Industrial and Corporate Change, Volume 16, Number 4, pp. 691–791
doi:10.1093/icc/dtm023
Advance Access published July 18, 2007

University entrepreneurship: a taxonomy of the literature

Frank T. Rothaermel, Shanti D. Agung and Lin Jiang

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.

1. Introduction

Universities in developed countries have become increasingly entrepreneurial (Mowery *et al.*, 2004; Siegel, 2006a). In the United States, several factors have facilitated what Chesbrough (2003) terms the shift from a "closed innovation system" to an "open innovation system." These factors include, among others, the rise in venture capital, the passage of the Bayh-Dole Act (providing incentives for universities to patent scientific breakthroughs accomplished with federal funding), the rise in the pool and thus mobility of scientists and engineers, and important technological breakthroughs in computing (microprocessor), biotechnology (genetic engineering), and, more recently, nanotechnology. As a result, since the early 1980s, US universities have greatly increased their entrepreneurial activities along many dimensions: patenting and licensing, creating incubators, science parks, and university spin-outs, and investing equity in start-ups, among other indicators (Mowery *et al.*, 2004; Siegel, 2006a).

A concomitant rise in university entrepreneurship can also be observed in Europe. The European Commission, the executive body of the European Union,

has launched several direct initiatives in an effort to proactively enhance the transfer of university technology to industry (EIMS, 1995). European universities, particularly some in Germany, Italy, Sweden, and the United Kingdom, are rich sources of technology; however, largely due to differing legal systems, these universities lag behind in their efficiency of technology transfer compared to their US counterparts. The structural shifts in the orientation of US universities, the European executive branch, and to some extent European universities, all pave the way for the inclusion of an economic development mandate for universities in addition to their traditional missions of education and research. As a result, these significant developments have attracted, not unexpectedly, the increasing attention of researchers both in the United States and in Europe.

While scholars have become quite active in the now vibrant field of university entrepreneurship, the academic literature remains rather fragmented.[1] Because the growing literature on university entrepreneurship has not yet been reviewed in a systematic and comprehensive fashion, it is difficult to assess what is known to date; consequently, scholars have little guidance on how to fruitfully focus their attention in the future. This gap calls for a detailed review and in-depth analysis of the existing literature, in order to better understand the current state of the field and to provide some guidance for future research.

This article presents a detailed analysis and synthesis of the stream of research on university entrepreneurship, now encompassing 173 academic articles published worldwide in a number of refereed scholarly journals between 1981 and 2005.[2] We purposefully define university entrepreneurship broadly, in order to include any published research pertaining to entrepreneurial activities in which a university could be involved, including, but not limited to: patenting, licensing, creating new firms, facilitating technology transfer through incubators and science parks, and facilitating regional economic development.

We attempt to make the following contributions: first, we conduct an unusually comprehensive review of the burgeoning literature in the field of university entrepreneurship. The assessment and synthesis should make this field of research more accessible to scholars, contributing to its diffusion among the scientific community. Second, we provide a detailed assessment of the state of the field. Third, we derive a conceptual framework containing four major research streams that have emerged over the last decade: (i) entrepreneurial research university, (ii) productivity of technology transfer offices (TTOs), (iii) new firm creation,

[1]For notable exceptions focusing on university-based technology transfer see Phan and Siegel (2006), Siegel (2006b) and Siegel and Phan (2005).

[2]To be included in the analysis, the research must have appeared in a refereed scholarly journal by December 31, 2005.

and (iv) environmental context including networks of innovation. Finally, we provide some directions for future research through which we hope to increase the number of scholars who will participate in the growing research on university entrepreneurship. The rich avenues for future research that we highlight are a result of the framework we derive from synthesizing the four major research streams identified.

2. Methodology

To develop a comprehensive overview and framework of the research patterns on university entrepreneurship over time, we applied a three stage exploration process. For initial access to the literature, we began by studying a recently edited volume on university entrepreneurship (Siegel, 2006a). By collecting some of the more influential papers in the field previously published in a diverse set of academic journals, Siegel's volume provides an immediate and accessible entry into the literature on university entrepreneurship. Next, we identified and studied all special issues published on topics related to university entrepreneurship. The search yielded 11 special issues, which we detail chronologically in Table 1.

We then attempted to sketch the development of the field over time by tracking all relevant articles referred to by any of the articles analyzed in stage one. To avoid a reference bias, we used comprehensive electronic reference retrieval services like Proquest's ABI/Inform, Business Source Premier, and EconLit to run keyword queries to identify all scholarly articles published in refereed journals pertaining to the broadly defined topic on entrepreneurial activity at universities.[3] We ended our literature search when we reached saturation: all references we encountered led back to articles already included in our database.[4] Clearly, electronic reference retrieval databases have certain shortcomings (e.g., only journals that are published in English are included), but we submit that these did not create a material bias in our analysis.

[3]Keyword combinations or variations thereof include, but are not limited to, "university" and "entrepreneur," "academia" or "academic" and "entrepreneur," "technology transfer," "technology transfer office," "technology licensing" and "university," "spin-off" or "spin-out" and "university," "science park" and "incubator," "incubator" and "university," and so on.

[4]As a robustness check, we relaxed the constraint of the keyword search for a subset of journals (e.g., *Administrative Science Quarterly, American Economic Review, IEEE Transactions on Engineering Management, Journal of Business Venturing, Journal of Technology Transfer, Management Science, Research Policy*, and *Review of Economics and Statistics*) and used very broad queries (only "university" or "universities"). Any additional articles identified did not materially influence the model induced from the literature synthesis.

Table 1 Special issues included in the literature analysis

Special Issue Title	Editor(s)	Journal
Organizational Issues in University-Industry Technology Transfer	Donald S. Siegel, Jerry G. Thursby, Marie C. Thursby, and Arvids A. Ziedonis	*Journal of Technology Transfer*, 2001:26 (1–2)
University Entrepreneurship and Technology Transfer	David C. Mowery and Scott Shane	*Management Science*, 2002:48 (1)
Economics of Intellectual Property Protection at Universities	Albert N. Link, John T. Scott and Donald S. Siegel	*International Journal of Industrial Organization*, 2003:21 (9)
Economic and Managerial Implications of University Technology Transfer	Donald S. Siegel and Bruno van Pottelsberghe de la Potterie	*Journal of Technology Transfer*, 2003:28 (1)
Technology Entrepreneurship	Scott Shane	*Research Policy*, 2003:32 (2)
Techno-Entrepreneurship	Phillip H. Phan and Maw Der Foo	*Journal of Business Venturing*, 2004:19 (1)
Entrepreneurship and University Technology Transfer	Mike Wright, Sue Birley, and Simon Mosey	*Journal of Business Venturing*, 2004:29 (3–4)
Science Parks and Incubators	Phillip H. Phan, Donald S. Siegel, and Mike Wright	*Journal of Business Venturing*, 2005:20 (2)
Essays in Honor of Edwin Mansfield	F. Michael Scherer and Albert N. Link	*Journal of Technology Transfer*, 2005:30 (1–2)
University-based Technology Initiatives	Albert N. Link and Donald S. Siegel	*Research Policy*, 2005:34 (3)
The Creation of Spin-off Firms at Public Research Institutions: Managerial and Policy Implications	Andy Lockett, Donald S. Siegel, Mike Wright, and Michael D. Ensley	*Research Policy*, 2005:34 (7)

In a final step, we read and analyzed each article to create a detailed database in which we coded the following data: (i) author name(s), (ii) article title, (iii) year published, (iv) journal of publication, (v) whether published in a special issue related to university entrepreneurship or in a regular journal issue, (vi) research question(s), (vii) data used, (viii) dependent variable(s), (ix) independent variables, (x) research methods, and (xi) findings. The resulting data revealed the patterns that we discuss in Section 3 subsequently.

With a fresh comprehensive perspective on the field of university entrepreneurship, we then revisited all articles in an attempt to answer our initial questions: how has the field developed over time, what patterns can be recognized, and what might the future hold? This discussion takes place in Section 4.

3. Results

Our extensive search efforts reveal that a total of 173 articles, focusing on some aspect of university entrepreneurship, have been published in various academic journals between 1981 and 2005. The US Bayh-Dole Act of 1980 and its European counterparts, which encouraged universities to patent inventions funded by federal agencies, marked the beginning of notably greater technology transfer from universities to industries and led to a corresponding rise in the growth of the scholarly literature on university entrepreneurship, especially in the United States and the United Kingdom. Despite the 25-year time span, the vast majority of articles were published in more recent years. Indeed, a structural break appears in the trend data after the research output on university entrepreneurship takes off considerably in the late 1990s. The increasing volume of studies on this topic corresponds with the increasing levels of entrepreneurship in universities around the world. In addition to institutional changes discussed earlier, a technology pull and a technology push can further explain this phenomenon. The increase in university entrepreneurship can be attributed in part due to industry's growing demand for technological innovation in recent decades. Here, universities are recognized as one of the key sources for innovation (Von Hippel, 1988),[5] especially in the context of innovations such as biotechnology (Zucker *et al.*, 1998) or nanotechnology (Darby and Zucker, 2006). Conversely, a technology push is also in effect as universities more proactively transfer technologies to industry, in part owing to reduced public funding for research (Thursby and Thurysby, 2002).

The exponential increase in the number of research articles published since 2000 is a direct result of several special issues devoted to university entrepreneurship. In the 6-year time period between 2000 and 2005, a total of 127 articles were published, of which 50 (39%) were published in one of the 11 recently edited special issues listed in Table 1. Our analysis shows that the take-off in the late 1990s accompanied the appearance of the first special issue focusing on university entrepreneurship (*Journal of Technology Transfer*, 2001).

[5]Works referenced, but not included in the literature analysis are identified with an asterisk (*) in the reference section.

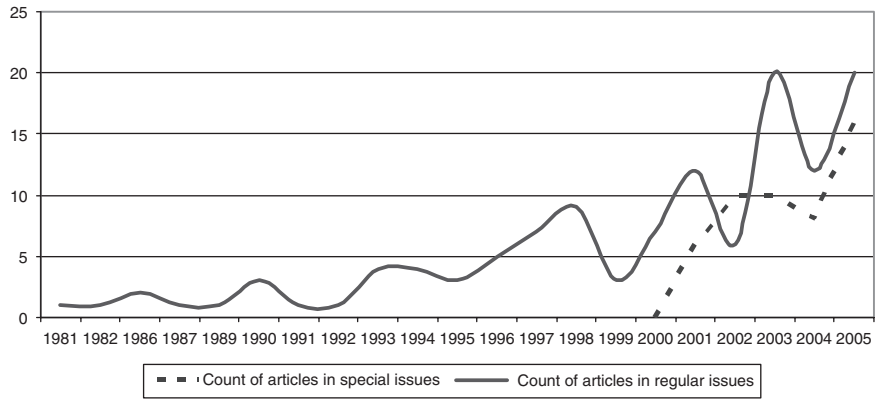

Figure 1 University entrepreneurship articles published per year in regular issues versus special issues, 1981–2005.

The editors listed in Table 1 deserve acknowledgment for undertaking an important trail-blazing activity. Their pioneering efforts have enabled research on university entrepreneurship to take off in the last decade, and to become a rapidly increasing and vibrant area for research spanning multiple disciplines. A cursory look at the social science citation index (SSCI) indicates that research on university entrepreneurship appears to be moving at a faster rate in terms of citations garnered from mainstream journals than strategy research and other entrepreneurship research have historically, controlling for the stage of the development.

Where is all this research published? Is it published predominantly in special issues or does it find its way into regular issues? Is it concentrated in a few journals or is it spread across a wide range of different journals? Does it appear in mainstream journals or more in specialty journals, and are they the most respected journals in each discipline? Figure 1 depicts the overall contribution of special issues to the rise of publications in this research stream, while Figure 2 depicts the number of articles published in regular and special issues of all the scholarly journals included in the study.

The 173 articles were published in a total of 28 academic journals. The distribution among the journals is, however, quite skewed. Taking at least five papers published as a cut-off point, we are left with only eight journals. This group constitutes 30% of the journal population but published 82% of all output (142 articles). Among the top eight publishing journals, five of them published at least one special issue. Taking at least 10 papers published as a cut-off point, we are left with five journals, and the distribution becomes even more skewed. These five journals make up only 19% of the journal population but published 73% of all articles (126). *Research Policy* published the most articles (47 or 27%)

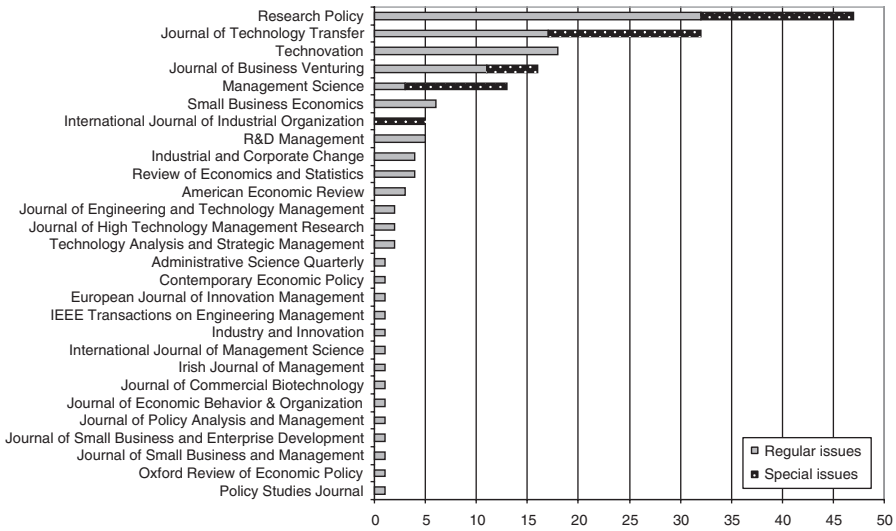

Figure 2 University entrepreneurship articles published per academic journal, 1981–2005.

followed by the *Journal of Technology Transfer* (32 articles or 18%), *Technovation* (18 articles or 10%), the *Journal of Business Venturing* (16 articles or 9%) in fourth place, and *Management Science* (13 articles or 8%) coming in fifth.

It is noteworthy, however, that the top-publishing journals vary significantly in their ratio of special issues to total number of publications. For example, none of the contributions in *Technovation* were published in a special issue. In contrast, all of the contributions in the *International Journal of Industrial Organization* were published in the November 2003 Special Issue on *Economics of Intellectual Property at Universities*. The other ratios of special issue articles to total number of articles in a journal are: 77% for *Management Science*, 47% for the *Journal of Technology Transfer*, 32% for *Research Policy*, and 31% for the *Journal of Business Venturing*.

All of the top-publishing journals, with the exception of *Management Science*, can be considered specialty or niche journals to some extent. While clearly reputable scholarly outlets, they are generally not considered premier journals at the leading research universities.[6] *Management Science*'s inclusion as a top-publishing journal

[6]Perceptions of journal prestige may differ from actual impact factors. In particular, this affects one journal listed in Figure 3, the *Journal of Business Venturing (JBV)*. While most leading business schools do not accept the *JBV* as a premier publication, it is ranked 9th in the 2005 journal ranking of the SSCI (see ISI's Web of Science) in the category "business." *JBV's* impact factor, which is defined as the average number of times articles from the journal published in the past 2 years have been cited in 2005, is 1.846. This impact factor, for example, is merely 0.051 less than that of the number 8th ranked journal (*Strategic Management Journal*), and only 0.354 less than that of the

must also be qualified by the fact that it is driven by the special issue on *University Entrepreneurship and Technology Transfer* published in January 2002. Notable here is the absence of leading discipline journals in economics, sociology, psychology, and political science, as well as leading journals in engineering, management, organization theory, and strategy.[7]

Close examination of both Figures 1 and 2 reveals that while there has clearly been an explosion of research output in recent years, most of this research has appeared outside of general management journals, thus limiting the impact of this scholarship as well as its impact on managerial practice. As a case in point, none of the publications included in this analysis have appeared in the leading management journal (*Academy of Management Journal*) or the leading strategy journal (*Strategic Management Journal*).[8]

Several reasons can be advanced to explain this finding. Applying a life-cycle model to the development of academic areas of inquiry, the field of university entrepreneurship is currently in the embryonic development stage. Prior to the passage of the Bayh-Dole Act in 1980, the phenomenon was basically non-existent. Moreover, it was not until the late 1990s that the research really took off (Figure 1). That the majority of articles on university entrepreneurship have been published in specialty or niche journals can be expected given the nascent nature of university entrepreneurship.

Kuhn's (1962) framework of how new scientific fields of inquiry emerge also complements this observation. New research areas first appear on the fringes of existing paradigms, as reflected in the type of outlets chosen for this research. It is only after the gatekeepers of the mainstream journals are convinced of the validity of a new field of inquiry, or are replaced by new gatekeepers, that this type of research will appear in more prestigious journals. In fact, more often than not, a new research field will spawn a set of new journals to create outlets for the newly emerging scholarly research, and these in turn eventually move up in the prestige ranking of journals.

