Laboratory and the University of New Mexico, and (2) entrepreneur-friendly. High-technology spin-offs are a particularly effective means of technology transfer. The process of technology transfer is a difficult type of communication, and demands trained and skilled personnel, adequate resources, and organizational and other reward/incentive structures.

Rosa, P. and A. Dawson (2006). "Gender and the commercialization of university science: academic founders of spinout companies." Entrepreneurship and Regional Development **18**(4): 341-366.

There is a great deal of interest in Europe and the USA on the commercialization of university science, particularly the creation of spinout companies from the science base. Despite considerable research on academic entrepreneurship, female entrepreneurship in general, and the causes of under-representation of female scientists in academic institutions, there has been little research on the influence of gender on academic entrepreneurship. The study researches female founders of UK university spinout companies using information from the Internet on company founders of spinout companies from 20 leading universities. The proportion of female founders at 12% is very low. The paper explores reasons for this low representation through follow-up postal interviews of the 21 female founders identified, and a male control sample. Under-representation of female academic science research is the dominant but not the only factor to explain low entrepreneurial rates amongst female scientists. Owing to the low number of women in senior research positions in many leading science departments, few women had the chances to lead a spinout. This is a critical factor as much impetus for commercialization was initially inspired by external interest rather than internal evaluation of a commercial opportunity. External interest tended to target senior academics, which proportionally are mostly male. A majority of the women surveyed tended to be part of entrepreneurial teams involving senior male colleagues. As a whole both male and female science entrepreneurs displayed similar motivations to entrepreneurship, but collectively as scientists differed appreciably from non academic entrepreneurs. Women science entrepreneurs also faced some additional problems in areas such as the conflict between work and home life and networks.

Rothaermel, F. T., S. D. Agung and L. Jiang (2007). "University entrepreneurship: a taxonomy of the literature." Industrial and Corporate Change **16**(4): 691-791.

The literature on university entrepreneurship is rapidly expanding, in both the United States and Europe. Since the literature is also fairly fragmented, however, we submit that it is time to take stock of the current knowledge to provide

directions for future research and guideposts for policy makers. To accomplish this, we present an unusually comprehensive and detailed literature analysis of the stream of research on university entrepreneurship, now encompassing 173 articles published in a variety of academic journals. Four major research streams emerge in this area of study: (i) entrepreneurial research university, (ii) productivity of technology transfer offices, (iii) new firm creation, and (iv) environmental context including networks of innovation. We inductively derive a framework describing the dynamic process of university entrepreneurship based on a synthesis of the literature. We submit that this framework is useful in guiding future research on this important, yet complex and under-researched topic.

Salvador, E. (2011). "Are science parks and incubators good "brand names" for spin-offs? The case study of Turin." Journal of Technology Transfer **36**(2): 203-232.

In recent years there has been an increasing focus on universities' entrepreneurial orientation and their ability to exploit and transfer scientific knowledge to the commercial sector. Spin-off firms are recognised as an important opportunity for universities. This paper aims to examine the university spin-off firm context, with particular attention to the relationship with science parks-incubators and their importance as brand names. Evidence is taken from Turin case-study. Turin has a consolidated university framework: the University and the Polytechnic are examples of success all around Europe. A particular characteristic of Turin is given by the presence of two science and technology parks and two incubators.

Salvador, E. and S. Rolfo (2011). "Are incubators and science parks effective for research spin-offs? Evidence from Italy." Science and Public Policy **38**(3): 170-184.

In recent years there has been an increasing focus on the research spin-off phenomenon. Spin-off firms are recognised as an important opportunity for universities. Notwithstanding the interest on this field at European and US levels, few analyses have focused on Italy. The goal of this paper is to contribute to the literature on research spin-offs by providing original empirical evidence on spin-offs from Italian research. More specifically, attention is focused on the relationship between science parks/incubators and spin-offs at regional level. The results of a linear regression model highlight that the higher the number of host structures the higher the number of spin-offs. This analysis is completed with the results of a questionnaire: 65 on-park and 90 off-park respondents provided similar answers with few conclusive differences. The debate about the effectiveness of incubators and science parks remains open in Italy (and elsewhere). © Beech Tree Publishing 2011.

Shane, S. (2002). "Selling university technology: Patterns from MIT." Management Science **48**(1): 122-137.

any research universities engage in efforts to license inventions developed by university-affiliated inventors. However, no systematic explanation of the conditions under which university inventions will be licensed or commercialized has been provided. Drawing on transaction cost economics, I provide a conceptual framework to explain which university inventions are most likely to be licensed, commercialized, and generate royalties, and who will undertake that commercialization. I test this framework on data on the 1,397 patents assigned to the Massachusetts Institute of Technology during the 1980-1996 period. The results show that (1) university inventions are more likely to be licensed when patents are effective; (2) when patents are effective, university technology is generally licensed to noninventors; (3) when patents are effective, licensing back to inventors increases the likelihood of license termination and reduces the likelihood of invention commercialization; and (4) the effectiveness of patents increases royalties earned for inventions licensed to noninventors. The implications of these findings for innovation management and strategy, entrepreneurship, and university technology commercialization are discussed.