For example, early notions of strategy date back to the work discussed in monographs by Penrose (1959), Chandler (1962), and Ansoff (1965), among other strategy pioneers. Yet it was not until the 1980 founding of the *Strategic*

number 6th ranked journal (*Academy of Management Journal*), both of which are generally considered premier publication outlets in leading business schools.

[7]Exceptions are each one article published in the *American Economic Review* (Jensen and Thursby, 2001), the *IEEE Transactions on Engineering Management* (Del Campo *et al.*, 1999), and the *Administrative Science Quarterly* (Louis *et al.*, 1989).

[8]In 2006, Agrawal published an article related to university entrepreneurship in the *Strategic Management Journal*. Since our analysis ends by necessity by December 31, 2005, we did not include the Agrawal (2006) article or any other article published in 2006 in our analysis.

Management Journal (SMJ) that academic research on strategy found its primary scholarly outlet. Subsequently, this journal transformed from a niche journal into a premier journal. The birth of the *SMJ* coincided with Porter's (1980) seminal monograph on competitive strategy, which provided an important paradigm for strategy research; in turn, the paradigm facilitated the pursuit of normal science (Kuhn, 1962), leading to an explosion of empirical research in strategy. Similarly, the *Journal of Business Venturing* was created as an outlet for entrepreneurship research, while the *Journal of Technology Transfer* was created especially as an outlet for research on technology transfer and innovation.

For these reasons, the general absence of university entrepreneurship research from the most prestigious journals may be explained by its embryonic stage in the life cycle of academic fields (Kuhn, 1962), where a 25-year history is considered a very short time when compared with, for example, the 50-year history of strategy or the more than 225-year history of economics. In addition, neither the broader field of entrepreneurship nor the more specialized area of university entrepreneurship possesses a dominant theoretical paradigm on which empirical research can coalesce. Indeed, these fields of inquiry have been described as being in a "chaotic pre-paradigmatic state of development" (Aldrich and Baker, 1997: 396).

Whether research on university entrepreneurship will appear more frequently in mainstream management journals in the future remains an open question. Clearly, research on entrepreneurship, in which university entrepreneurship is embedded, is a topic that is of interest to the most prestigious journals. For example, Evans and Jovanovic's (1989) article on entrepreneurial choice has appeared in the *Journal of Political Economy*, while Lerner's (1995) article on venture capitalists and private firms has appeared in the *Journal of Finance*. Not only has this entrepreneurship research been published in some of the field's most selective journals, it has also been highly cited, indicative of a high impact. In regard to the leading management journal, the *Academy of Management Journal (AMJ)* published Sapienza and Gupta's (1994) article on the impact of agency risk and task uncertainty on the interaction between venture capitalist and new venture CEO. In addition, *AMJ* also published Sapienza and Korsgaard's (1996) article on the influence of entrepreneur's management of information flows on entrepreneur-investor relations. Recently, *AMJ* published a "From the Editors" forum (Ireland *et al.*, 2005), in which they document the fact that *AMJ* has been publishing a significant number of articles pertaining to entrepreneurship, especially since the mid-1990s. Yet by the same token, progress in entrepreneurship research has been limited, as documented by Busenitz *et al.* (2003: 237), who recently concluded that "no powerful unifying paradigm exists, nor do multiple coherent points of view. Entrepreneurship studies tend to be less sophisticated in sampling frames, hypotheses development, statistical analysis, and dynamic longitudinal analysis than are organizational studies in more established disciplines."

It is important to note that research on university entrepreneurship is, while an important and clearly relevant topic, a specialty within the broader entrepreneurship research community. Hence, current research on university entrepreneurship has addressed issues primarily from the perspectives of a small group of stakeholders, i.e., university administrators, university faculty, and the firms that source university technology. Moreover, the research topics have been somewhat technical in nature, since they frequently involve legal (e.g., intellectual property) issues. For these reasons, university entrepreneurship has to date been more the domain of public policy researchers rather than management scholars. It is only fairly recently that the phenomenon of university entrepreneurship has gained attraction among more traditional entrepreneurship and strategy researchers.

Another possible explanation for why research on university entrepreneurship has not appeared in mainstream management journals is that these journals tend to emphasize theory building and theory testing, while most studies on university entrepreneurship tend to be more qualitative in nature, and thus offer less on the "how" and "why" aspects of a theory (exceptions e.g., Bercovitz *et al.*, 2001; Nicolaou and Birley 2003a; Murray, 2004; Vohora *et al.*, 2004). Moreover, it is not entirely clear as to whether management theories can be easily exported and retrofitted to study the domain of university entrepreneurship. Finally, the lack of availability of systematic, longitudinal data that is needed to produce studies that are considered for premier journals poses another roadblock; for example, in the United States there exists no equivalent to Compustat data for entrepreneurship research. These type of data, however, are available in several European countries, such as the United Kingdom and Sweden.

The next question that we approached was: who published the existing articles? To answer this question, we focused on a simple count of the number of articles authored or co-authored by each participating scholar. We are well aware that several methods to adjust these simple counts are possible: by citations, by article length, by journal quality, by the number of co-authors (on average there are 1.34 authors per article), etc. We decided against employing a performance metric adjusted by citations received due to the recent vintage of the articles; since the median publication date was 2003, employing this metric would have been premature. In addition, adjusting paper counts by the length of journal space devoted to each article would require normalization along several dimensions, including the quality of the journal and the length of the average article published. This undertaking would have been complicated not only because the 173 articles were published in a total 28 different academic journals, but also because of significantly different publication norms across the several academic disciplines represented in this research. In addition, one might need to make an adjustment for publications in special versus regular journal issues. While we are fully aware of the shortcomings of the metric employed herein, we rely on simple counts

as a first approximation of individual research productivity.[9] A total of 232 scholars participated in the publication of the 173 articles included, of which 65 (28%) each authored or co-authored a minimum of two articles. These leading scholars published 120 (69%) articles altogether. The distribution of published papers among the 65 leading authors is depicted in Figure 3.

We then turned to research methods. Given the field's early stage of development, in combination with the difficulty of obtaining fine-grained (dynamic) data to capture different phenomena of interest, it is no surprise that more than one-half of all studies (93 articles or 54%) relied on qualitative methods like case studies, while 39% (67 articles) relied on econometric analysis based on quantitative data. Comparing the entire period spanning university entrepreneurship literature (1981–2000 as early stage[10] and 2001–2005) to the pooled publication period of the *Strategic Management Journal* (1980–1985 as early stage and 2000–2005), we cannot reject a similarity between two fields: in their early stages both had more qualitative than quantitative studies, while the trend was reversed in more recent stages ($p = 0.14$). The relatively large number of qualitative studies can therefore be attributed to the field's early stage of development. This progression is one that appears to hold across different fields of study.

Given the fairly early developmental stage of university entrepreneurship research, one may have expected an even greater percentage of qualitative studies due to the fact that theory development, either inductive or deductive, generally precedes empirical testing and validation in a new field of inquiry. The relatively high percentage of quantitative studies in recent years may be explained because scholars rely on theories and frameworks drawn from neighboring disciplines like economics, sociology, or management, which allow for deductively derived hypotheses to be tested, thus circumventing the need for developing new theory specifically for the realm of university entrepreneurship. This in turn lowers the entry barrier into the field for scholars trained in the more traditional disciplines. The availability of quantitative data such as the now popular survey of the Association of University Technology Managers (AUTM), patent data form the US Patent and Trademark Office (USPTO), or data from the European Patent Office (EPO) may further explain the relatively large number of quantitative studies.

Please note that the first study using the AUTM survey data (Thursby *et al.*, 2001) did not appear, however, until 2001. Thus, the relatively high percentage of quantitative studies is a rather recent phenomenon, as the proportion of quantitative

[9]As the field of university entrepreneurship progresses, future research is invited to provide a more fine-grained analysis of productivity by and impact of individual scholars.

[10]We chose the year 2000 as a cut-off year, because there was a structural break in the number of studies published (Figure 1). Only 46 articles (27%) were published before 2000, while 127 (73%) were published between 2000 and 2005.

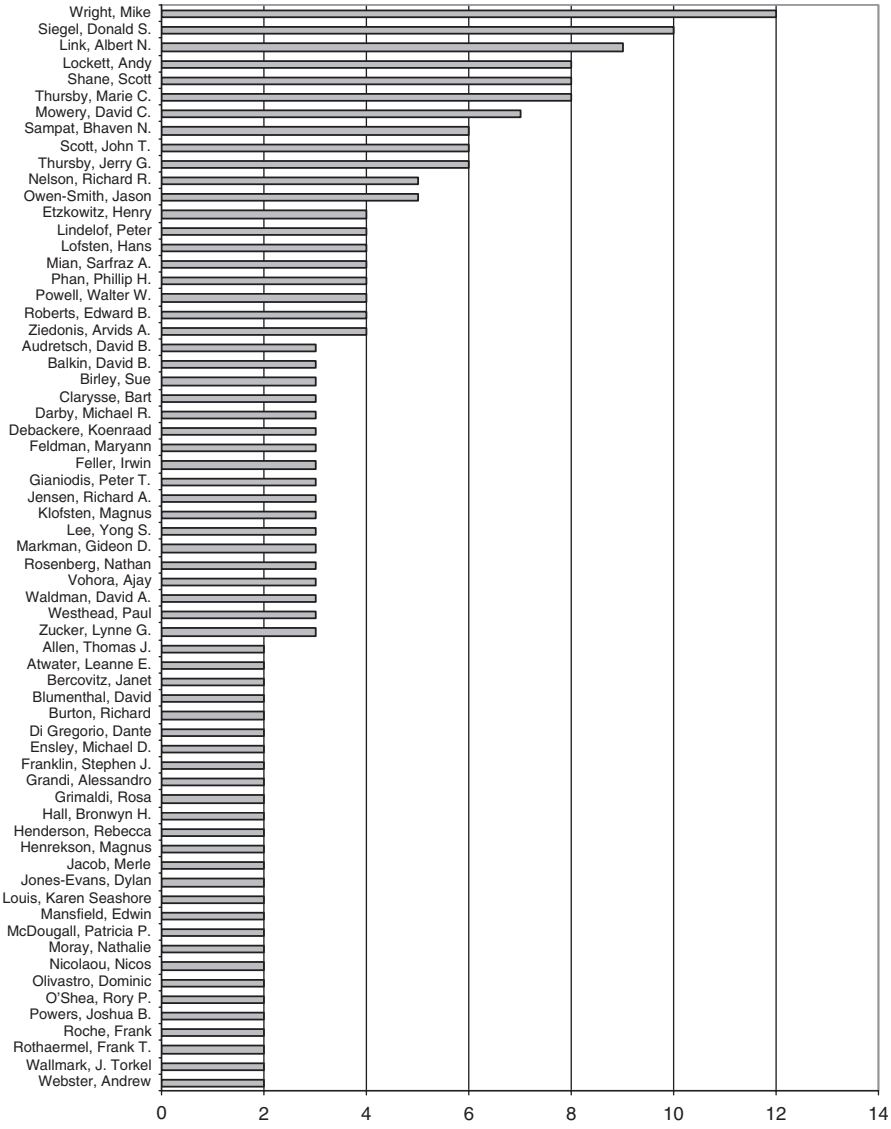

Figure 3 University entrepreneurship articles in academic journals ≥2 by authors, 1981–2005.

studies was lower prior to 2001 (only 17%). Indeed, a comparative *t*-test reveals that the number of quantitative studies was significantly larger ($p < 0.05$) from 2001–2005 than before 2000. This pattern may not be unfamiliar to scholars in other areas of study in the social science fields. For example, the field of corporate social responsibility was also characterized by a larger number of quantitative than

qualitative studies, despite the field's relative newness (Lockett *et al.*, 2006; McWilliams *et al.*, 2006).

As a field develops beyond the embryonic stage, researchers tend to shift from more qualitative studies to more quantitative ones, a pattern consistent with the one observed in mainstream management journals. A cursory inquiry into two major management journals also reveals an increase in the adoption of quantitative methods in fields in later stages of development, where the proportion of qualitative studies decreased correspondingly. During an early period of the *Strategic Management Journal* (1980–1985), for example, there were more qualitative (41%) than quantitative (22%) studies published (the remaining 37% were mainly studies without any data analysis, such as theoretical treatments and commentaries). During a more recent period (2000–2005), we see a significantly higher amount of quantitative (75%) studies than qualitative ones (11%). Similarly, in the publication span of the *Academy of Management Journal* over the last 25 years, the proportional difference between qualitative and quantitative studies widens over time. Between 1980 and 1985 in the *Academy of Management Journal*, 32% of qualitative studies versus 66% of quantitative studies were published. During a more recent period (2000–2005), we see many more quantitative (79%) than qualitative studies (12%). In the case of both journals, the differences are statistically significant ($p < 0.01$).

While we witness a significant increase in quantitative studies pertaining to entrepreneurial activities at research universities, we also note a recent increase in the number of qualitative studies. The increase can be explained by the fact that we do not limit the set of journals that we include in our analysis. The surge in both quantitative and qualitative studies correlates with the recent explosion of research output noted in the field overall (Figure 1).

Although the body of qualitative studies appears to grow slower in comparison to the number of quantitative studies, it does provide a contribution to the advancement of the field, as well as to the growing body of knowledge. For instance, the set of qualitative studies describes the drivers of entrepreneurial activities at the individual level (Owen-Smith and Powell, 2001) and at the university level (Mowery *et al.*, 2001; Laukkanen, 2003; Powers and McDougall 2005a), demonstrates how a traditional university transitions into a more entrepreneurial university (Etzkowitz, 2003; Jacob *et al.*, 2003), identifies the barriers in the university commercialization process (Argyres and Liebeskind, 1998; Collins and Wakoh, 2000; Henrekson and Rosenberg 2001; Feldman and Desrochers, 2003; Siegel *et al.*, 2003a), discusses factors that may facilitate the process, and attempts to identify ways to make universities more entrepreneurial (Henrekson and Rosenberg 2001; Saragossi and van Pottelsberghe de la Potterie, 2003; Siegel *et al.*, 2003a, 2004; Debackere and Veugelers, 2005). These qualitative studies also identify various commercialization options (Lee and Gaertner, 1994; Bains, 2005), explain why different stakeholders care about technology transfer from universities

to industries (Bell, 1993), discuss the consequences or effects of entrepreneurial activities at universities (Freier, 1986; Chrisman *et al.*, 1995; Wallmark, 1997; Etzkowitz, 1998; Powell and Owen-Smith, 1998), and speculate about the future of entrepreneurial universities (Grigg, 1994; Etzkowitz *et al.*, 2000).

Because most qualitative studies are guided by exploratory questions (e.g., how a phenomenon emerges, what factors are involved, etc.), they usually do not have dependent variables. On the other hand, those qualitative studies with dependent variables tend to have a strong deductive logic directing their interviews or case studies (Bercovitz *et al.*, 2001; Lockett *et al.*, 2003; Clarysse *et al.*, 2005). Bercovitz *et al.* (2001), for example, deduce their logic from organizational theory prior to testing the implications of TTO structure on its productivity.

Very few theory-only papers (4 or 2%) or literature reviews (9 or 5%) have been published. It is important to note that the few prior literature reviews focused on one specific topic like incubators or science parks (e.g., Siegel *et al.*, 2003c; Phan *et al.*, 2005), rather than providing a comprehensive synthesis of the literature on university entrepreneurship.

When focusing on the unit of analysis on which the research was based, we found that in most articles the unit of analysis was the university (87 articles or 50%). This result confirms our speculation that the major stakeholders of this research are policy makers and university administrators, who are concerned about the future of the research university. Questions at the forefront of their concerns include whether universities should become more entrepreneurial, engage more in applied research, and so on. At the university-level of analysis, the most commonly used data sources were direct surveys and interviews with university administrators, faculty, and technology transfer officers (31 studies or 36%), followed by patent databases (US PTO and EPO) (13 studies or 15%), and survey data from the AUTM (10 studies or 12%).

The next largest segment of studies used the firm-level as their unit of analysis (39 articles or 23%), followed by the individual-level of analysis (18 studies or 10%). The most prevalent data sources in firm-level studies were direct interviews with informants in the selected firms (11 studies or 28%). At the individual-level of analysis, interviews were also the most common source of information (five studies or 28%). Fewer studies focused on incubators/science parks (15 studies or 9%), TTOs (nine studies or 5%), or the region (five studies or 3%). While most studies have traditionally chosen the university or firm as their unit of analysis, the late 1990s showed a drastic rise in these studies, making the university or firm the preferred unit of analysis, marked by an increasing interest of firms in their relationships with universities, and vice verse.

What are the perspectives taken in theses articles? Are they US-centric or do they have more of an international focus? It is interesting to note that almost one half (77 studies or 45%) of all 173 articles included in this literature review

study university entrepreneurship outside of the United States. However, the international studies are set predominantly in European countries, mainly in the United Kingdom and Sweden; very few studies are based in Asian or Latin American countries. Non-US countries included in the internationally focused articles are, in order of frequency: United Kingdom (26), Sweden (14), Belgium (11), Italy (6), Netherlands (5), Canada (4), Germany (4), Ireland (4), Israel (4), Japan (4), France (3), Norway (3), Spain (3), Denmark (2), Finland (2), Portugal (2), Australia (1), China (1), Greece (1), Hungary (1), Korea (1), Latin American countries (1), and Switzerland (1).[11]

Finally, what are the common themes among the 173 articles? Based on our detailed content analysis, the following taxonomy of the literature, representing four research streams, emerged: (i) entrepreneurial research university (86 articles or 50%), (ii) new firm creation (42 articles or 24%), (iii) environmental context including networks of innovation (29 articles or 17%), and (iv) productivity of TTOs (16 articles or 9%). The rise in the overall number of articles published since the late 1990s (Figure 1) can mainly be attributed to the first two streams: entrepreneurial research university and new firm creation. Most of the researchers to date take a relatively macro view of the phenomenon, reflecting the prevalence of scholars trained in economics, sociology, and strategy. Researchers trained in more microdisciplines like psychology are likely to come aboard once individual-level datasets on research scientists, for example, are created and made available.

More insights emerge when we analyze the research methods employed in each literature stream. The results reveal significant variance in the chosen research methods among the four areas. Quantitative regression methods are most often used when studying the productivity of TTOs (63%), followed by studies on the entrepreneurial research university (38%), and environmental factors and networks of innovation (38%). On the other hand, the most commonly used methods to study new firm creation are qualitative, case-based methods (64%). The choice of methods appears to be not only a reflection of the underlying research questions, but also conditioned upon the availability of appropriate data. The challenge of obtaining fine-grained, preferably longitudinal data, therefore, appears to be greatest at the firm-level of analysis. As discussed previously, this lack of high-quality firm-level data constitutes a significant entry barrier into the premier management and strategy journals.

When applying the description, categorization, and theory development framework commonly observed in the evolution of research fields (Kuhn, 1962; Sutton and Staw, 1995; Christensen *et al.*, 2002), we find that 111 articles (64%) describe the phenomena, 14 articles (8%) offer some kind of categorization, and 48 articles (28%) theorize about underlying relationships. The large number of articles focusing on the

[11]Please note that some articles are studying university entrepreneurship in more than one country.

description of the university entrepreneurship phenomena is indicative of a highly fragmented field in the early stages of development. This is also echoed in the small number of categorization attempts, which can bring more focus to the research on university entrepreneurship.

We also assess what theoretical lenses, if any, are applied in these articles. Not surprisingly for an emerging field, we find that the vast majority of the articles (71% or 122 articles) are more or less atheoretical, focusing mainly on the description of the phenomena and/or testing casually observed relationships without invoking any discernible deductive logic. Most of the articles highlight specific knowledge characteristics (e.g., tacit versus explicit), and how different types of knowledge affect the technology transfer process. Of the 51 articles (30%) that use some kind of a theoretical lens, the most common lenses are derived from sociology (11 articles or 32%), using predominantly network theory, and from strategic management, applying the resource-based view of the firm (nine articles or 26%).

In summary, two important observations are noteworthy. First, the vast majority of research on university entrepreneurship is atheoretical, indicative of a field in the embryonic stage of development. Second, all articles published using some kind of dominant theoretical lens (34 articles or 20%) were published post-1998, with 32 of these articles (94%) published since 2001. This latter observation is heartening, as the field clearly appears to be moving toward more theory-driven research, a trend that is reflective of the field's increasing maturity.

4. Discussion

Research on university entrepreneurship is clearly burgeoning, yet it remains a fragmented field. Currently, no literature review exists that specifically focuses on university entrepreneurship and provides an overarching framework to encompass the different pieces making up university entrepreneurship (e.g., technology transfer, university licensing, science parks, incubators, university spin-offs, TTOs, etc.). The development of such a framework is a worthwhile exercise because a field cannot advance to a stage of theory building without an agreed-upon categorization scheme (Christensen *et al.*, 2002). This literature review and the resulting framework will also serve to make the field of university entrepreneurship more accessible to novices, which in turn should enhance its diffusion and impact. In addition, the framework presented herein acknowledges how each scholar's contribution is related to the overall contribution of the other scholars in the field, further enhancing the process of theory building.

The four research areas that emerged from a detailed analysis of the 173 articles [(i) entrepreneurial research university, (ii) productivity of TTOs, (iii) new firm creation, and (iv) environmental context including networks of innovation],

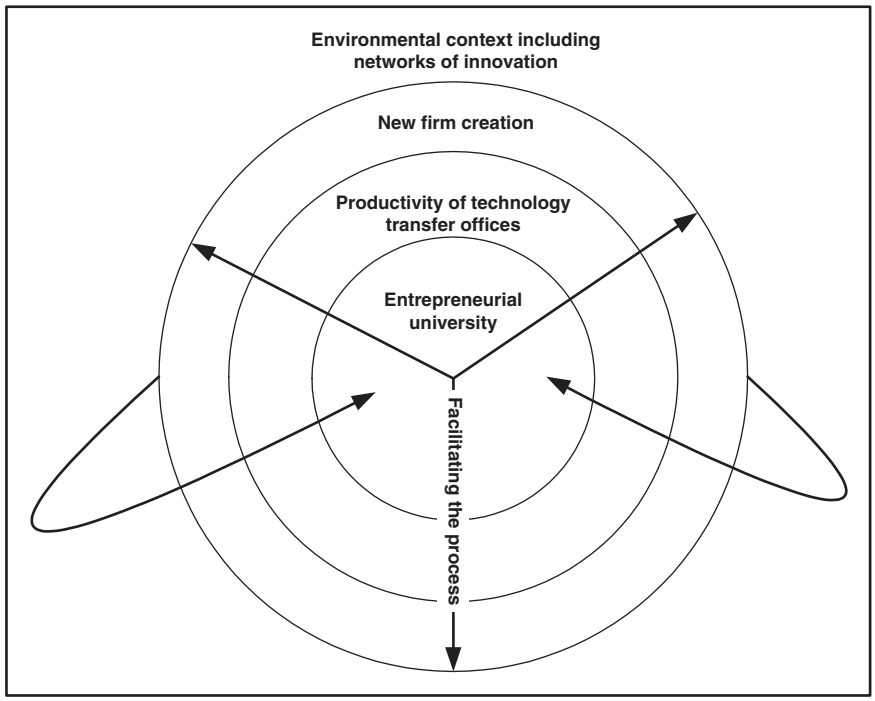

Figure 4 Conceptual framework of university entrepreneurship.

capture the major research streams on university entrepreneurship and the trends within each stream over the last two decades. More importantly, the integration and interaction of the four streams mirror the dynamic and evolutionary process of the university innovation system. The connections between the four interrelated and complementary streams are illustrated in the conceptual framework that emerged from this study, as depicted in Figure 4.

In the heart of the overall university innovation system lies the "entrepreneurial university" that generates technology advances and facilitates the technology diffusion process through intermediaries such as technology transfer offices and the creation of incubators or science parks that spawn new firms. Increasingly engaging in interactions with industry, the core of the university system expands to include activities outside the ivory tower with the goal of transforming inventions into innovations for the betterment of society and to enhance the university system's cash flow and capital endowments. This is the area where we have seen an increasing number of commercialization activities in (as well as a corresponding number of studies focusing on) licensing, new venture creations, and the like, mostly facilitated through TTOs and other network mechanisms (e.g., incubators and science parks). At the same time, universities are embedded

in a larger environmental context including networks of innovation. Feedback from the external environment, including policy decisions, continuously influences the way the universities participate in entrepreneurial activities. In recent years, policy and culture have also shifted to become more favorable toward university entrepreneurship. As the scope of an entrepreneurial university expands, the core of the system self-organizes in order to renew and transform its mission, and moves toward embracing an economic development mandate. In turn, interactions both within the university system itself and between the system and industry continue to renew the role of the university system, affect significant societal influences from academia to society, and vice versa, as captured by the feedback loops in Figure 4.

It is noteworthy that a few existing studies focus on the intersection of elements within our framework: between the university system and TTOs (Jones-Evans and Klofsten 1999; Bercovitz *et al.*, 2001; Siegel *et al.*, 2003b), between the university system and new firms (Di Gregorio and Shane, 2003; Lockett *et al.*, 2003; Lockett and Wright, 2005), between TTOs and new firms (Siegel *et al.*, 2003a, 2004; Leitch and Harrison, 2005), and between new firms and their external network (Nicolaou and Birley, 2003a,b; Johansson *et al.*, 2005; Rothaermel and Thursby, 2005a). Eliminating the barriers within innovation systems requires further studies of how to effectively facilitate the technology transfer process and what the key resources and capabilities that reduce these barriers are. For instance, conflicting opinions over the university system's mission have been consistently identified across the four streams as a key barrier to university entrepreneurship. This issue has not been studied in the necessary depth, such as exploring how universities should redesign their mandates to effectively manage technology transfer involving TTOs, new firm creations, and linkages with external innovation networks. We discuss each of the research streams that emerged in greater detail below, highlighting not only contrasting findings within each stream, but also avenues for future research.

4.1 Entrepreneurial university

The research stream on the entrepreneurial university views entrepreneurial activity as a step in the natural evolution of a university system that emphasizes economic development in addition to the more traditional mandates of education and research. Consequently, most of the articles in this research stream attempt to reveal organizational designs of universities that inhibit or enhance the commercialization of university inventions. Studies have revolved around incentive systems, university status, location, culture, intermediary agents, focus, experience, and defined role and identity. In addition to organizational design, other studies focus on the characteristics and roles of faculty and the nature of the technology

to be commercialized. Table 2 depicts the studies pertaining to the entrepreneurial university.[12]

While the above-mentioned factors comprise internal elements of an entrepreneurial university, scholars have also recognized that the process of university entrepreneurship is influenced by external factors (Etzkowitz, 2003), most notably federal laws and policies like the Bayh-Dole Act in the United States (Mowery *et al.*, 2001; Jacob *et al.*, 2003), the surrounding industry (Gulbrandsen and Smeby, 2005), and regional conditions (Friedman and Silberman, 2003).

In this stream, entrepreneurial activities are measured in various ways: existence of a formal program, cooperation agreements, research support, licensing, marketing activities, quality of commercial output (licenses, patents), involvement in research joint ventures, existence of incubators and science parks, etc. Figure 5 illustrates a conceptual overview of this research stream, with representative articles that focus on certain key aspects detailed in the boxes below the figure.

Overall, scholars in the entrepreneurial university research stream attempt to answer important questions, such as: why are some universities more entrepreneurial than others? (Harmon *et al.*, 1997; Henrekson and Rosenberg, 2001; Owen-Smith and Powell, 2001; Coupe, 2003; Etzkowitz, 2003; Friedman and Silberman, 2003; Jacob *et al.*, 2003; Siegel *et al.*, 2003a, 2004); what are the barriers to universities becoming more entrepreneurial? (Van Dierdonck *et al.*, 1990; Reitan, 1997; Argyres and Liebeskind, 1998; Collins and Wakoh, 2000; Henrekson and Rosenberg, 2001; Feldman and Desrochers, 2003; Schmiemann and Durvy, 2003; Siegel *et al.*, 2003a, 2004; Mowery and Sampat, 2005); how can universities be more successful in entrepreneurial activities? (Lee and Gaertner 1994; Friedman and Silberman, 2003; Owen-Smith and Powell, 2003; Saragossi and van Pottelsberghe de la Potterie, 2003; Thursby and Thursby 2004; Grandi and Grimaldi, 2005; Powers and McDougall, 2005a); and how do entrepreneurial universities relate to entities outside the ivory tower? (Segal, 1986; Van Dierdonck *et al.*, 1990; Bell, 1993; Mansfield, 1995; Narin *et al.*, 1997; Wallmark, 1997; Hall *et al.*, 2001; Mowery *et al.*, 2001; Cohen *et al.*, 2002; Shane, 2002b; Gulbrandsen and Smeby, 2005; Moray and Clarysse, 2005; Link and Scott, 2005b). There is no smooth path for any paradigm change (Kuhn, 1962); the shift of the university system from an ivory tower focusing on (basic) research and teaching into a collective entrepreneurial source of technology is no exception. The paradigm shift calls for facilitation from inside the system to accelerate technology diffusion (Etzkowitz and Klofsten, 2005). Not surprisingly, many scholars are attempting to resolve the conflicts that arise as universities become more entrepreneurial (Del Campo *et al.*, 1999; Jensen and Thursby, 2001; Debackere and Veugelers, 2005), joining the debates pertaining to the evolution of the traditional university mission (Feller, 1990; Grigg, 1994;

[12]While some articles span multiple themes, we categorized each article based on its dominant theme in one research stream only to avoid overlap and redundancy.

Table 2 Entrepreneurial university

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Agrawal and Henderson (2002)	To what extent do patents represent the magnitude, direction, and impact of the knowledge transfer from a university?	Interview with 68 professors	Publication behavior, stock of paper citations	Focus on patents, in isolation, may significantly misrepresent the nature of universities' impact on the economy. Patents alone do not describe the nature of knowledge creation and transfer.
Argyres and Liebeskind (1998)	What inhibits universities from adjusting their policy and organizational forms to commercialize the intellectual commons?	n/a	n/a	Social-contractual commitments and organizational standards can affect property rights. The barriers come from internal and external parties' adherence to university's historic commitment to the intellectual commons.
Audretsch and Lehmann (2005)	Are technical universities more successful in facilitating the spillover and commercialization of knowledge than other universities?	276 IPOs of high-tech firms in Germany and 73 public universities	Firm's growth	Firm performance is not influenced by the type of university. Technical universities do not have a differential impact on firm performance when compared to more general universities.
Bains (2005)	How can UK academics make money through commercialization options?	Interviews with senior academics and commercialization officers in several British universities; 95 UK biotech firms; biotech academia's salaries, and business success rates	n/a	Four commercialization options for academics: licensing their intellectual property, owning shares in a spin-out, personal consulting and writing books. Consulting is the economically most rewarding option.

Bell (1993)	What is technology transfer (TT), and why academia, industry, and governments may have an interest in technology transfer?	n/a	n/a	Academia has an interest in TT because of (i) contribution to the society, (ii) financial security and (iii) access to relevant industrial assets. Industries are interested to (a) maintain a comparative advantage in the core technologies, (b) access to complementary research, (c) save R&D time and cost,(d) build image of affiliation with academic partners.
Brouwer (2005)	What is the relative inventive performance of inside inventors in incumbent firms vs. outside inventors (e.g., in universities)? What are the effects of licensing modes for both outside and inside inventors?	n/a	n/a	Outside inventors (e.g., university inventors) have greater incentives to invent if they can fully appropriate the gains from invention. Outside inventors can accelerate technical progress as they prompt established firms to commercialize inventions. Outside inventors would prefer to license to an entrant firm when fixed fee licenses cannot be auctioned due to the immaturity of the invention.
Chrisman *et al*. (1995)	What are the extent and impact of entrepreneurial activities of the faculty of the University of Calgary?	Survey of 367 faculty; 29 personal interviews	n/a	Faculty entrepreneurship, which contributes to the advancement of technology and industrial diversification, has been increasing over time. Faculty of medicine created more ventures. Ventures created by faculty who remain at the university tend to be smaller.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Cohen *et al*. (2002)	What are the extent and nature of the contribution of public research (university and government research institutes) to industrial R&D?	1478 laboratories	Percentage of R&D projects using public research; suggestion of new R&D projects; contribution to R&D project completion	Firms' own manufacturing operations (e.g., buyers, suppliers) are more dominant sources of information compared to public research. Public research contributes to industries: (i) new R&D projects and (ii) completion of existing projects in equal measure. Large firms use public research more than small firms.
Collins and Wakoh (2000)	What are the barriers of the technology transfer in Japan?	n/a	n/a	Japan's barriers in university technology transfer are: (i) little experience managing the technology transfer processes, and (ii) lack of complementary and intermediary institutions that can facilitate transferring technologies.
Conceicao *et al*. (1998)	What are the main determinants of the successful policies for university intellectual property protection?	n/a	n/a	University policy on intellectual property should avoid excessive commercialization concerns that could threaten university's integrity.
Coupe (2003)	Does more money spent on academic research lead to more patents? Will universities get more patents per dollar spent on R&D once they established a technology transfer office (TTO)?	R&D expenditure data and patents	Number of university patents	More money spent on academic research leads to more university patents, with elasticities that are similar to those found for commercial firms. Bayh-Dole Act was not found to have a positive effect on patenting activities of universities. TTOs increased patenting output.