Shane, S. and T. Stuart (2002). "Organizational endowments and the performance of university start-ups." Management Science **48**(1): 154-170.

The question of how initial resource endowments—the stocks of resources that entrepreneurs contribute to their new ventures at the time of founding—affect organizational life chances is one of significant interest in organizational ecology, evolutionary theory, and entrepreneurship research. Using data on the life histories of all 134 firms founded to exploit MIT-assigned inventions during the 1980-1996 period, the study analyzes how resource endowments affect the likelihood of three critical outcomes: that new ventures attract venture capital financing, experience initial public offerings, and fail. Our analysis focuses on the role of founders' social capital as a determinant of these outcomes. Event history analyses show that new ventures with founders having direct and indirect relationships with venture investors are most likely to receive venture funding and are less likely to fail. In turn, receiving venture funding is the single most important determinant of the likelihood of IPO. We conclude that the social capital of company founders represents an important endowment for early-stage organizations.

Siegel, D. S., M. Wright and A. Lockett (2007). "The rise of entrepreneurial activity at universities: Organizational and societal implication." Industrial and Corporate Change **16**(4): 489-504.

Universities are increasingly emphasizing the creation of new companies as a mechanism for commercialization of intellectual property. This special issue provides a timely opportunity to assess the rise of entrepreneurial activity at

universities and its organizational and societal implications. In this introductory article, we summarize the papers from the special issue and frame them in the context of the literature. In the concluding section, we discuss some organizational and societal issues that arise from these papers. © The Author 2007. Published by Oxford University Press on behalf of Associazione ICC. All rights reserved.

Slaughter, S., C. J. Archerd and T. I. D. Campbell (2004). "Boundaries and quandaries: How professors negotiate market relations." Review of Higher Education **28**(1): 129-+.

Closer university-market relations are evidenced in increased university patenting, the formation of start-up companies, and partnerships with industry. They are part of a state and policy effort to link science and engineering to the market, thereby developing new technologies, stimulating economic growth, and creating new jobs. Yet the blurring of boundaries between the two institutions creates quandaries for faculty and administrators. Using a National Science Foundation database and interviews, this article explores the effects of redrawn boundaries, the need to negotiate disputed boundaries, and the role of start-up companies in the new academic environment.

Smith, H. L. and K. Ho (2006). "Measuring the performance of Oxford University, Oxford Brookes University and the government laboratories' spin-off companies." Research Policy **35**(10): 1554-1568.

The paper reports on a recent study, which uses various indicators to provide an insight on the performance of spin-off companies from the public sector research base in Oxfordshire (UK). The study builds upon the other studies and fills a gap in the field by gathering empirical information on the performance of technology-based spin-off companies. While the main geographical focus is the county of Oxfordshire, UK, the findings will also be of value for other researchers and institutions with an interest in assessing the performance of spin-off firms. The evidence shows that the number of spin-offs in Oxfordshire has increased rapidly over recent years, as the result of evolving national policy and the entrepreneurial culture of the universities and laboratories. However, the academics and scientists in Oxfordshire's institutions were already entrepreneurial in the 1950s, less so in the 1960s, but increasingly in the 1970s and 1980s, particularly in Oxford University, which is by far the largest generator of spin-offs in the region. (c) 2006 Elsevier B.V. All rights reserved.

Soetanto, D. P. and M. Van Geenhuizen (2009). "SOCIAL NETWORKS AND COMPETITIVE GROWTH OF UNIVERSITY SPIN-OFF FIRMS: A TALE OF TWO CONTRASTING CITIES." Tijdschrift Voor Economische En Sociale Geografie **100**(2): 198-209.

A key assumption in agglomeration theory is that knowledge-based firms benefit from knowledge spillovers in cities. Cities however may have different locations in the national context, such as embedded in a network of nearby cities or

relatively isolated. We examine social networks employed by university spin-off firms in urban environments that contrast in such a way, namely, Delft (the Netherlands) and Trondheim (Norway). A set of growth models is explored with a focus on characteristics of social networks through which knowledge is acquired, such as tightness, strength and spatial orientation. The networks appear to differ in various respects, except for a positive influence on growth of heterogeneity in the social background of partners. The largest difference is observed in strength of relationships: an increase in strength tends to hamper growth in Delft, while it tends to enhance growth in Trondheim.

Soetanto, D. P. and M. van Geenhuizen (2010). "SOCIAL CAPITAL THROUGH NETWORKS: THE CASE OF UNIVERSITY SPIN-OFF FIRMS IN DIFFERENT STAGES." Tijdschrift Voor Economische En Sociale Geografie **101**(5): 509-520.