Debackere and Veugelers (2005)	How do technology transfer mechanisms evolve to contribute into an effective commercialization of academic science base?	Katholieke Universiteit Leuven R&D	n/a	Framework of governance structure that captures the formation of effective mechanisms: an appropriate organizational structure (e.g., unambiguous regulation of ownership titles and property rights, appropriate mix of incentive mechanisms targeted to the research group and individual researchers, decentralized management style, a matrix structure for the interface/liaison), process (e.g., a well-balanced process to manage and monitor contract research), and context (e.g., active management policy) within university.
Del Campo *et al*. (1999)	What is the lesson from the university's attempt to commercialize SQUID (superconducting quantum inference devices)?	n/a	n/a	Lessons: (i) failure of university to align intellectual property (IP) incentives are likely to weaken the potential for a strong IP position; (ii) Technology transfer office needs to take a business-like approach in identifying appropriate technology-transfer strategies.
Etzkowitz (1998)	What are the cognitive effects of the new university/industry linkages on the way scientists view research, interpret the scientific role, and interact with colleagues, companies and universities?	150 interviews and longitudinal case studies of University of Colorado and the State University of New York	n/a	The closing gap between research and capitalization of knowledge has encouraged scientist faculty to look at their research results from two perspectives: traditional and entrepreneurial. Three styles of participation in technology transfer have emerged: hands-off, knowledgeable participant, and seamless web.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Etzkowitz (2003)	How does a university transition from a research university into the entrepreneurial university?	Interviews at US universities, case studies of European and Latin American universities, and archival research	n/a	Academic entrepreneurship is endogenous since the internal organization of a research university consists of research groups that have firm-like qualities (when research funding is awarded on a competitive basis). It is also exogenous since university-based invention is part of the result of external influence.
Etzkowitz and Klofsten (2005)	How does a university undergo its second revolution into entrepreneurial university?	n/a	n/a	Research groups in the university share homologous qualities with a start-up firm. There is a parallel bi-directional evolution in a shift from an individual to a group focus. An entrepreneurial university can generate a focused strategic direction in both academic and economic development goals. It also follows an interactive model of innovation that incorporates linear and reverse linear modes.
Etzkowitz *et al*. (2000)	What is the future and evolving role of the university globally?	n/a	n/a	It is an entrepreneurial university with an academic structure and function that is based on an alignment of economic development with research and teaching as academic missions.

Feldman and Desrochers (2003)	How does historical context shape research universities' interaction with commercial activity?	John Hopkins University used for case study	n/a	John Hopkins university has not generated highly visible economic benefits for the local area because it was never one of the university's objectives. In addition, there was a general lack of incentives and encouragement for commercial activity.
Feller (1990)	What are the effects that changing university participation in equity arrangements to commercialize faculty research may have on the traditional roles of an university?	n/a	n/a	Commercialization efforts by universities have changed the determinants of universities' intellectual and political capital. Previously, those types of capital were determined solely by scientific and technical expertise. Currently, they are also driven by universities' role as engaged but monetarily disinterested participants in social discourse.
Freier (1986)	Can research institutes contribute to the development of science-based industry without any industrial expertise?	Weizmann Institute of Science used for case study	n/a	University and research institutes can become the center of science-based industries without altering their character, as shown by one university in Israel. This model was successfully copied by other institutions in Israel.
Friedman and Silberman (2003)	What are the characteristics of research universities that affect the number of invention disclosures? What are the university policies, incentives, regional and local characteristics that affect the technology transfer (TT) output?	AUTM, National Research Council, universities' published policy on distribution of royalty income	Invention disclosure, licenses executed, licenses generating income, cumulative active licenses, license income	Factors enhancing university TT: greater rewards for faculty involvement in TT, proximity to regions with concentration of high-tech firms, a clear mission in support of TT, and the experience of technology transfer office. The number of invention disclosures influences licensing agreements, while faculty quality affects the number of disclosures.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Geuna (1998)	What are the factors that influence university participation in R&D cooperative projects supported by the European Union (EU)?	Population of universities in EU countries (except Austria, Finland, Luxemburg, and Sweden), university characteristics, and their frequency in EU-funded R&D projects. International Association of Universities (1991, 1993), and the World of Learning (1995).	Whether a university participated in an EU-funded R&D project; number of times a university participated in EU-funded R&D projects.	The probability of taking part in an EU-funded R&D project depends primarily on the scientific research productivity of the respective university. Scientific research productivity, size of university, scientific fields, and differences among countries explain the frequency of university participation in EU-funded R&D projects.
Goldfarb and Henrekson (2003)	What are the national policies that are most efficient in promoting the commercialization of university-generated knowledge?	n/a	n/a	Top-down nature of Swedish policies of commercializing university inventions and Swedish academic environment discourage academics in actively participating in the commercialization of their inventions. US institutional setting, characterized by competition among universities for research funds and scientists, has led to a more active commercialization of faculty inventions.

Grandi and Grimaldi (2005)	What are the organizational factors of an university that affect the success of its start-ups ?	42 Italian university start-ups	Market attractiveness and articulation of business idea (BI)	(i) Attractiveness of BI is positively influenced by the market orientation of the academic founders as well as their frequency of interaction with external agents. (ii) Articulation of BI is positively affected by the role-articulation as well as prior joint experience of the academic founders.
Grigg (1994)	How do universities need to change given the new realities?	n/a	n/a	Universities need to be entrepreneurial organizations if they are to fulfill and sustain their role and purpose in society, which is to foster creativity and responsiveness to change in cultural and ethical as well as in scientific, technological and economics dimensions.
Gulbrandsen and Smeby (2005)	What does industry funding contribute to university faculty's research and entrepreneurial activities?	1967 tenured professors at four Norwegian universities	Publication output, commercial output (patents, commercial products, and new firms, consulting contracts)	There exists a significant relationship between industry funding and research performance: faculty with industry funding conduct more applied research, collaborate more with external researchers both in academia and in industry, and report more scientific publications and entrepreneurial results.
Hall *et al*. (2001)	Why is the percentage of universities as a research partner in RJV (research joint ventures) so low (only 15%)? What are the barriers?	38 Advanced Technology Program projects	Probability of insurmountable intellectual property (IP) barriers	IP issues between firms and universities do exist. The likelihood of IP issues increases when (i) the research is expected to lead to less appropriable results, (ii) the firm has had partnering experience with a university, and (iii) the duration of research is relatively short.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Hall *et al*. (2003)	What roles do universities play in research partnerships? What are the economic consequences associated with such roles?	352 Advanced Technology Program pre-commercial research projects	Probability of early termination, difficulty of acquiring basic knowledge, problems in the project, unproductive research time and cost, performance (new applications of technology developed, commercialized sooner than expected)	Projects with university involvement tend to be in areas involving new science and therefore experience more difficulty and delay, yet are more likely not to be aborted prematurely. Universities are contributing to basic research awareness and insights.
Harmon *et al*. (1997)	Does the technology transfer (TT) process depend on size and age of recipient (firm)?	19 companies who had acquired 23 different technologies	n/a	Identified five TT processes based on source of technology and nature of the transferee. Most successful transfers are based on strong prior connections between people in the laboratories and in the business communities.
Henderson *et al*. (1998)	Does the explosion of university patenting imply an increasing university contribution?	Patents assigned to universities in period 1965–mid 1992, and citations of those patents until the end of 1992.	Importance of patent (total citations received), generality of patent	The relative importance and generality of university patents has fallen at the same time as the sheer number of university patents has increased.

Henrekson and Rosenberg (2001)	What are the key institutional factors that are crucial determinants of science-based entrepreneurship?	National accounts, basic science and technology statistics, main economic indicators; science and engineering indicators	n/a	The authors point out the weaknesses of the Swedish incentive structure: low rate of return to human capital investment, low incentives to become an entrepreneur and to expand existing entrepreneurial ventures, and low incentives within the university system to become more entrepreneurial. It follows that to become a more entrepreneurial university, there need to be stronger individual incentives.
Hicks *et al*. (2001)	Is the national innovation system itself being reshaped during this time of transition? Can we see at least a hint of new US national system of innovation emerging?	CHI's Tech-Line® database, Social Citation Index	n/a	One of the changes underway is the enhanced entrepreneurial activity by universities. For instance, universities have played an important role in patenting (e.g., Harvard and MIT in Boston). There also has been intensifying of links between research and innovation (e.g., from higher citation rates of patents to scientific papers).
Jacob *et al*. (2003)	How does one Swedish University become an entrepreneurial university?	Chalmers University of Technology	n/a	Creating an entrepreneurial university requires changes in infrastructure and culture. Elements for Swedish innovation policy are macrolevel (policy vision and implementation) and microlevel (university organization) flexibility and diversity.
Jensen and Thursby (2001)	Does giving the right to a university to license its inventions increase the speed of commercialization?	62 TTOs of US universities	Managers responses to outcome about license revenue, license agreements executed, inventions commercialized, sponsored research, and patents awarded	Vast majority of inventions licensed are so embryonic that technology managers consider inventor cooperation in further development crucial for the commercialization process. To induce such cooperation from research faculty, they have to be provided with piece-rate incentive, e.g., royalty.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Kenney and Goe (2004)	What explains the difference of professorial entrepreneurship patterns?	Historical data on UC-Berkeley and Stanford and 179 mail surveys at both universities.	n/a	Being embedded in an academic department and disciplines in which cultures are supportive to entrepreneurial activity can help counteract the disincentives created by a university environment that is not strongly supportive of these activities.
Klofsten and Jones-Evans (2000)	What are the entrepreneurial activities of academics in two small European countries (Sweden and Ireland)?	1194 academics from four universities in Sweden, and 663 academics from five universities in Ireland	n/a	There is considerable entrepreneurial experience among academics in both Sweden and Ireland. There is a high degree of involvement in soft activities such as consultancy and contract research but not in new firm creation via technology spin-offs.
Laukkanen (2003)	What are the drivers and issues when a university pursues the third task (regional engine of innovation and economic growth)?	Interview with four faculty members	n/a	It is important for faculty to understand basic economic mechanisms and preconditions of business. Research suggests unintentional, but dysfunctional business attitudes of faculty.
Lee (1996)	What is the emerging role that US academics are expected to play in economic development? What roles they believe they can play in industrial innovations?	A national survey of approx. 1000 faculty	Faculty support for user-oriented applied research, faculty support for commercialization of university research	Most faculty support universities' active role in economic development. However, a majority of them refused the idea of a close business partnership with private industry. Two concerns regarding university technology transfer are raised: (i) the perception of declining federal R&D support, (ii) interference of university-industry cooperation with academic freedom.

Lee (2000)	What are the incentives for faculty members to collaborate with firms and for firms to collaborate with university faculty?	Two separate but similar surveys conducted in 1997, one for faculty members ($N = 427$) and another for industry technology managers in member firms of the Association for University Technology Managers ($N = 306$).	n/a	The most significant benefit realized by firms through collaboration is an increased access to new university research and discoveries, and the most significant benefits by faculty members is complementing their own academic research by securing funds for graduate students and lab equipment, and by seeking insights into their own research. A relatively small percentage of faculty members believe that such collaboration offers entrepreneurial opportunity for them.
Lee *et al*. (1994)	Does commercialization of academic invention have a place in a research university?	Iowa State University	n/a	The probability of commercializing academic research depends on the speed and the ability of the university to reduce its commercial risk. Commercialization of university invention is not a sequential process.
Link and Scott (2005)	Under what conditions will a research joint venture (RJV) involve a university as a research partner?	913 RJVs	Probability of university participation in an RJV	Larger RJVs are more likely to invite a university to join the venture as a research partner than smaller RJVs, because larger ventures are less likely to expect substantial additional appropriability problems because larger ventures have both a lower marginal cost and receive a higher marginal value from university R&D contribution to the venture's innovative output.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Louis *et al*. (1989)	What are the behavioral patterns of academic entrepreneurs?	997 scientists and key administrators in major research universities	Large-scale science, supplemental income, industrial support for university research, patenting, direct commercial involvement	Life scientists in research-intensive universities are modestly entrepreneurial. There is some evidence that they have become more interested in commercial activities. Individual-level variables are important in predicting large-scale science and supplemental income. Institutions cannot easily engineer entrepreneurship.
Louis *et al*. (2001)	Are there differences in entrepreneurial behavior between clinical and non-clinical faculty in the life sciences and industry relationships?	847 clinical and non-clinical life sciences faculty in 49 US universities.	Secrecy about own research, productivity in teaching and publishing, service	Non-clinical faculty are more likely to be involved in academic-industry relationships. Non-clinical faculty are more likely to be secretive about their research. Faculty involved in entrepreneurial behavior are more likely to be secretive about their research in general.
Lowe (1993)	Which mechanism will universities choose in exploiting their innovations: spin-off, licensing, collaboration, or consultancy?	203 respondents from British universities	n/a	Internal appropriability and external appropriability determine the overall opportunity of an innovation and assist in understanding university's optimum exploitation options. Both appropriabilities help universities to decide the appropriate exploitation mechanism.

Mansfield (1995)	What are characteristics of universities that have contributed the most towards technological changes in the economy?	66 firms and 321 scientists	Contribution to technological change (the number of citations to faculty's work)	The extent to which a university is credited by firms are related directly to the quality of university's faculty in the relevant department, to the R&D expenditures of the university, and the proportion of the industry's members located near by. For basic research, firms strive for best scientists regardless the location. For applied research, location does matter.
Mansfield (1998)	Does the finding of the contribution of academic research in Mansfield (1991) continue to hold?	77 major firms	n/a	The evidence for 1986–1994 confirms earlier results for 1975–1985. Compared to the previous findings, however, there is an increase in the percentage of new products and processes based on academic research and a decrease in the average time lag between academic research results and the first commercialization.
Markman *et al*. (2004)	Does the incentive system affect entrepreneurial activities at US universities?	Interviews with 128 TTO directors, AUTM licensing surveys	The number of equity licenses to new ventures, the number of university business incubators, the number of startup ventures that are based on university technology	Incentives to scientists and to their departments are negatively related to entrepreneurial activity. Pay to transfer technology offices' personnel is positively related to entrepreneurial activity.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Mok (2005)	How and what strategies do universities in Hong Kong have adopted to promote an entrepreneurial spirit and practices among academics? What is the role of the Government of the Hong Kong Special Administrative Region (HKSAR) in promoting entrepreneurship?	n/a	n/a	The HKSAR plays a coordinator and facilitator role to engage the university and industry in collaboration and fostering entrepreneurship. HKSTAR has promoted entrepreneurialism by extending its network system and involving non-governmental actors in entrepreneurial activities. The reductions of government financing in higher education coupled with revitalization and marketization processes in universities may enhance university entrepreneurial activities.
Moray and Clarysse (2005)	How do changes of technology transfer (TT) policies in the parent organization affect resource endowments of entrepreneurial firms?	Interviews, survey and secondary data from a public research organization in Belgium and its science-based entrepreneurial firms	n/a	Changes in TT policies and practices have an impact on entrepreneurial firms' resource endowments (financial, technology, and people) and performance (financial value and employment). Development of a successful incubator requires continuous organizational learning.

Morgan *et al*. (2001)	n/a	Patent applications, grant awards and commercialization outcomes from two 1995 National Science Foundation surveys	n/a	The paper defined and used some new indicators—patent activity rates, patent activity shares and patent success rates—to examine patent activity by faculty's employment sector, educational field, age, gender, status and location, technological area, and selected S&E job characteristics. A significant portion of university patent activities results in commercialized outputs. Study recommends that NSF collect survey data on patenting activity, including commercialization outcomes, of the S&E workforce at least every four years.
Mowery *et al*. (2001)	Is the Bayh-Dole Act the basic cause of the rise of university patenting and licensing, or have other factors influenced growth in these activities?	Patenting and licensing activities from University of California, Stanford University, and Columbia University	n/a	Bayh-Dole was only one of several important factors (e.g., federal financial support, shifted portfolio of university research) behind the rise of university patenting and licensing activity. The act appears to have had little effect on the content of academic research. Nevertheless, it hastened the entry into patenting and licensing by many universities.
Mowery and Sampat (2001b)	How did US university patent policies and university patenting evolve during the 'pre-Bayh-Dole' era?	US Patent and Trademark Office's (USPTO), DIALOG Corporation's Patents/ CLAIMS database, NBER database	n/a	The data show rapid growth of patenting by private universities during 1970s, the expansion of direct university involvement in patent management, and the steady growth of biomedical patents as a share of overall university patenting during the postwar period.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Mowery and Sampat (2005)	Can the model of US university-industry technology transfer be applied in other OECD countries?	n/a	n/a	Paper examines the effect of Bayh-Dole on university-industry collaboration and technology transfer in the United States, and concludes that efforts to emulate the Bayh-Dole in other OECD countries are likely to have modest success at best without greater attention to the underlying structural differences among the higher education systems of these nations.
Mowery *et al.* (2002)	Whether and why did the importance of the post 1980s patents improve during the 1980s and 1990s?	All university patents applied (1981–1992), and issued before 1994	The number of citations (to academic patents or to the sample of non-academic control patents), the number of citations (to academic patents-incumbent, to academic patents-entrants, to the sample of non-academic control patents)	The importance of entrant institutions' patents improved during the 1980s and 1990s, thus increasing the average importance of overall academic patents relative to non-academic patents. Links with a research corporation during the 'pre-Bayh-Dole' era has little influence over changes in the importance and generality of incumbent or entrant institutions' patents during the 1980s and 1990s.

Mowery and Ziedonis (2002)	Whether and how academic patent quality and quantity have changed before and after the Bayh-Dole Act (BDA) in the United States?	Invention disclosures, patents, and licenses of Columbia University, University of California and Stanford University	Importance of patent, generality of patent	Effects of BDA on patenting and the content of academic research are found to be modest in two universities. After BDA licensing intensified but with declining yield. Authors found no decrease of importance and generality of patents in two universities after BDA, in contrast to Henderson *et al*. (1998). However, less experienced incumbents and new entrant universities appear to have lower patent quality than that of the experienced universities, which may explain the overall decreasing quality.
Narin *et al*. (1997)	What is the contribution of public science to industrial technology?	430,226 non-patent references of the 397,660 US patents issued in 1987–1988 and 1993–1994	n/a	Public science is a driving force behind high technology and supporting US industry. Science that is contributing to high technology is mainstream, quite basic, quite recent, and published in highly influential journals.
Nelson (2005)	In regards to university technology licensing activities, how can multiple logics be enacted and manipulated; and how can the results of the manipulation become institutionalized?	Data associated with the music department (such as licensing activities and graduates) at Stanford University.	n/a	The paper examines the Stanford University music department's activities, and the interaction between technical, commercial, and musical logics over a 30-year period. The positive feedback between various logics leads to a mutual dependence, solidifying the centrality of musical composition within the department while emphasizing the complementary role of technical and commercial efforts.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Nelson (2001)	n/a	n/a	n/a	Observes the performance of universities after Bayh-Dole. To be effective over the long run, universities should stay focused in the arenas of open public science and education, that is, focus on their comparative advantage in national innovation systems.
Nerkar and Shane (2003)	When do start-ups that exploit patented academic knowledge survive?	128 firms founded to exploit MIT-assigned inventions, interviews with founders, and a survey of R&D managers	Hazard rate of failure	Start-up's survival is a function of the effectiveness of radical technology and patent protection scope. Those two factors are contingent on and moderated by the industry environment (i.e., industry concentration).
Oliver (2004)	What are the relations between existing scientific collaborations and the capital (scientific and intellectual) of scientists? Does their institutional employment affect the relationship?	Survey of 291 biotechnology-related scientists in Israel	Number of academic, industrial, local, international, and total collaborations	At the time of the survey, few scientists in Israel had industrial collaborations. Scientists with significantly more industrial collaborations were more likely to submit patent applications.
Owen-Smith (2003)	What is the effect of increased university engagement in commercial activities?	18 years of panel data of 89 most research-intensive US universities, USPTO data.	Patents, publications' impact, R&D expenditures	Increased patenting and commercial engagement of US universities has altered the rules of inter-university competition. The success in competition becomes dependent on interplay between commercial and academic achievements.

Owen-Smith and Powell (2001)	What are the factors that explain faculty disclosures?	Two university campuses	n/a	Faculty decisions to disclose are shaped by their perceptions of the benefits of patent protection. The incentives are influenced by the perceived costs of interacting with technology transfer offices and by institutional environments (supportive or oppositional to commercialization).
Owen-Smith and Powell (2003)	How do universities learn to commercialize research and develop the capacity to patent effectively?	Panel data of 89 universities, interview with two TLOs	Number of forward citations, blockbuster patents	The increase of patenting enhances the impact of patent-portfolios. Connections to commercial networks are of great value, but too many linkages can preclude the development of a stable flow of higher impact patents. The advantages of embeddedness and experience depend upon having both available stocks of basic life science and a higher volume flow of patents.
Powell and Owen-Smith (1998)	What are the primary factors that blur the division of labor between academia and industry in life sciences? What are the consequences for universities treating knowledge as intellectual property?	Data were from National Science Board	n/a	Changes in the nature of knowledge, in federal policy and corporate practice have caused the irreversible change of research universities. Key factors driving the development in life sciences and the blurring boundary are the expanding opportunities, not resource scarcity. In consequence, it might distort the traditional university goal.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Powers and McDougall (2005a)	How do the university's technology transfer (TT) strategy and its local environment affect the university's TT success at spinning-off firms?	134 US universities (92 public, 42 private) data from various sources	The number of licenses with private companies that subsequently went public, royalties received on product sales	University TT selectivity, TT support, and the local entrepreneurial density have main effects on TT performance. At public universities, entrepreneurial density negatively moderates the relation between university TT selectivity and its success at spinning-off firms.
Poyago-Theotoky *et al*. (2002)	What are the antecedents and consequences of policies to promote university-industry partnerships?	n/a	n/a	Review of the literature indicates that there is still little knowledge about the impact of the rise of university–industry partnerships. These partnerships are needed to address innovation market failures, especially those relating to basic research.
Reitan (1997)	Was a specific entrepreneurial program appropriate and successful?	64 entrepreneurs in Norway	n/a	The entrepreneurial program was not appropriate in terms of compatibility, complementarity, and realism. It was successful quantitatively (number of start-ups, survival, and commercial utilization rates). But it was not successful in creating substantial employment.

Roberts and Peters (1981)	Why do so few university-generated ideas ever achieve commercial impact?	Interview with 66 faculty members from four departments at MIT	n/a	Although a majority of faculty can be expected to generate ideas of potential commercial value, a smaller fraction of them act to commercialize the ideas. Commercialization behavior is linked to background characteristics of the person and is predicted by the previous behaviors.
Rosenberg and Nelson (1994)	What are universities' roles in promoting technical advances in American university (given historical and current circumstances)?	n/a	n/a	Although strength of university research lies in basic research, significant portion of university research are allocated in engineering and applied science. University should develop policy concerning a division of labor between basic and applied research since industry does a better job in the short-term problem solving.
Sampat *et al*. (2003)	Does the result of Henderson *et al*. (1998)'s study hold if the study is replicated using a larger period of data set?	University patents applied (1975–1988); patent granted before 1992; counts of citations until the end of 1999.	Importance of patent (total citations received), generality of patent	Result of Henderson *et al*. study reflect changes in the intertemporal distribution of citations to university patents, rather than a significant change in the total number of citations these patents eventually receive. Quality decline identified by Henderson *et al*. disappears in the analysis with longer time period.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Saragossi *et al*. (2003)	What is the evolution of patenting performance in Belgian Universities?	European patent applications of six Belgian universities	n/a	Patent applications increased in the late nineties. One determinant of patenting performance is the effective collaboration with specialized institutions. Patent statistics could be a misleading indicator of university's technological productivity since inventions can be assigned to other institutions.
Schmiemann and Durvy (2003)	n/a	n/a	n/a	Authors examine some differences in university technology transfer between Europe and the United States. They suggest that European universities can enhance their effectiveness in technology transfer if such activities are given more visibility and prestige, enhanced public support, and formal procedures to facilitate benchmarking.
Segal (1986)	What is implied by the Cambridge Phenomenon?	n/a	n/a	Cambridge Phenomenon is the growth of high-tech industries inside and around Cambridge, England. Here, small firms and universities have special roles. It implies that the university-industry linkages are central to the start-ups' strategic evolution, but this was under-researched and misunderstood in Britain.

Shane (2004b)	What is the effect of the Bayh-Dole Act in the US on university patenting?	Patents assigned to universities across 117 lines of business	Annual log-odds of the university share of patents	The effectiveness of licensing in a line of business is significantly correlated with university's share of patents in the post-Bayh-Dole period, but not in the pre-Bayh-Dole period. The Bayh-Dole Act provided incentives for universities to increase patenting in those fields in which licensing is an effective mechanism for acquiring new technical knowledge.
Shane (2002)	How does the interaction between university and entrepreneurial firms differ from that between university and large firms?	n/a	n/a	There are six different ways in which university-entrepreneurial firm interaction may differ from university-large firm interaction in contract research, four ways in consulting, eight ways in technology licensing, and three ways in technology development.
Siegel *et al*. (2003a)	What are the processes and outcomes of UITT (university–industry technology transfer)? And how to improve the process?	98 interviews with UITT stakeholders	n/a	Three categories of stakeholders (university scientists, university technology managers and administrators, firm managers and entrepreneurs) have different perspectives on the outputs of UITT. Barriers to UITT: culture clashes, bureaucratic inflexibility, poorly designed reward systems, and ineffective management of TTO. How to improve: eradicating cultural and informational barriers; flexible university policies; improve staffing practices; devote more resources to UITT; reward the engagement in UITT; encourage informal relationships and social networks.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Siegel *et al*. (2004)	How do stakeholders of university-industry technology transfer (UITT) define the outputs of the process? What are the organizational/managerial barriers to UITT?	55 interviews of 98 UITT stakeholders at five US research universities	n/a	Proposed improvements: greater rewards for faculty involvement in TT; allocate more resources to TTO; mutual understanding, especially in terms of culture; establishing personal relationships between scientists and practitioners which are more important than contractual relationships in UITT; TTO staff with experience and skills in marketing, negotiation, and know-how; and increase of university flexibility. Finally, university involvement in UITT will increase its basic research activities.
Sine *et al*. (2003)	What are the effects of institutional prestige on the ability of a university to license its inventions?	Licensing rate of 102 US universities from (AUTM), US News & World Report, Gourman Report	Annual count of new technology licensing and option agreements established by the university	Institutional prestige influences the number of licenses that a university annually generates over and above the rate that is explained by the university's past licensing performance.
Thursby and Kemp (2002)	What is the overall productivity of university licensing activities as well as the productivity of individual universities?	AUTM licensing survey data of US universities	University's efficiency measured by comparing its commercialization input (i.e., TTO staffs and federal support) and output (licenses, patents, royalties, and disclosures)	The increase of commercial activities is attributed to the changing environment within universities and an increasing desire of industries for university technologies. Private universities tend to be more efficient in commercialization than public, while universities with a medical school are less likely to be efficient. The lower the research quality of a university the more efficient it is in commercial activity. The low efficiency of high-quality research universities in TT may be a result of the preference for outputs unrelated to licensing (such as basic research) instead of incompetence in licensing.

Thursby and Thursby (2004)	How important are university faculty in the licensing and development of inventions?	112 firms that recently licensed university inventions	The percentage of time that faculty are used in further development	Faculty participation through informal and formal channels is important to licensing process. The use of faculty through sponsored research in lieu of license is closely related to the amount of basic research conducted by firms. The use of faculty within the terms of a license is related to the prevalence of personal contacts between industry researchers and university faculty.
Thursby and Thursby (2005)	What is the relationship between faculty gender and faculty disclosure and licensing activity?	4621 science and engineering faculty at eleven US universities over 17-year period. These faculty are listed in PhD-granting departments in National Research Council 1995 report.	First regression: gender. Second: whether there is a disclosure or not.	There are 8.55% of the faculty who are female, and mostly younger faculty. These women are most represented in the biological sciences. They are less likely to disclose inventions than men while there are no significant differences in publication patterns. The disclosure activity of women and men converges over the sample period.
Van Dierdonck *et al*. (1990)	What are the attitudes of the Belgian academic community towards university-industry technology transfer?	300 university laboratories at 13 Belgian universities	n/a	Authors' findings refute the received wisdom that academia has a cultural aversion towards involvement with industry. Professors fear, however, that industrial liaison office will control this relationship with industry. Technology brokerage firms, as a transfer mechanism, are considered less effective due to the importance of personal relations.

(continued)

Table 2 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Van Looy *et al*. (2004)	Can entrepreneurial and scientific performance in academia be reconciled?	14 Katholieke Universiteit (KU) Leuven, Research and Development divisions of the KU Leuven	Amount of publication outputs	Entrepreneurial performance and scientific performance do not hamper each other. Engagement in entrepreneurial activities coincides with increased publication outputs without affecting the nature of the publications involved. As resources increase, this interaction becomes more significant, pointing towards a Matthew effect.
Wallmark (1997)	What is the economic value of university patents?	Data of Chalmers University: over 400 patents filed, companies spun off, investors, during 1943 and 1994, and age of inventors at invention	n/a	University's spin-off manufacturing companies with products protected by patents have contributed to job creation. There is a significant economic impact of university patents.
Wright *et al*. (2004a)	What are the contributions made by the papers in the special issues of "Entrepreneurship and University Technology Transfer"	n/a	n/a	At the spin-out level, issues raised: identification of typologies of spin-out firms, the evolution of spin-outs and external resources. At university level, issues raised: policies, internal resources and processes.

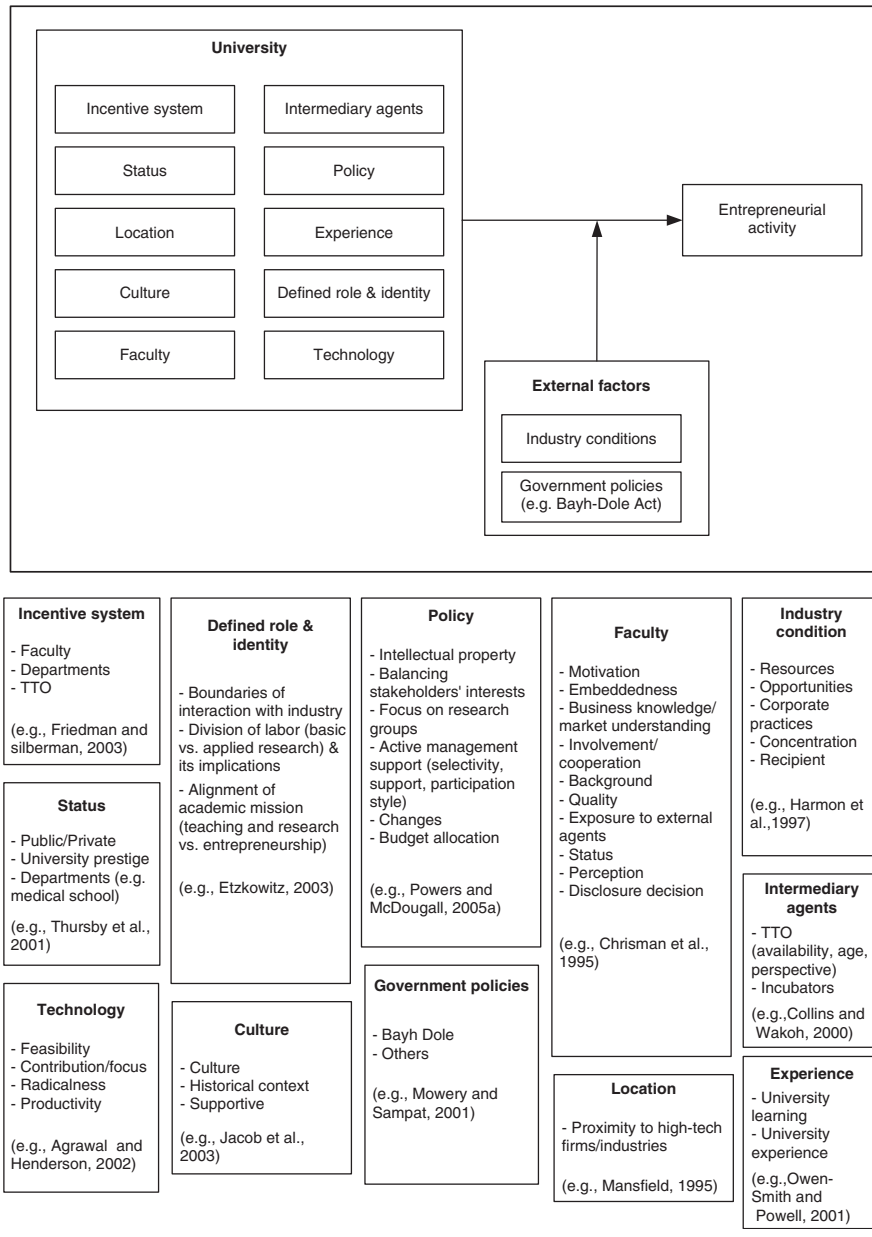

Figure 5 Entrepreneurial research university.

Lee, 1996; Powell and Owen-Smith, 1998; Etzkowitz *et al.*, 2000; Louis *et al.*, 2001; Nelson, 2001; Siegel *et al.*, 2004; Van Looy *et al.*, 2004; Gulbrandsen and Smeby 2005), and offering suggestions on how to address these issues (Rosenberg and Nelson, 1994; Laukkanen, 2003). For instance, the types of barriers that universities

face appear to follow different patterns contingent on the social context. In Western countries, the major obstacles lie in the internal or external parties' adherence to the university's historic commitment to the intellectual commons (Argyres and Liebeskind, 1998; Feldman and Desrochers, 2003; Goldfarb and Henrekson, 2003), while in Eastern countries like Japan the obstacle appears to be the lack of complementary and intermediary institutions that can facilitate entrepreneurial activities (Collins and Wakoh, 2000).