University spin-off firms in their first, often critical, years face a shortage of basic resources needed for growth. A major way of gaining such resources is through knowledge derived from social networks. However, social networks may be quite different in nature such that the influence of these networks on growth of university spin-offs may vary, like according to tightness, strength, social heterogeneity and spatial proximity of network partners. In this paper, we first examine theoretical ideas on social capital and the role of social networks. This is followed by an empirical study of university spin-off firms to explore differences in social networks between two development stages and to estimate the influence of network characteristics on growth in these stages. Early stage spin-offs tend to employ networks dominated by tightness, strong relationships, more homogeneous partners and local partners, whereas networks of spin-offs in later stages tend to face clearly contrasting features. Furthermore, network characteristics tend to influence growth mainly in years following the early stage, with a positive influence of social capital in networks that are relatively open to new knowledge and information.

Steffensen, M., E. M. Rogers and K. Speakman (2000). "Spin-offs from research centers at a research university." Journal of Business Venturing **15**(1): 93-111.

Spin-offs are a means of technology transfer from a parent organization that represent a mechanism for creating jobs and new wealth. We investigated 6 of the 19 spin-offs from the 55 research centers at the University of New Mexico (UNM) in 1997. The Albuquerque area in Northern New Mexico is rich in technology, thanks to the presence of three large Federal R&D laboratories and the University of New Mexico. University administrators and community leaders envision a future technopolis (technology city), but achieving this goal will be difficult, given the lack of needed infrastructure, entrepreneurship, and venture capital in the Albuquerque region. Nevertheless, in the early 1990s the amount of research funding at UNM increased at a faster rate than at other U.S. research universities (total research funding rose to \$197 million in 1996). Most of this

increase (about 85%) took place through the efforts of UNM's 55 research centers, which are multidisciplinary units supported mainly by funding from federal and state government agencies, private companies, and foundations. The research centers transfer technological innovations across the university's boundary via various mechanisms, including spin-offs. A spin-off is a new company that is formed (1) by individuals who were former employees of the parent organization (a UNM research center in the present case), and (2) a core technology that is transferred from the parent organization. A previous study by the present authors identified 71 spin-offs from the three federal R&D laboratories in New Mexico. The fact that high-technology spin-offs are occurring in New Mexico, and at an increasing rate, suggests that a technopolis may be getting underway. In recent years the University of New Mexico and the federal R&D laboratories have established organizational and procedural mechanisms intended to encourage spin-offs and other types of technology transfer such as patenting and technology licensing. An important factor in the success of a spin-off company is the degree of support that it receives from its parent organization. The six UNM spin-offs of study here experienced few conflicts with their parent, in each case a university-based research center. However, lengthy negotiations with university officials over intellectual property rights to a spin-off's core technology were often involved. The director of a spin-off's parent research center usually played a key role in the spin-off process. Often the university research center continued to provide laboratory facilities and access to research equipment to the spin-off. Generally, both the spin-off and the parent organization perceived of the spin-off process as a win-win situation (which might not be the case when the parent is a private company and the spin-off becomes a competitor). In the present investigation we identify two types of spin-offs: (1) planned, when the new venture results from an organized effort by the parent organization, and (2) spontaneously occurring, when the new company is established by an entrepreneur who identifies a market opportunity and who founds the spin-off with little encouragement (and perhaps with discouragement) from the parent organization. Both types of spin-offs were represented in the present study. UNM professors, directors of the parent research centers, and others played important roles in instigating three of the six spin-offs, while the other three were launched mainly by entrepreneurs. Spin-offs represent an important mechanism for technology transfer, as a spin-off is typically founded around a core technological innovation that was initially developed at the parent organization. One reason that a research university is a vital ingredient in a technopolis is because of the considerable role that university-based research centers play in spinning-off new ventures. Stanford University in Silicon Valley, MIT on Route 128, and the University of Texas in Austin are all examples of this important relationship. The University of New Mexico is a smaller research university than Stanford, MIT, or Texas, but it is beginning to play a similar role in the spin-off process. If indeed a technopolis

eventually develops in Albuquerque, perhaps in 10 or 20 years, lessons may be learned about the roles of a research university and its research centers (and federal R&D) laboratories, in contributing to regional economic development. (C) 1998 Elsevier Science Inc.

Stuart, T. E. and W. W. Ding (2006). "When do scientists become entrepreneurs? The social structural antecedents of commercial activity in the academic life sciences." American Journal of Sociology **112**(1): 97-144.

The authors examine the conditions prompting university-employed life scientists to become entrepreneurs, denned to occur when a scientist (1) founds a biotechnology company, or (2) joins the scientific advisory board of a new biotechnology firm. This study draws on theories of social influence, socialization, and status dynamics to examine how proximity to colleagues in commercial science influences individuals' propensity to transition to entrepreneurship. To expose the mechanisms at work, this study also assesses how proximity effects change over time as for-profit science diffuses through the academy. Using adjusted proportional hazards models to analyze case-cohort data, the authors find evidence that the orientation toward commercial science of individuals' colleagues and coauthors, as well as a number of other workplace attributes, significantly influences scientists' hazards of transitioning to for-profit science. © 2006 by The University of Chicago. All rights reserved.

Taheri, M. and M. van Geenhuizen (2011). "How human capital and social networks may influence the patterns of international learning among academic spin-off firms*." Papers in Regional Science **90**(2): 287-U259.