The question of how to make a university more entrepreneurial can be addressed on two levels. First, in the absence of strong conflicts between supporting traditional and entrepreneurial roles, scholars have suggested a diverse set of strategies, such as offering greater incentives for faculty's involvement in entrepreneurial activities (Henrekson and Rosenberg, 2001; Jensen and Thursby, 2001; Friedman and Silberman, 2003), or adopting a decentralized management or a business-like style in the process of technology transfer (Del Campo *et al.*, 1999; Debackere and Veugelers, 2005). In European countries, the transparent regulation of ownership titles and property rights are a priority (Debackere and Veugelers, 2005), while in Japan the establishment of intermediary institutions seems necessary before the field can progress (Collins and Wakoh, 2000). Second, with regard to the pronounced conflicts surrounding a university's role, the debate here is far more complicated and less examined. In this context, transforming a university to be more entrepreneurial requires not only changes in organizational infrastructure but also the adaptation of the university's culture and mission itself (Jacob *et al.*, 2003).

Entrepreneurial activities have the potential to affect the university system's mission and its traditional focus on academic governance of faculty. Some scholars suggest that a more entrepreneurial university drives more applied and problem-solving research, results in more secretive behaviors among faculty, aggravates the conflict between advancing knowledge and generating revenues, and thus interrupts or even threatens academic freedom (Lee, 1996; Powell and Owen-Smith, 1998; Louis *et al.*, 2001; Gulbrandsen and Smeby, 2005). In contrast, other scholars find no empirical evidence that the shift toward more applied research occurs at the expense of basic research (Van Looy *et al.*, 2004). An evolution of the university mission is advocated accordingly: universities need to be entrepreneurial if they are to fulfill and sustain their role and purpose in society, which is to foster creativity and responsiveness to change in cultural, ethical, scientific, technological, and economic dimensions (Grigg, 1994).

Scholars have also attempted to reconcile these opposing opinions by observing that the mission of universities today requires a balance of both traditional and entrepreneurial roles (Etzkowitz *et al.*, 2000; Van Looy *et al.*, 2004); and suggesting that the two roles may actually complement and reinforce each other (Siegel *et al.*, 2004). According to these scholars, this balancing act should follow a division of labor between universities and industry as they each

leverage their respective comparative advantages: universities are better at basic research, while industry is better at developing and commercializing technology (Rosenberg and Nelson, 1994). This solution suggests that although faculty may be involved in industrial activities, the university does not need to become an expert in making commercial decisions. It follows, then, that a key challenge for university governance is to support entrepreneurial activities without losing control over its academic mission or sacrificing academic freedom. Some observers suggest that university governance should adopt an "umbrella strategy" (Mintzberg and Waters, 1985); that is, the university should set general guidelines and boundaries of behavior, and create the condition for innovation and strategy to emerge within its defined boundaries (Grigg, 1994). A deeper understanding of these issues (i.e., the effectiveness of certain strategies, impact of entrepreneurial activities on university governance, etc.), calls for more rigorous analysis, such as longitudinal studies across different universities and different contexts.

We also identified other conflicting findings in this research stream, including the role of incentive structures. Most studies recommend providing incentives and rewards directly to faculty to encourage invention disclosures and commercialization activities (Henrekson and Rosenberg, 2001; Jensen and Thursby, 2001; Friedman and Silberman, 2003; Debackere and Veugelers, 2005). It is argued that providing incentives to faculty encourages an entrepreneurial culture within the university. This culture is often needed because the commercialization of embryonic technologies from university laboratories to industry generally requires further involvement from the inventing faculty (Jensen and Thursby, 2001). In contrast, a different study finds that it is the reward to technology transfer personnel that is positively related to a university's entrepreneurial activity (Lockett *et al.*, 2005). In light of these differing findings, we suggest controlling for the effect of incentives on one group while studying the effect of incentives on the other, because some of the conflicting results may be explained by unobserved heterogeneity. In addition, using a more encompassing approach would help us to move beyond a focus on only one circle in the university entrepreneurship framework, as depicted in Figure 4.

Another conflicting finding in this research stream centers on the effect of policies such as the Bayh-Dole Act on university patenting activity. A positive effect was found in one empirical study (Mowery *et al.*, 2001), but not in a more recent study (Coupe, 2003). Scholars have suggested decomposing the effect into two dimensions—the entry and content effect of public policy on patenting activities (Mowery and Ziedonis, 2002). That is, public policies like the Bayh-Dole Act may affect both the entry rate of universities involved in patenting, and the content characteristics (e.g., applied or basic science) of the patents. Future studies may explore what other factors drive patenting activities, and whether the incentives of key individuals (faculty and technology transfer officers) mediate the relationship between external drivers and university patenting activities.

Some conflicting viewpoints that have been addressed in the line of university patenting studies revolve around patent quality (Wallmark, 1997; Henderson *et al.*, 1998; Agarwal and Henderson, 2002; Mowery and Ziedonis, 2002; Mowery *et al.*, 2002; Coupe, 2003; Sampat *et al.*, 2003). Some scholars suggest that patent quality increased after the Bayh-Dole Act (Mowery and Ziedonis, 2002; Sampat *et al.*, 2003), while a previous study claimed that it decreased (Henderson *et al.*, 1998). The change of the quality in university patents is important as it may affect existing firms' technology sourcing decisions to license from universities, consummate acquisitions of and allying with start-ups based on university technologies, or focus on internal new venturing.

Taken together, the line of research on university entrepreneurship can clearly benefit from a more holistic systems perspective across different levels of analysis, rather than its current focus on distinct subsystems, which is a reflection of its fragmented and embryonic state. Current research lacks a complexity in models or richness in data to understand the interdependent processes across many different actors, agents, and institutions involved in university entrepreneurship. Thus, studies of multilevel interactions across units of analysis attempting to explain university entrepreneurship appear to be an important avenue for future study. Research efforts in this regard can aid us in moving beyond understanding the individual pieces of the entrepreneurial university puzzle, and aid in a more holistic understanding of this complex and multifaceted process. Last but not least, studies on the results of entrepreneurial activities and the effectiveness of university governance would benefit from going beyond the widely used case study method or history analysis (Grigg, 1994; Rosenberg and Nelson 1994; Debackere and Veugelers, 2005), beyond the quantitative analysis within the setting of a single university (Van Looy *et al.*, 2004), and conducting longitudinal analyses using samples that are more representative of the population studied. The results would be less idiosyncratic to individual, often premier, research universities.

4.2 Productivity of technology transfer offices

With the increasing entrepreneurial activities at universities, TTOs have been in the spotlight of research, because they are often regarded as the formal gateway between the university and industry. This research stream views university entrepreneurship as a function of the productivity of their TTOs. Most measures of entrepreneurial activities are focused around commercial output, including university licensing (number of licenses, licensing revenue), equity positions, coordination capacity (number of shared clients), information processing capacity (invention disclosures, sponsored research), royalties, and patents (number of patents, efficiency in generating new patents). Factors that have been identified to be important in explaining the productivity of TTOs include technology

transfer offices' systems, structure, and staffing, as well as the different mechanisms of technology transfer, nature and stage of technology, faculty, university system, and environmental factors. Table 3 describes the studies pertaining to the productivity and efficiency of technology transfer offices, while Figure 6 provides a schematic overview of this research stream, with representative articles that focus on certain key aspects in the boxes.

In examining the implications of TTO structure, scholars have found that the choice of organizational structure influences TTO performance through the shaping of the flow of resources, reporting relationships, degree of autonomy, incentives, and commercialization strategy (e.g., Bercovitz *et al.*, 2001; Feldman *et al.*, 2002; Markman *et al.*, 2005b). For example, research reveals that TTO structure that creates financial independence from the parent university encourages more equity than licensing agreements (Bercovitz *et al.*, 2001; Feldman *et al.*, 2002). These studies provide insight on how TTO structures and the attitudes of TTO officials play an important role in shaping both formal and informal systems. For example, the process of choosing among various commercialization strategies in a discriminating fashion is an internal procedure that has drawn considerable attention in recent years (Bray and Lee, 2000; Meseri and Maital, 2001; Feldman *et al.*, 2002; Shane 2002a).

Besides the organization and management of TTOs, scholars have also explored external factors that contribute to different TTO productivities. For example, the stage of technology (e.g., embryonic) is related to the rate of invention disclosures and commercialization strategy (Thursby *et al.*, 2001; Markman *et al.*, 2005b). Moreover, both tangible and intangible resources from the university and locality, such as research support and R&D activities, have been understood as input factors of TTO productivity (Jones-Evans and Klofsten, 1999; Siegel *et al.*, 2003b; Chapple *et al.*, 2005). Scholars have also found that the shorter the time between input factors and TTO's commercialization output, the more productive the TTO (Markman *et al.*, 2005a).

In addition to factors that enhance TTO productivity, prior literature informs us about challenges faced by TTO personnel in facilitating technology transfer. One problem pertains to the apparent "identity crisis of the university," as previously discussed. This discussion shapes a university's policy and determines a TTO's degree of freedom, such as the existence of a policy against equity holdings in university start-ups (Bercovitz *et al.*, 2001). TTO officials also often encounter difficulties in convincing faculty to disclose their inventions and, in some cases, to involve faculty in further development of the technology by partnering with industry (Chapple *et al.*, 2005; Jensen *et al.*, 2003; Siegel *et al.*, 2003b). In practice, TTO officials also struggle with a lack of financial and human resources, and may exhibit a suggested lack of competency (Jones-Evans and Klofsten, 1999; Siegel *et al.*, 2003b). Yet, another challenge for TTO officials is the organization of their internal systems with the aim of balancing

Table 3 Productivity of technology transfer offices

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Bercovitz *et al.* (2001)	How does the organizational structure of a TTO mediate the relationship between inputs that give rise to intellectual property and outputs?	21 interviews with TTO personnel, faculty and research administrators	Coordination capability (the likelihood that "customer-firms" will be shared), information processing capacity (yield as measured by invention disclosures/TTO, licensing/TTO, sponsored research agreements/TTO), incentive alignment (trade-off between royalty rate/licensing fees)	Technology transfer activities (e.g., eliciting and processing invention disclosures, licensing university-created knowledge, seeking additional sponsorship of R&D projects) are shaped by the resources, reporting relationships, autonomy, and/or incentives of technology transfer offices (TTOs).
Bray and Lee (2000)	How do the financial returns and attitudes differ between taking equity and traditional licensing?	10 US TTOs (seven private and three public universities)	n/a	The average returns from taking equity are higher than that from a license. Although the highest returns on equity depend on a few million-dollar equity sales, the financial return of the equity will be within the range normally received as a license issue fee. Thus, taking an equity route maximizes the financial returns for universities.
Chapple *et al.* (2005)	What is the performance of UK university technology transfer offices? Do different methods (non-parametric and parametric) result in different conclusions?	50 UK universities	The annual number of licensing agreements consummated by the university, annual invention disclosures/total research income	Invention disclosure, total research income, the number of technology transfer employees, and protection of licensee affect TTO's licensing performance. Regions with a higher R&D intensity, younger TTOs, and universities with medical schools are more efficient at generating new licenses. Parametric methods results in higher efficiency measures than those of non-parametric.

Colyvas *et al*. (2002)	What are the roles of patents and technology transfer offices in facilitating the transfer of university invention into practice?	11 case studies of university inventions	n/a	In the case of embryonic invention, it is unlikely that technology transfer would have occurred absent intellectual property protection. In others cases, technology would have been used in industry even absent patenting and licensing by the university. TTO's marketing activities are the most important for inventions in technological areas where existing links between academia and industry are weak.
Feldman *et al*. (2002)	Why equity has emerged as a technology transfer mechanism? What are the factors that explain differences in adoption strategies?	124 Carnegie I and II research universities; 67 universities' TTO participating in 679 deals	The intensity of equity involvement (total number of a university's equity interests/the number of university's active licenses)	Universities are more likely to use equity as they gain experience in licensing (or get older). But the relationship has an inverted U shape in which the use of equity decreases when the university has executed a large number of licenses. Other factors affect the use of equity: industrial research support (+), the dependency of TTO on the university (–), and experience relative to other institutions (+).
George (2005)	What is the influence of an organization's experience-based learning on the development and deployment of its capabilities?	Interview and archival data from the University of Wisconsin Alumni Research Foundation	Cost of patenting and revenues from licensing	Changes in efficiency (cost of patenting) is driven by changes in routines and processes (experiential learning). When cumulative experience increases, routines in a primary capability may impede the efficient deployment of complementary capabilities.

(continued)

Table 3 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Jackson and Audretsch (2004)	n/a	n/a	n/a	The Indiana University Advanced Research and Technology Institute (ARTI, the technology transfer organ of the Indiana University System) contributes to Indiana's economic landscape through technology transfer, economic development programs and job creation. This case study focuses on the formation of ARTI, its structure and mission, recent initiatives, and metrics for technology transfer initiatives (e.g., revenue metrics and throughput metrics).
Jensen *et al*. (2003)	How does technology transfer office (TTO) balance the objectives of the university and faculty? Will faculty disclose their inventions? If so, when?	62 US research universities	Sponsored research, royalties, licenses executed	TTOs prove to be the agent of both faculty and university administration. TTOs' objectives are thus influenced by both of them. Inventions disclosure in US universities is a function of faculty quality, equilibrium licensing income, sponsored research, and the inventor's rate of time preference.
Jones-Evans *et al*. (1999)	What are the general role and function of the industrial liaison office (ILO)?	Academic entrepreneurship policies in universities in Ireland and Sweden	n/a	In Sweden: (i) ILOs are a part of a network of technology-transfer organizations, acting as a gateway to areas of expertise; (ii) ILO function is more sophisticated. In Ireland: (a) The system is more centralized in which ILOs are directly responsible for the technology transfer function; (b) There were more fundamental problems like a lack of financing and resources to further develop the role of ILOs.

Markman *et al*. (2005a)	What links antecedents and outcomes of university technology commercialization?	AUTM licensing surveys, interview with 91 US UTTOs directors from of 138 US universities, and their patents	Outcomes (licensing revenues, the number of new ventures), innovation speed (commercialization time of patent-protected technologies to industry)	The faster TTOs can commercialize patent-protected technologies, the greater their licensing royalties and the more new ventures they spin off. Speed is determined by TTO resources, their competency in identifying licensees, and participation of faculty-inventors in the licensing process.
Markman *et al*. (2005b)	Which university technology transfer offices' (UTTOs) structures and licensing strategies are most conducive to new venture formation? How are the structures and licensing strategies correlated?	Interviews with 128 UTTO directors	Number of start-ups	For-profit UTTO structures are positively related to new venture formation. Traditional university and non-profit UTTO structures correlate with the presence of university-based business incubators. Licensing-for-equity strategy is positively related to new venture formation. Sponsored research licensing is negatively related to new venture formation. Licensing-for-cash strategy is least correlated with new venture formation.
Meseri and Maital (2001)	How do technology transfer organizations (TTOs) at Israeli universities evaluate projects and how do they perceive the success or failure of these projects once they are selected? Are their decision criteria similar to those used by venture capitalists and TTO at MIT?	Survey of six Israeli universities that operate one or more organizations dedicated to facilitating technology transfer	n/a	The criteria for Israeli TTOs to decide on technology transfer projects are similar to venture capitalists and TTO at MIT (factors that score highest include market need, market size, etc). For the criteria of success/failure, one TTO, Dimotech, focuses on the characteristics of the individuals involved in launching a new venture, but most other Israeli TTOs focus on licensing; the former is closer to the criteria used by Venture Capitalists.

(continued)

Table 3 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Shane (2002a)	Which university inventions will be licensed and commercialized? Who will conduct that commercialization?	1397 patents assigned to MIT	Licensing, inventor licensees, license termination, first sale, royalties	University inventions are more likely to be licensed when patents are effective. If effective, university technology is generally licensed to non-inventors. Otherwise, licensing back to inventors increases the likelihood of license termination and reduces the likelihood of invention commercialization.
Siegel *et al.* (2003b)	What affects the performance or productivity of university-industry technology transfer (UITT) activities?	113 US universities from AUTM survey; 55 interviews of UITT stakeholders	Number of average annual licensing agreements, average annual licensing revenue	Environmental/institutional factors and licensing process do affect the productivity of TTO. Most of the variation is explained by organizational factors which are: reward systems for faculty involvement in UITT, compensation and staffing practices in the TTO, and efforts to reduce informational and cultural barriers.
Thursby *et al.* (2001)	How do the objectives of technology transfer offices (TTO) and characteristics of inventions influence the outcomes of university licensing?	TTOs of 62 research universities and AUTM survey	Royalties, sponsored research (amount, frequency), patents, licenses executed	University technologies are not likely to go to large firms if the technologies are in early stage. The most important objectives of the TTO are obtaining royalties and licensing fees. When technology is licensed at an early stage, royalties are lower and sponsored research is preferred. When TTO evaluates the technology as not very important, licensing agreement is less likely to include sponsored research.
Thursby and Thursby (2002)	Where does the increase of university's commercial output come from?	AUTM survey data for 64 US universities; Businesses that licensed university inventions	Disclosure for university, the number of new patent applications, the number of licensing agreements	There is an increase in faculty propensity to disclose and apply for patents. This increase is small in comparison to high increase of administrators' propensity to license. There is a decrease in administrator's ability to market. Thus, universities are diving to their available pools of inventions.