The extent and background of establishing international knowledge relations among young academic spin-off firms are explored in this paper. Drawing on survey data of 100 of such firms, the influence of human capital and social networks of these firms is examined, alongside their innovation level. International learning is measured in two ways, adoption of the strategy and spatial reach related to this adoption namely, from Europe to worldwide. The paper fits into a stream of research in which it is recognized that new technology-based firms interact both in local knowledge networks and knowledge networks abroad to remain competitive. A majority of the spin-off firms were found to be engaged in international networks and the most powerful influences tended to be the presence of PhD experience and size of the starting team. Social capital released through social networks is a relatively strong influence only in the spatial reach of knowledge relations, supporting the idea that strong social networks form a solid base from which global learning can be undertaken. The implications of the results of this work and future research steps are discussed.

Thursby, J., A. W. Fuller and M. Thursby (2009). "US faculty patenting: Inside and outside the university." *Research Policy* **38**(1): 14-25.

In a sample of 5811 patents with US faculty as inventors, 26% are assigned solely to firms rather than universities as dictated by US university employment policies and Bayh-Dole. We relate assignment to patent characteristics, university policy, and inventor field. Patents assigned to firms (whether established or start-ups with inventor as principal) are less basic than those assigned to universities suggesting firm assigned patents result from faculty consulting. Assignment to inventor-related start-ups is less likely the higher the share of revenue inventors receive from university-licensed patents. Firm assignment also varies by inventor field and whether the university is public or private. (C) 2008 Elsevier B.V. All rights reserved.

Toole, A. A. and D. Czarnitzki (2007). "Biomedical academic entrepreneurship through the SBIR program." *Journal of Economic Behavior & Organization* **63**(4): 716-738.

This paper considers the U.S. Small Business Innovation Research (SBIR) program as a policy fostering academic entrepreneurship. Using unique data on NIH supported biomedical scientists, we trace the incidence of academic entrepreneurship through the SBIR program and examine the impact these scientists have on the performance of the SBIR firms they found or join. Our results show that the SBIR program is used as a commercialization channel by biomedical academic scientists. Moreover, the SBIR firms associated with these scientists perform significantly better than other SBIR firms in terms of follow-on venture capital funding, SBIR program completion, and patenting. (c) 2007 Elsevier B.V. All rights reserved.

Toole, A. A. and D. Czarnitzki (2009). "Exploring the Relationship Between Scientist Human Capital and Firm Performance: The Case of Biomedical Academic Entrepreneurs in the SBIR Program." *Management Science* **55**(1): 101-114.

There is an emerging debate in the scholarly literature regarding the extent to which academic human capital contributes to firm performance. This debate centers on the nature of an academic scientist's human capital and its institutional specificity. Using data on the human capital of biomedical scientists developed during their careers in academe, this paper analyzes how the depth of their scientifically and commercially oriented academic human capital contributes to firm performance when these scientists subsequently start or join for-profit firms. We find that the scientific and commercial components of an academic scientist's human capital have differential effects on the performance of research and invention tasks at the firm. We also find that the contribution of an academic scientist to a firm's patent productivity is decreasing with the depth of their scientifically oriented human capital, all else constant. These results support the view that academic human capital is heterogeneous and has an institutional

specificity that mediates its value when applied in a commercialization environment.

Toole, A. A. and D. Czarnitzki (2010). "Commercializing science: Is there a university "brain drain" from academic entrepreneurship?" Management Science **56**(9): 1599-1614.

When academic researchers participate in commercialization using for-profit firms, there is a potentially costly trade-off-their time and effort are diverted away from academic knowledge production. This is a form of brain drain on the not-for-profit research sector that may reduce knowledge accumulation and adversely impact long-run economic growth. In this paper, we examine the economic significance of the brain drain phenomenon using scientist-level panel data. We identify life scientists who start or join for-profit firms using information from the Small Business Innovation Research program and analyze the research performance of these scientists relative to a control group of randomly selected research peers. Combining our statistical results with data on the number of university spin-offs in the United States from 1994 to 2004, we find the academic brain drain has a nontrivial impact on knowledge production in the not-for-profit research sector. Copyright © 2010 INFORMS.

Valentin, F., H. Dahlgren and R. L. Jensen (2007). "Research strategies in science-based start-ups: Effects on performance in Danish and Swedish biotechnology." Technology Analysis & Strategic Management **19**(3): 303-328.

Although biotech start-ups fail or succeed based on their research, few attempts have been made to examine if and how they strategise in this core activity. Using a unique comprehensive dataset on Danish and Swedish biotech start-ups in drug discovery this paper adopts a Simonean approach to analysing the research strategies of small dedicated biotech firms (DBFs), focusing on three interrelated issues: (i) characterising the problem architectures addressed by different types of DBFs; (ii) testing and confirming that DBFs form requisite research strategies, by which we refer to problem- solving approaches developed as congruent responses to problem architectures; and (iii) testing and confirming that financial valuation of firms is driven by achievements conforming to requisite research strategies. These strategies, in turn, require a careful combination of multiple dimensions of research. The findings demonstrate that Schoonhoven's argument that 'strategy matters' is valid not only for the larger high-tech firms covered by her study, but also for small researchbased start-ups operating at the very well-springs of knowledge where science directly interacts with technologies. Although more research is needed along these lines, these findings offer new implications for the understanding, management and financing of these firms.

van Burg, E., A. G. L. Romme, V. A. Gilsing and I. Reymen (2008). "Creating university spin-offs: A science-based design perspective." Journal of Product Innovation Management **25**(2): 114-128.

Academic entrepreneurship by means of university spin-offs commercializes technological breakthroughs, which may otherwise remain unexploited. However, many universities face difficulties in creating spin-offs. This article adopts a science-based design approach to connect scholarly research with the pragmatics of effectively creating university spin-offs. This approach serves to link the practice of university spin-off creation, via design principles, to the scholarly knowledge in this area. As such, science-based design promotes the interplay between emergent and deliberate design processes. This framework is used to develop a set of design principles that are practice based as well as grounded in the existing body of research on university spin-offs. A case-study of spin-off creation at a Dutch university illustrates the interplay between initial processes characterized by emergent design and the subsequent process that was more deliberate in nature. This case study also suggests there are two fundamentally different phases in building capacity for university spin-off creation. First, an infrastructure for spin-off creation (including a collaborative network of investors, managers and advisors) is developed that then enables support activities to individual spin-off ventures. This study concludes that to build and increase capacity for creating spin-offs, universities should do the following: (1) create university-wide awareness of entrepreneurship opportunities, stimulate the development of entrepreneurial ideas, and subsequently screen entrepreneurs and ideas by programs targeted at students and academic staff; (2) support start-up teams in composing and learning the right mix of venturing skills and knowledge by providing access to advice, coaching, and training; (3) help starters in obtaining access to resources and developing their social capital by creating a collaborative network organization of investors, managers, and advisors; (4) set clear and supportive rules and procedures that regulate the university spin-off process, enhance fair treatment of involved parties, and separate spin-off processes from academic research and teaching; and (5) shape a university culture that reinforces academic entrepreneurship by creating norms and exemplars that motivate entrepreneurial behavior. These and other results of this study illustrate how science-based design can connect scholarly research to the pragmatics of actually creating spin-offs in academic institutions.

van Geenhuizen, M. (2003). "How can we reap the fruits of academic research in biotechnology? In search of critical success factors in policies for new-firm formation." Environment and Planning C-Government and Policy **21**(1): 139-155.

There is often a gap between the creation of knowledge and the use of new knowledge in the economy, a situation which has pushed many governments to establish programmes for knowledge transfer and new-firm formation. I examine the initiatives taken by the government in the Netherlands to advance new-firm

formation in biotechnology. Drawing on experience in entrepreneurship-its institutional setting in general, and more specifically on developments in biotechnology start-ups I aim to identify critical success factors for this policy. The policy seems promising in covering all development stages of start-up firms and in using a network approach-with implementation by an intermediary organisation as a solution for coordination problems. The low popularity of entrepreneurship, including some negative regulatory factors in biotechnology, and the danger of the policy focusing on the top innovative start-ups are threats to success. Other threats may be a fragmentation of forces and a narrow focus on a national situation rather than cooperation with adjacent countries. I suggest a number of critical success factors that can be used in policies to enhance new-firm formation in biotechnology, and indicate some lines for further research.

van Geenhuizen, M. and D. P. Soetanto (2009). "Academic spin-offs at different ages: A case study in search of key obstacles to growth." *Technovation* **29**(10): 671-681.

Support to enhance early growth of academic spin-off firms is at the core of many economic policies. Efficiency of this support has been recently questioned due to slow growth of spin-off firms in various European countries. However, despite many studies to improve support, there is virtually no empirical insight into resistance of obstacles that constrain growth over time and how this differs between distinct types of spin-offs. This article explores the incidence and nature of obstacles to growth in a cross-section and longitudinal approach, and uses Delft University of Technology (the Netherlands) as a case study. We find evidence that (1) the overall ability to overcome obstacles decreases at the age of four, most probably reflecting the rise of the so-called credibility juncture, and that (2) highly innovative spin-offs start with an accumulation of obstacles but move relatively quickly to sustainable growth. The paper concludes with recommendations for the design of new (renewed) incubation policies and for further research. (C) 2009 Elsevier Ltd. All rights reserved.

Van Looy, B., P. Landoni, J. Callaert, B. van Pottelsberghe, E. Sapsalis and K. Debackere (2011). "Entrepreneurial effectiveness of European universities: An empirical assessment of antecedents and trade-offs." *Research Policy* **40**(4): 553-564.