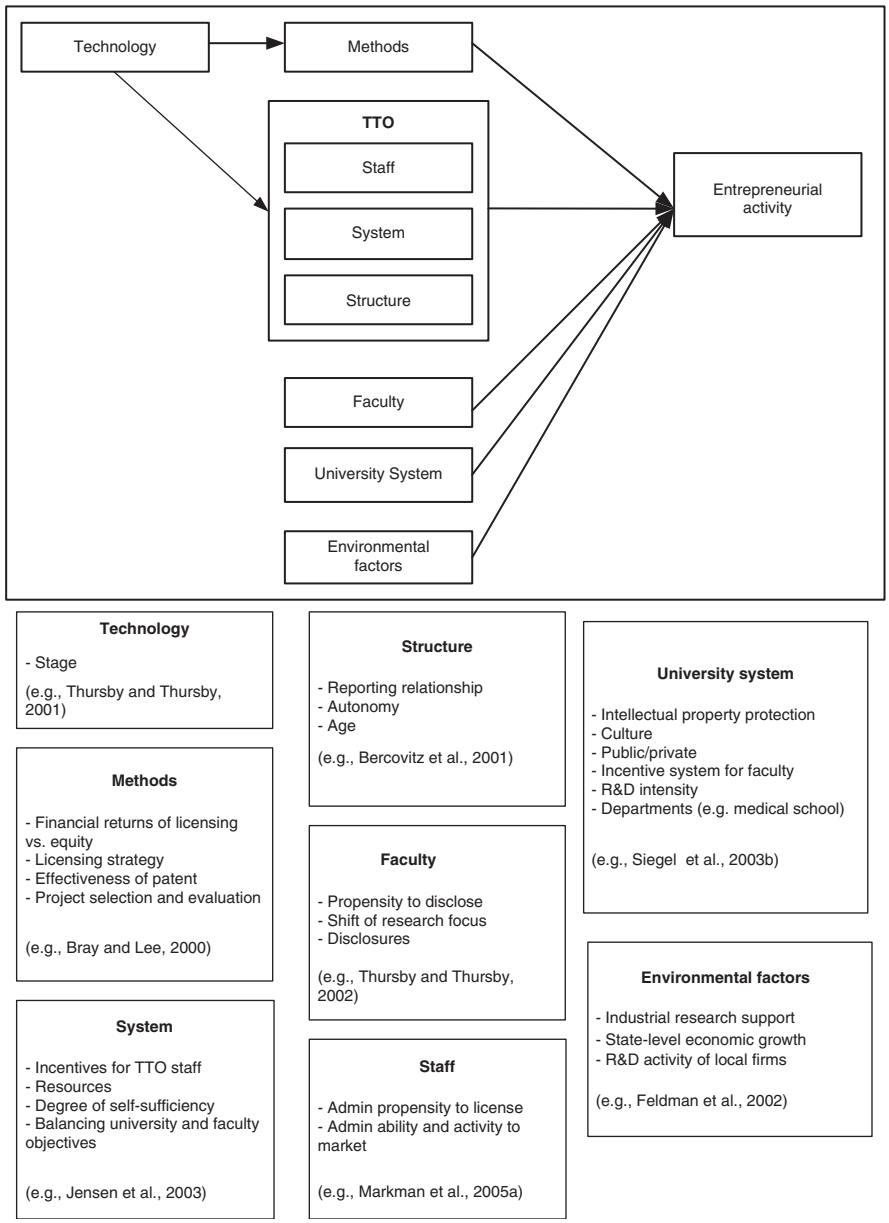

Figure 6 Productivity of technology transfer offices.

objectives from different stakeholders (e.g., university administration, faculty, and industry) (Jensen *et al.*, 2003; Siegel *et al.*, 2003b). In order to address some of these issues, studies have noted that TTO officials arrange licensing contracts so that their structures provide incentives for faculty to disclose inventions, as well as motivate

their future involvement in developing the technology toward industrial use (Thursby *et al.*, 2001; Jensen *et al.*, 2003; Siegel *et al.*, 2003a). Furthermore, it is noted that TTO officials have started to hire a mix of employees with scientific and business backgrounds so as to have a competent and complementary pool of staff (Siegel *et al.*, 2003b).

While all these findings are deduced with a similar understanding that the TTO is a gateway for university inventions, other scholars differ in their very definition of a TTO's role. Here, some argue that a TTO's role includes establishing a link between the university and industry (Jones-Evans and Klofsten, 1999; Siegel *et al.*, 2003b; Debackere and Veugelers, 2005), while others suggest that scientists in universities and industry are embedded in the same formal and informal networks, thus limiting the TTO's role in facilitating these relationships (Colyvas *et al.*, 2002).

In addition to this disagreement about the TTO's role, a stark divergence exists between opinions on what constitutes TTO performance. Scholars have reached some consensus that acceptable measures of TTO performance include the number of licensing agreements and licensing revenues (e.g., Bray and Lee, 2000; Bercovitz *et al.*, 2001; Jensen *et al.*, 2003). However, alternative measures, such as number of invention disclosures and the amount of sponsored research agreements, are emphasized by some researchers as antecedents to TTO productivity (Thursby and Thursby, 2002; Chapple *et al.*, 2005), while others view them as direct measures of TTO productivity (Bercovitz *et al.*, 2001; Jensen *et al.*, 2003). These differences suggest that researchers have started to view technology transfer and the role of the TTO as a complex process. Finally, feedback loops have a potential for affecting TTO activity both positively and negatively. A future research agenda to explore the routines within TTOs and the feedback loops may be a valuable course of action (see Thursby *et al.*, 2001).

Lastly, the debate on TTO strategies has frequently been limited to its legal decisions, particularly pertaining to intellectual property and transfer arrangements. At the same time, studies on other TTO routines have been limited to their identification and general impact on TTO performance. Thus, potential contributions await in understanding the variety of TTO strategies beyond an intellectual property strategy, how the identified characteristics and processes of TTOs increase or decrease their performance, and how TTOs are developing their organizational routines in response to these challenges. For instance, TTOs are facing staffing problems (e.g., Siegel *et al.*, 2003b; Markman *et al.*, 2005a), but we do not know much about how well (or not) TTOs are recruiting, selecting, training, and retaining employees. This area of research may be an interesting entry point for micro-oriented researchers trained in psychology, organizational behavior, and human resources.

4.3 New firm creation

This research stream focuses on entrepreneurial activity in the form of new firm creation (e.g., university spin-offs). Among instruments available for university entrepreneurship, spin-offs appear to be the one of which the recent literature exhibits the most understanding. Accordingly, measurements of university entrepreneurship revolve around the quantity of new firms created, their performance (VC funding, IPO, survival/failure, revenues, growth), and their attributes (i.e., timing and location, rate of establishment, types, founding team characteristics). Scholars in this stream have found university policy, faculty, technology transfer offices, underlying technology, investors, founding teams, networks in which a firm is embedded, and external conditions to affect the creation of new firms. Different university policies, such as attitude toward surrogate entrepreneurs, preferred methods of technology transfer, equity investments, intellectual property protection, and the developmental model (e.g., proactive, planned, or spontaneous, see Chiesa and Piccaluga, 2000; Lockett *et al.*, 2003), all play a role in contributing to or inhibiting university spin-off activities. Aspects of faculty that have been studied include their location, roles in the new ventures, personality, expectations, quality, experience, and timing of inventions. As to the technologies commercialized, studies have assessed the effect of both the quantity and quality on new venture creations. Table 4 depicts the studies pertaining to new firm creation, while Figure 7 provides a schematic overview of this research stream, with representative articles that focus on certain key aspects detailed in the boxes the figure.

The study of new venture creation is clearly a vibrant area, and provides a promising research avenue for further study. Research in this area has explored the various types of spin-outs. Based on the transferee, spin-offs are classified into "technology only," "technology and personnel," and "personnel only" (Carayannis *et al.*, 1998; Nicolaou and Birley, 2003a,b). Based on their business activities and resource requirements, spin-offs are categorized as "consultancy," "intellectual property licensing," "software," "product," and "infrastructure creation" (Druilhe and Garnsey, 2004). Scholars have also sought to account for the variety of antecedents to spin-offs. For instance, some argue that a university spin-off is mainly the result of development-oriented technology and the personality of the scientists involved (Roberts, 1991). Meanwhile, others argue that the structure of spin-offs is determined by the scientist's business network. Other characteristics of university spin-offs concern the stage of its development (Nicolaou and Birley, 2003a,b). Development stages have been defined with reference to start-up date (Clarysse and Moray, 2004), main business activities (Ndonzuau *et al.*, 2002), and critical resources needed (Sine *et al.*, 2003; Wright *et al.*, 2004b). Scholars find that the dynamics of development stages in university spin-offs are related to the dynamics of its founding team (Clarysse and Moray, 2004). For recent review

Table 4 New firm creation

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Bania *et al*. (1993)	Does university research affect the opening rate of new manufacturing establishments?	87 firms in SIC 36 and SIC 38 from 1976 to 1978	The number of new establishments within an industry or the number of "potential" entrepreneurs	A link exists in one industry (electronic equipment industries), but it does not exist in others (instrument and related industries). Pipeline between university research and local commercialization (measured as new establishments) has substantial leaks.
Carayannis *et al*. (1998)	What are the lessons from spin-off formations?	Seven spin-off companies from US and Japan	n/a	Generally, either founder leaves or the technology transfers out of the parent organization.
Chiesa and Piccaluga (2000)	What are the profiles, opportunities, obstacles of spin-off companies in Italy?	48 Italian spin-off companies	n/a	The Italian model of research spin-off companies has modest growth rates. Very few cases of spin-off companies were the result of planned initiatives by the mother institution. Barriers include: Stability and lifelong employment at universities, difficulty to obtain funding, entrepreneur's limited management skill.
Clarysse and Moray (2004)	How are entrepreneurial teams formed and how do they evolve?	Spin-offs from the largest French-speaking university in Belgium	n/a	Shocks in the founding team and the position of its champion co-exist with those of business development. Evolution phases are idea, pre-start-up, start-up, and post-start-up. It is better to coach the start-up team and give them chance to learn than hire a CEO.

Clarysee *et al*. (2005)	How do research institutions (RI) differ in their goals and incubation strategies for creating new spin-out ventures?	First stage: Seven RIs. Second stage: 43 RIs	The number of spin-outs per thousand researchers, the number of new jobs created per thousand researchers, total capital raised, total spin-outs since proactive spin-out policy implemented per RI	Incubation strategies (low selective, supportive, and incubator) differ in their resources and competence relating to finance, organization, human resources, technology, network, and physical infrastructure. Environment is important in shaping the goals and incubation strategies of RIs.
De Coster (2005)	How to assess new technology venture spin-offs from universities?	14 university spin-offs and 14 company spin-offs in United Kingdom	n/a	Assessment criteria categories: technological and commercial risk; level of product innovation; how it satisfies a market sector; market timeliness; fitness into a family of products; longevity of product/process line; previous record of technical innovation; intellectual property rights.
Degroof and Roberts (2004)	How does the process involved in the spin-off policies affect the growth potential of the ventures?	Belgium: Nine spin-off policies in the eight largest academic institutions and in 47 firms.	n/a	Spin-off policies involving strict selectivity (high standard in selecting which NTBFs to support) combined with high support aid ventures capable in exploiting opportunities. Spin-off policies with low selectivity and low support predispose ventures to adopt small and medium enterprise formats. Spin-off policies involving strict selectivity combined with high support are more suited to environments with weak entrepreneurial infrastructure and culture, but require a significant amount of resources.

(continued)

Table 4 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Di Gregorio and Shane (2003)	Why do some universities generate more start-ups than others?	101 US universities from AUTM	Number of start-ups	University policies (making equity investments in lieu of patent and licensing costs, a low inventor share of royalties) and the university's intellectual eminence increase the creation of new firms.
Doutriaux (1987)	How do academic entrepreneurial firms evolve? What are the effects of their linkages with a university?	Survey of 38 Canadian start-up firms created by entrepreneurs at universities	n/a	There is a difference in the growth behavior and dynamics between technical service firms and manufacturing firms. There is a seemingly negative effect on the growth and development of manufacturing firms with continuing contracts with the university.
Druilhe and Garnsey (2004)	Do academic spin-outs differ and does it matter?	109 direct spin-outs from University of Cambridge in United Kingdom	n/a	Academic spin-outs differ in the intensity of resources requirements and entrepreneurs' relevant knowledge/experience. Recognizing the differences has implication for policy makers to provide appropriate support.
Ensley and Hmieleski (2005)	What are differences between top management teams (TMT) of university-based and that of independent high-tech startups?	217 managers from 102 university start-ups; 417 executives from 154 independent start-ups	Net cash flow; revenue growth	TMTs of university start-ups are more homogenous and have less developed dynamics. Link between TMT variables and firm performance is weaker in university start-ups than that in independent start-ups. University start-ups have lower performance than independent high-tech start-ups in terms of revenue growth and net cash flow.

Fontes (2005)	What is the role of academic spin-offs in transforming scientific and technological knowledge to economy?	18 academic spin-offs in biotechnology in Portugal.	n/a	Biotechnology spin-offs have an agency role in accessing and disseminating knowledge produced by research organizations. They are an alternative to other technology transfer mechanisms and technology transfer organizations.
Franklin *et al*. (2001)	Do more successful universities perceive academic and surrogate entrepreneurs in university spin-outs differently?	TTO officers at 57 UK universities	n/a	The most significant barriers to the adoption of entrepreneurial-friendly policies are cultural and informational. Universities that generate the most start-ups have more favorable attitudes towards surrogate entrepreneurs. A combination of academic and surrogate entrepreneurship might be the best approach for successful spin-outs.
Grandi and Grimaldi (2003)	How does the relational structure of academic spin-offs at the time of the founding look like? How does the relational structure affect the success of new ventures?	40 Italian academic spin-offs	Founding teams' intention to set up relations with external agents, frequency of interaction of the founding teams with external agents	Two factors lead to the success of new ventures: (i) Founding teams' intention to set up relations with external agents and (ii) their frequency of interaction with external agents. The intention is shaped by the articulation of roles and the degree of completeness (i.e., knowledge and competencies to run the business).
Gubeli and Doloreux (2005)	What are the implications of spin-off firms' network activities with parent organizations and local environments?	Three spin-out firms of Linköping University; directors and employees at the university.	n/a	Spin-offs' collaborations with parental and outside organizations result in the access to technological competencies. The parental organization helps the spin-off process by providing infrastructures and expertise.

(continued)

Table 4 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Johansson *et al.* (2005)	How do spin-offs perceive the nature and motivation of their ties with universities?	Cases of Swedish high-tech university spin-outs	n/a	The network relations consist of small number of strong ties that are characterized by a high degree of trust and informality. Strong ties are fruitful for the transfer of complex knowledge and they cost less than building an intensive social network. Yet, strong ties makes spin-offs dependent on continuous support of basic research.
Kinsella and McBrierty (1997)	How is the academic entrepreneurship paradigm manifested through campus companies?	Performance parameters of Irish higher education	n/a	(i) Knowledge should be used as a form of equity; (ii) Campus companies have lower risk level compared to small and medium enterprises since they share their risk with university; (iii) Barriers: inadequate infrastructural support, university budget distribution, and the absence of holistic approach.
Leitch and Harrison (2005)	What is the role of the university technology transfer office (TTO) in spin-outs?	Interviews with the TTOs director and directors of the original and second order spin-outs at Queen's University	n/a	Roles of TTO in second order spin-outs: supports their development and takes equity stakes in them. The original parent/incubator organization can continue to play a role in channeling resources into start-up ventures and providing legitimacy and credibility for them.
Lerner (2005)	What are the lessons and challenges in managing the spin-out and technology transfer (TT) process?	Traditional academic research, case studies, service on advisory panels, and special projects	n/a	(i) The process is challenging, due to uncertainty and informational gaps; (ii) The illusion of generating enormous returns for academic institutions; (iii) Directly financing firms through internal venture capital funds is unlikely to be a successful strategy; (iv) University transfer offices can educate new firms (v) Old frameworks about conflicts-of-interest must be rethought.

Link and Scott (2005a)	What are the determinants in the formation of university spin-off firms within the university's research park?	81 university research parks	Percentage of park organizations that are university spin-off firms in year 2002	Higher proportion of university spin-offs are founded in older parks, parks associated with richer university research environments, parks located closer to their university, and parks with a biotechnology focus.
Lockett *et al*. (2005)	What are the managerial and policy implications of the rise of spin-offs at public research institutions (PRIs) based on the Knowledge Based View?	n/a	n/a	To understand the development of spin-offs, researchers should focus on "knowledge gaps" that spin-offs encounter. Such gaps can occur at various level of analysis (e.g., individual, team, firm) and at various stages of venture development.
Lockett and Wright (2005)	What are the most important attributes of resource and capabilities of university and its technology transfer office (TTO) in determining the creation of university spin-offs?	48 UK universities; Higher Education Statistics Agency	The number of university spin-outs, the number of equity investments in existing spin-outs	Both the number of spin-out companies created and the number of equity investments in existing spin-outs are positively associated with university's expenditure on external intellectual property protection, business development capabilities of TTO, and the royalty regime of the university.
Lockett *et al*. (2003)	Do more successful universities have different policies, strategies, roles of academic inventor, access to expertise and networks, opportunity identification, and distribution of equity ownership in spinning-out companies?	57 UK universities	Strategies toward spin-out companies, the entrepreneurial role of academic inventor expertise and networks in implementing spinning-out strategies, opportunity recognition, equity ownership in the spin-out	More successful universities have more explicit and proactive strategies towards the development of spin-out companies. They also have more expertise and better networks. Their commercial offices have more important roles in opportunity recognition. The role of academic inventor is not significantly different. Equity appears to be distributed among interested parties. Successful universities always have an equity stake in spin-out companies.