The phenomenon of entrepreneurial universities has received considerable attention over the last decades. An entrepreneurial orientation by academia might put regions and nations in an advantageous position in emerging knowledge-intensive fields of economic activity. At the same time, such entrepreneurial orientation requires reconciliation with the scientific missions of academia. Large-scale empirical research on antecedents of the entrepreneurial effectiveness of universities is scarce. This contribution examines the extent to which scientific productivity affect entrepreneurial effectiveness, taking into account the size of universities and the presence of disciplines, as well as the R&D intensity of the regional business environment (BERD). In addition, we assess the

occurrence of trade-offs between different transfer mechanisms (contract research, patenting and spin off activity). The data used pertain to 105 European universities. Our findings reveal that scientific productivity is positively associated with entrepreneurial effectiveness. Trade-offs between transfer mechanisms do not reveal themselves; on the contrary, contract research and spin off activities tend to facilitate each other. Limitations and implications for future research are discussed. (C) 2011 Elsevier B.V. All rights reserved.

Vanaelst, I., B. Clarysse, M. Wright, A. Lockett, N. Moray and R. S'Jegers (2006). "Entrepreneurial team development in academic spinouts: An examination of team heterogeneity." *Entrepreneurship Theory and Practice* **30**(2): 249-271.

This article examines the dynamics of entrepreneurial teams as they evolve through the different stages of a spin-out process. Using a unique, hand-collected set of data covering all team members in 10 cases, an in-depth analysis of the heterogeneity of team members' experience and perception of the strategic orientation needed to attain different milestones in the spin-out process was performed. Our findings suggest that teams evolve over time and change in composition, and therefore, they cannot be studied as immutable entities. At the start of the venture formation, we introduced a new team role, the privileged witness, potentially specific for spinouts. Analysis of the teams indicates that the team's heterogeneity changes as it evolves through the different stages of the spin-out process. In particular, we found that new team members brought in different kinds of experience; however, they did not introduce a different view on doing business from the initial team members.

Vincett, P. S. (2010). "The economic impacts of academic spin-off companies, and their implications for public policy." *Research Policy* **39**(6): 736-747.

The importance of academic research ("AR") to economic growth is widely accepted but quantification of incremental impacts, and their attribution to any one country's expenditures, is difficult. Yet quantitative justification of government AR funding is highly desirable. We therefore attempt to quantify one impact which can be directly and causally attributed to one country's funding: spin-off companies. We focus on AR in the non-medical natural sciences and engineering (NSExm) in a whole country, Canada. 'Applied' disciplines are sometimes assumed to be the most commercializable, so we also separately investigate an especially 'basic' science, physics. Using a novel methodology, we estimate the lifetime impacts of companies spun-off directly from AR performed in 1960-1998, and compare the impacts with all government funding, direct and indirect, over the same period. This picks up virtually all funding and most company-formation since WWII, up to 1998. Such long-term studies are rare but essential, since we show that successful spin-offs grow (often exponentially) over several decades. With very conservative assumptions, and allowing for the time value of money, the impacts exceed government funding by a substantial margin.

Physics actually fares 30-60% better than the combined NSEm; this reflects more successful companies, rather than greater numbers, and therefore does not seem inconsistent with earlier studies on company numbers. Firm lifetimes are long, with Canadian impacts truncated primarily by some foreign acquisitions. We argue that the spin-off impacts represent incremental contributions to GDP, much larger (even on a time-discounted basis) than the government funding and directly attributable to it; governments will also receive more in additional tax than they spent. The impacts therefore provide a quantitative justification for the public investment, allowing the much more important (but less quantifiable) long-term benefits to be regarded as a 'free' bonus. The very good showing of physics also suggests that reduced emphasis on basic work or on the basic disciplines could actually weaken the commercialization of AR. (C) 2010 Elsevier B.V. All rights reserved.

Vohora, A., M. Wright and A. Lockett (2004). "Critical junctures in the development of university high-tech spinout companies." *Research Policy* **33**(1): 147-175.

This paper investigates the development of university spinout companies (USOs). Employing a case-based research method, our study found that there are two important elements in their development. First, USOs go through a number of distinct phases of activity in their development. Each venture must pass through the previous phase in order to progress to the next one but each phase involves an iterative, non-linear process of development in which there may be a need to revisit some of the earlier decisions and activities. Second, at the interstices between the different phases of development we found that ventures face "critical junctures" in terms of the resources and capabilities they need to acquire to progress to the next phase. The different phases are critical as these ventures cannot develop into the next phase without overcoming each of the junctures. We identify four different critical junctures that spinout companies need to overcome if they are to succeed: opportunity recognition, entrepreneurial commitment, credibility and sustainability. (C) 2003 Elsevier B.V. All rights reserved.

Wallmark, J. T. (1997). "Inventions and patents at universities: The case of Chalmers University of Technology." *Technovation* **17**(3): 127-139.

Demands for increased relevance of university research to society needs have stimulated interest in inventions at universities and raised questions about the proper balance between basic research and applied research at universities. Inventions from Chalmers University in the form of more than 400 patents, 1943-1994, are presented and the patent output is compared to that from other universities and from industry. The rate of inventing has increased sixfold in the period and is now showing a tendency to taper off at 15-20 new patents per year. The inventors are undergraduate students (8%), postgraduate students (33%), and professors (60%). The roles of professors and students are reversed with

regard to starting spin-off companies. About 50% of the university patents have been used for start-up of new spin-off companies and for supporting their growth, while the other 50% have gone to established non-spin-off industry. The most prestigious US universities have an output of patents per capita which is more than twice as high (MIT, CalTech). The patent intensity (output of patents in relation to R&D) in Swedish industry is comparable to that at Chalmers. The economic value of the patents has been estimated on the basis of employment (turnover) in the spin-off companies. A general idea of the economic impact of the patents may be obtained from the fact that direct spin-off manufacturing companies with products protected by patents have contributed about 10% as many new jobs (70 each year) as the output of graduates from the university (700 per year). For all spin-off companies together the figure is estimated to be about 50% (350 per year). The results constitute a good basis for the many different actions the university may take to support an increased output of inventions. At the same time they offer a convenient means of measuring the efficiency of these actions. (C) 1997 Elsevier Science Ltd.

Walter, A., M. Auer and T. Ritter (2006). "The impact of network capabilities and entrepreneurial orientation on university spin-off performance." Journal of Business Venturing **21**(4): 541-567.

Drawing on a database of 149 university spin-offs, we investigated the impact of network capability (NC), defined as a firm's ability to develop and utilize inter-organizational relationships, and entrepreneurial orientation (EO) on organizational performance. Not only do the results suggest that a spin-off's performance is positively influenced by its NC, but the findings also indicate that a spin-off's EO fosters competitive advantages. Although no direct relationship is apparent between EO and sales growth, sales per employee, or profit attainment, moderated hierarchical regression analyses reveal that NC strengthens the relationship between EO and spin-off performance. In sum, our research shows that a spin-off's organizational propensities and processes that enhance innovation, constructive risk taking, and proactiveness in dealing with competitors per se do not enhance growth and secure long-term survival. However, we found that NC moderates the relationship between EO and organizational performance. (c) 2005 Elsevier Inc. All rights reserved.

Wood, M. S. (2009). "Does One Size Fit All? The Multiple Organizational Forms Leading to Successful Academic Entrepreneurship." Entrepreneurship Theory and Practice **33**(4): 929-947.

This paper offers an integrative theory, through the use of transaction cost theory principles, that attempts to match the attributes of university-held innovations with the specific organizational form that best supports the identified attributes in innovation commercialization efforts. Two commonly utilized organizational forms are considered: the spin-off and the technology license

agreement. Additionally, innovation transfer is conceptualized as a transaction and each of the organizational forms is considered an alternate governance mechanism for the management of the commercialization transaction. It is further conceptualized that by minimizing transaction costs, through the proper selection of the organizational form, universities may increase the odds of successful revenue generation from their entrepreneurial efforts. The overall goal of the paper is to enhance our understanding of proper organizational form-innovation attribute alignment as a key driver of innovation commercialization success, so that universities and their industry partners can increase their effectiveness in commercialization activities.

Wright, M., S. Birley and S. Mosey (2004). "Entrepreneurship and university technology transfer." Journal of Technology Transfer **29**(3-4): 235-246.

This paper argues that it is important to devote greater attention to the study of entrepreneurship in technology transfer in the light of greater government attention, the growth in the phenomenon, the need to identify how wealth can be created from spin-outs, changes in the cultures of universities and differences with technological entrepreneurship in general. The paper summarizes the contributions made by the papers presented in the special issue in terms of their levels of analysis. At the spin-out level, issues are raised concerning identification of typologies of spin-out firms, the evolution of spin-outs and external resources. At the university level, issues concerning policies, internal resources and processes are discussed. An agenda for further research is elaborated which relates to the need to examine further levels of analysis: the academic entrepreneurs themselves and how they recognize opportunities and shape their ideas to meet the market; the nature of internal university environments, processes and resources; and the nature of the scientific discipline which may have implications for the process of creation and development of spin-out ventures. © 2004 Kluwer Academic Publishers.

Wright, M., B. Clarysse, A. Lockett and M. Knockaert (2008). "Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries." Research Policy **37**(8): 1205-1223.

We analyze how mid-range universities can contribute to industrial change through the transfer of tacit and codified knowledge in the areas of spin-offs; licensing and patents; contract research, consultancy and reach-out; and graduate and researcher mobility. We use archival, survey and interview data relating to mid-range universities in mid-range environments in the UK, Belgium, Germany and Sweden. Our findings suggest that mid-range universities primarily need to focus on generating world-class research and critical mass in areas of expertise, as well as developing different types of intermediaries. Mid-range universities may need to develop a portfolio of university-industry linkages in terms of the scope of activities and the types of firms with which they interact.

We also show that different intermediaries have important roles to play in developing university-industry linkages for mid-range universities.

Wright, M., A. Lockett, B. Clarysse and M. Binks (2006). "University spin-out companies and venture capital." Research Policy **35**(4): 481-501.

The creation of university spin-out companies that create wealth is a major policy objective of governments and universities. Finance is a catalyst of this wealth creation yet access to venture capital is a major impediment faced by these companies. In this article we adopt a finance pecking order perspective to examine the problems faced by those university spin-out companies seeking to access venture capital. We triangulate evidence from spin-out companies, university technology transfer offices and venture capital firms in the UK and Continental Europe to identify the problems and to suggest policy developments for these parties as well as government. We compare perceptions of high-tech venture capital firms that invest in spin-outs with those that do not, and also consider VCs' views on spin-outs versus other high-tech firms. Our evidence identifies a mismatch between the demand and supply side of the market. In line with the pecking order theory, venture capitalists prefer to invest after the seed stage. However, in contrast to the pecking order theory, TTOs see venture capital as more important than internal funds early on. We develop policy implications for universities, technology transfer offices, academic entrepreneurs, venture capital firms and government and suggest areas for further research. (c) 2006 Published by Elsevier B.V.

Wright, M., A. Vohora and A. Lockett (2004). "The formation of high-tech university spinouts: The role of joint ventures and venture capital investors." Journal of Technology Transfer **29**(3-4): 287-310.

We explore the joint venture route to commercializing university owned intellectual property. We present comparisons between two spinouts formed as joint ventures between universities and industrial partners and two spinouts where this was not the case. The research employs a resource-based framework, with new high tech spinout firms (or firms in gestation) facing severe resource and capability constraints. We show that spinouts typically lack the financial means and managerial expertise to acquire the resources and develop the capabilities they need in order to fully exploit the commercial potential of their technologies. We argue that creating a spinout company as a joint venture with an industrial partner, may be a means of overcoming some of the potential problems associated with managing resource weaknesses and inadequate capabilities that may be difficult to achieve as a free-standing spin-out company with or without venture capital backing. © 2004 Kluwer Academic Publishers.

Xie, W. and S. White (2004). "Sequential learning in a Chinese spin-off: the case of Lenovo Group Limited." R&D Management **34**(4): 407-422.

This paper analyzes the learning process and sequential capabilities development in Lenovo, China's most successful PC manufacturer, which originated as a spin-off from a government-supported research institute. The case study reveals this firm's evolutionary, path-dependent and stage-wise progress from initial sales, distribution and service activities to manufacturing, product and process design and, finally developmental R&D. The study shows the interaction among the firm's changing environment, its competitive strategy, and its set of resources and capabilities. The case has implications for research on such organizations, as well as implications for management.

Zahra, S. A., E. Van de Velde and B. Larraneta (2007). "Knowledge conversion capability and the performance of corporate and university spin-offs." Industrial and Corporate Change **16**(4): 569-608.

Corporate and university spin-offs are often created to commercialize new technologies. Yet, it is not clear how these spin-offs transform their inventions into new products, goods and services that create value. In this article, we use the knowledge-based theory to argue that this transformation requires a "knowledge conversion capability" (KCC) that has three components: conceptualization and visioning of applications of that knowledge; configuration and design of potential products and other applications; and the embodiment and integration of knowledge into products. Using data from 91 corporate and 78 university spin-offs, we find that these two sets of firms differ in their emphasis on the three KCC components, benefit differentially from these three components in terms of their performance, and vary significantly in their performance.

Zhang, J. F. (2009). "The performance of university spin-offs: an exploratory analysis using venture capital data." Journal of Technology Transfer **34**(3): 255-285.

University spin-offs are defined as firms founded by university employees. Using a large database on venture-backed start-up companies, I describe the characteristics of university spin-offs and investigate whether they perform differently than other firms. I find that venture-backed university spin-offs are concentrated in the biotechnology and information technology industries. Moreover, a spin-off tends to stay close to the university, suggesting that technology transfer through spin-offs is largely a local phenomenon. Multivariate regression analyses show that university spin-offs have a higher survival rate but are not significantly different from other start-ups in terms of the amount of venture capital raised, the probability of completing an initial public offering (IPO), the probability of making a profit, or the size of employment.

Zomer, A. H., B. W. A. Jongbloed and J. Enders (2010). "Do Spin-Offs Make the Academics' Heads Spin?" *Minerva* **48**(3): 331-353.

As public research organisations are increasingly driven by their national and regional governments to engage in knowledge transfer, they have started to support the creation of companies. These research based spin-off companies (RBSOs) often keep contacts with the research institutes they originate from. In this paper we present the results of a study of four research institutes within two universities and two non-university public research organisations (PROs) in the Netherlands. We show that research organisations have distinct motivations to support the creation of spin-off companies. In terms of resources RBSOs contribute, mostly in a modest way, to research activities by providing information, equipment and monetary resources. In particular, RBSOs are helpful for researchers competing for research grants that demand participation of industry. Furthermore, RBSOs may be seen as a proactive response by Dutch public research organisations to demands of economic relevance from their institutional environment. RBSOs enhance the prestige of their parent organisations and create legitimacy for public funds invested in PROs. At the same time, most RBSOs do not have a significant impact on the direction of the research conducted at the PROs.