(continued)

Table 4 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
McQueen and Wallmark (1982)	What are the characteristics of Chalmers University's spin-off companies compared to those of MIT and Stanford?	38 spin-off companies from Chalmers University of Technology	n/a	Compared to spin-off companies from MIT and Stanford, those of Chalmers are smaller and newer. The average age of the founders at Chalmers is the same as that at MIT and Stanford.
Ndonzuau *et al*. (2002)	What are the issues in the creation of university spin-offs according to public and academic authorities?	Interviews with technology transfer related personnel at 15 universities in different countries	n/a	Stage (Issues): Generating business idea (academic culture, internal identification), finalizing new venture projects (protection and development of the idea, financing), launching spin-off firms (access to resources, relationship with university), enhancing the economic-value creation (relocation of risk, change trajectories).
Nicolaou and Birley (2003a)	What generates different university spin-out structures?	n/a	n/a	Social networks are determining the structure of spin-outs. The social network contains the exo-institutional network, intra-departmental network, inter-departmental network, and surrogate entrepreneur and technology transfer office. The structures are based on the academic's embeddedness in a network of exo-institutional and endo-institutional ties.
Nicolaou and Birley (2003b)	What are the influences of social networks in the university spin-out phenomenon?	45 spin-outs comprising 111 inventors originated from Imperial College London.	Academic exodus	A high level of non redundancy in the academic's exo-institutional business discussion networks, coupled with a high strength of ties, increases the propensity of academic exodus. Academic teams whose role in the spin out is only consultation, are more likely to have lower numbers of non-redundant contacts in the team's business network.

O'Shea *et al*. (2005)	Why are some universities more successful than others at generating technology-based spin-off companies?	AUTM and patent data of 141 US universities	The number of spin-off companies	Previous success in technology transfer, faculty quality, science and engineering funding base with an orientation in life science, chemistry, and computer science disciplines, percentage amount of industry funding, and a strong commercial resource base are all positively related to university spin-off activity.
O'Shea *et al*. (2004)	What are the streams of literature on university spin-off activities?	n/a	n/a	(i) Individual and the personality of the individual as the key determinant of whether spin-off activity occurs; (ii) Organizational configuration studies explaining spin-off activity in terms of the resources of the university; (iii) Socio-cultural development studies explaining spin-off activity in terms of culture and the rewards within the university; (iv) Studies explaining spin-offs in terms of external environmental influences; (v) Measurements of the performance of spin-offs; and (vi) Measurements of the economic impact of spin-off activity.
Powers and McDougall (2005b)	Do some particular resources predict performance of university technology transfer?	120 universities data from various sources	Total number of start-ups formed by a university, IPO companies to which a university had licensed a technology	The level of industry R&D funding, faculty quality, the age of the technology transfer office, and the level of venture capital investment in a university's metropolitan statistical area are positive predictors of both measures of technology transfer performance, i.e., the number of start-ups and IPOs.
Rappert *et al*. (1999)	What is the extent of academic-industry linkages? What are the main benefits of such relations? What are the most pressing problems university spin-offs (USOs) face in their linkages with universities?	Interview of 94 individuals from 59 USOs in the United Kingdom	n/a	USOs are engaged in various forms of linkages with universities. Different linkages result in benefits of knowledge, mainly on keeping abreast of research, and provide general and specific assistance. Three main types of channel to maintain linkages are identified: contracts, literature, and recruitment. The most important tension between USOs and universities is misconceptions of the value of intellectual property rights for small and medium-sized firms.

(continued)

Table 4 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Roberts (1991)	What are the determinants of the initial technological basis for new enterprises?	125 MIT-based spin-off companies and 62 spin-off from two large technological corporations	n/a	Technological determinant: Development-oriented work at the source organization. People determinant: Greater exposure to the technological source, personal ability to perceive, understand and apply advanced technology, younger age, a sense of challenge and satisfaction with sources. Other determinant: dissipative influence on technology transfer and opportunities for technology use.
Roberts and Malone (1996)	What are the guides in spinning off new companies from R&D organizations?	Eight R&D organizations in United Kingdom and United States	n/a	The authors identify five conditions of spin-offs. Selectivity and support are the two main dimensions of a technology commercialization policy at facilitating the formation of spin-off ventures from an R&D organization.
Rothaermel and Thursby (2005a)	How does the strength of the tie between the sponsoring university and incubator firms affect their life chances?	79 tech ventures incubated at Georgia Tech	Firms' failure, remaining in the incubator, and successful graduation.	Strong ties to the sponsoring university reduce the likelihood of firm failure because of the strong intellectual property protection, quality signaling effect, and involvement of potential investors. Strong ties, however, retard graduation from the incubator. Weak ties, such as informal interaction with faculty, do not affect outright firm failure or timely graduation.
Samson and Gurdon (1993)	Is there any conflict in scientists pursuit of knowledge and business ventures?	22 university scientist-started firms	n/a	There are tensions between business partners and with the university due to clash of business and scientific cultures.

Shane (2001)	When are new firms created to commercialize new technological opportunities?	1397 patents assigned to MIT between 1980 and 1996. Firm status from MIT Technology Licensing Office.	Firm formation	The probability that an invention will be commercialized through firm formation is influenced by its importance, radicalness, and patent scope.
Shane and Stuart (2002)	How do initial resource endowments affect the performance of new ventures?	134 firms founded to exploit MIT-assigned inventions, interviews with founders and survey of R&D managers	Venture capital funding, IPO, and failure	Founder's direct and indirect relationships with venture investors help new ventures to receive venture capital (VC) funding and to avoid failure. Founder team's industry experience and patent effectiveness have positive effect on IPO, VC funding rate, and negative effect on failure. Technology endowment increases the likelihood of IP and decreases the likelihood of failure.
Smilor *et al*. (1990)	What are the factors that enhance and inhibit the formation and development of spin-out companies from a university?	23 technology-based spin-out companies from the University of Texas at Austin	n/a	Pull factors are more important than push factors. The university has the most important organizational influence in the formation and development of the spin-outs in terms of the sources for ideas and personnel. It is also important as a source of consultants and research expertise. The federal government was the next most important in terms of a source of funding.
Steffensen *et al*. (2000)	What mechanisms facilitate or inhibit the spin-off process?	Data from 55 research centers and their 19 spin-offs	n/a	Inhibitors: Conflicts on intellectual property rights. Enhancers: Research center and its directors facilitating the flow of information and other resources across the university's boundary and well planned (rather than spontaneous) spin-offs.

(continued)

Table 4 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Vohora *et al*. (2004)	How do university spin-outs (USO) progress through different stages from a research activity to compete in the commercial market?	Nine USOs from seven UK universities	n/a	USOs go through five distinct phases of activity in their development. At the intersection between phases, USOs face "critical junctures" in terms of the resources and capabilities for the next phase. These four junctures are opportunity recognition, entrepreneurial commitment, credibility and sustainability.
Wright *et al*. (2004b)	Can joint venture spin-outs (JVSOs) help overcome the critical junctures faced by university spin-outs (USOs) and if so, how?	36 interviews of four UK spin-outs, venture partners, representatives from the universities and venture capital firms	n/a	JVSO's contributions: (i) enhance entrepreneurial awareness and enable access to prior knowledge, (ii) improve the likelihood of finding a committed entrepreneur, (iii) nurture trust, reduce information asymmetry, obtain necessary resources, and (iv) sustain returns to academic and industrial partners.
Zucker *et al*. (1998)	Is the commercialization of technology intertwined with the development of the underlying science?	751 US firms and 327 active star scientists in the life sciences	Stock and birth of biotech-using firms at the beginning of 1990	The timing and location of initial usage by both new dedicated biotechnology firms and new biotech subunits of existing firms are primarily explained by the presence at a particular time and place of scientists who are actively contributing to the basic science.

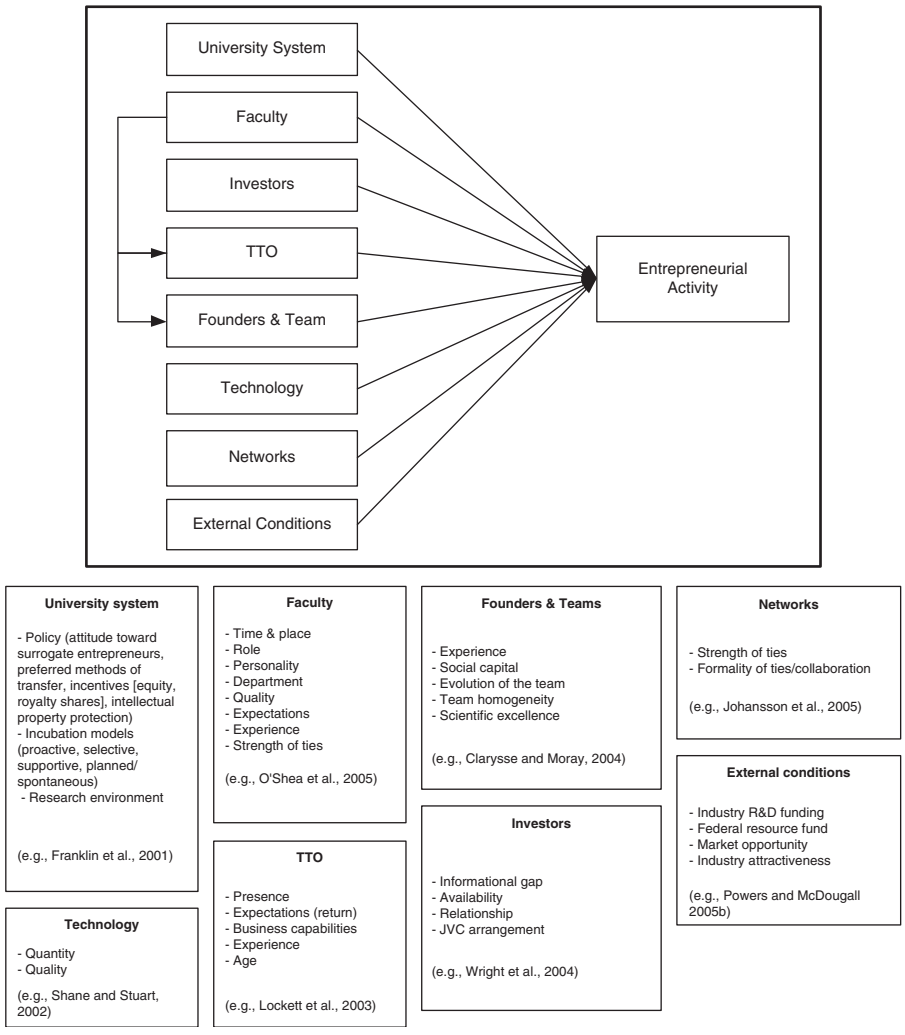

Figure 7 New firm creation.

on typology of university spin-offs, see Mustar *et al.*'s (2006) detailed and insightful analysis.

Besides understanding the nature of university spin-offs, this research stream has progressively illuminated our knowledge of how best to manage the process of new firm creation through two approaches (e.g., Lockett *et al.*, 2005). The first approach pertains to comprehensive factors that impede the formation and growth of spin-offs, including informational gaps, unrealistic expectations, lack of competency in founding teams, resource scarcity, and cultural problems (Samson and Gurdon, 1993; Kinsella and McBrierty, 1997; Rappert *et al.*, 1999;

Chiesa and Picccaluga, 2000; Steffensen *et al.*, 2000; Franklin *et al.*, 2001). Resource scarcity refers to inadequate funding and inadequate structural support (Kinsella and McBrierty, 1997; Chiesa and Piccaluga, 2000). Cultural problems are comprised of an unsupportive university culture toward spin-offs, clash of culture between industry and academia, and a non-holistic approach (i.e., a predominant focus on technology and less on human or social aspects) toward university spin-offs (Samson and Gurdon, 1993; Kinsella and McBrierty, 1997; Franklin *et al.*, 2001).

The other approach is the identification of success factors behind the process of new firm creation. These factors mainly revolve around four themes: intellectual property, networking activities of university spin-offs, resources, and overall university involvement. University policies on intellectual property strategy, such as the encouragement of equity investments, are associated with a higher number of university spin-offs (Di Gregorio and Shane, 2003; Lockett *et al.*, 2003). University expenditure on external intellectual property protection is another factor that appears to contribute to the success of spin-offs (Lockett and Wright, 2005).

A second theme focuses on networking activities of university spin-offs, and explores the impact of founder intention on networking as well as frequency of interaction with external parties (e.g., firms, research institutes, and public organizations) on the success of the new ventures (Grandi and Grimaldi, 2003). Scholars in this area also attempt to identify benefits to networking activities. They find that ties with parent universities provide infrastructure and expertise (Grandi and Grimaldi, 2003; Johansson *et al.*, 2005), and that ties with venture capitalists have been shown to increase funding rates and decrease the probability of failure (Shane and Stuart, 2002).

Besides university policies on intellectual property strategy and networking activities, resource endowments play a factor into the success of university spin-offs. Prior research attributes such success to the quality of human resources, (i.e., faculty, founding team, and TTO personnel), technology endowment, and funding from university, industry, and venture capitalists (Shane and Stuart, 2002; Link and Scott, 2005a; Lockett and Wright, 2005; O'Shea *et al.*, 2005; Powers and McDougall, 2005b).

The fourth theme in this literature stream is concerned with the overall university system (Smilor *et al.*, 1990; Chiesa and Piccaluga, 2000; Di Gregorio and Shane 2003; Lockett *et al.*, 2003; Clarysse and Moray, 2004; Degroof and Roberts, 2004; Clarysse *et al.*, 2005; Johansson *et al.*, 2005; Leitch and Harrison, 2005). Research on the impact of university systems comprises university policy, incubation models, and research environments. The common thread running through these factors is the degree to which university entrepreneurship revolves around new firm creation, a factor that varies significantly along a spectrum from slight to intense. University positions at each

end of the continuum have been debated in the literature. While most scholars find that a high degree of involvement is beneficial for newly created firms, as proxied by higher survival rates, higher performance, and greater reputation effects (Di Gregorio and Shane, 2003; Degroof and Roberts, 2004; Clarysse *et al.*, 2005; Leitch and Harrison, 2005), other scholars demonstrate that greater university involvement can lead to dependency, non-beneficial reputation effects, and delayed graduation from incubators (Johansson *et al.*, 2005; Rothaermel and Thursby, 2005a). Future studies can contribute to this debate by addressing the varying conditions (e.g., firm development stage, technology stage, effectiveness of intellectual property regime, and founding team composition) under which different degrees of university involvement provide an advantage or disadvantage for newly created firms.

Examining the founding teams of university-based technology ventures as the locus of analysis when explaining early firm performance differentials is an under-studied area (exceptions Nicolaou and Birley, 2003b; Clarysse and Moray, 2004; Ensley and Hmieleski, 2005). Current issues on founder teams revolve around their composition and their affect on new firm performance. Team composition has been observed in relation to founder affiliation, education profile and business experience (i.e., amount and quality). This research has fruitfully informed us about the importance of team heterogeneity (Ensley and Hmieleski, 2005), while inviting future researchers to further identify how university spin-outs can more effectively develop a founding team conducive to superior firm performance.[13]

This issue is, however, quite challenging and complex, and not surprisingly far from resolved. For instance, some (Franklin *et al.*, 2001) have shown that universities that are successful in creating spin-outs tend to have more favorable attitudes toward surrogate entrepreneurs. On the other hand, others (Clarysse and Moray, 2004) argued that instead of hiring outsiders, coaching inventors leads to better performance. Those two seemingly conflicting findings open numerous future avenues for research: what are the criteria of surrogate entrepreneurs for successful spin-offs? Under what conditions is coaching preferable? Do spin-offs necessarily hire surrogate entrepreneurs for their expertise or can a founder's social network fulfill such a role? Finally, how do the nature and stage of the technology affect the process and outcome of hiring surrogate entrepreneurs or the effectiveness of coaching by original founders?

The issue of a founding team's heterogeneity is further complicated by contradictory implications pertaining to firm performance highlighted in the literature. One argument is that founding-team heterogeneity endows the new

[13]For a promising start in this area, see Vanaelst *et al.* (2006) for an in-depth examination on the evolution of team heterogeneity along through different stages of the process for academic spin-outs.

venture with a higher diversity of expertise, thus allowing the firm to better assess its opportunities and threats (Ensley and Hmieleski, 2005). Yet, higher diversity increases team self-sufficiency, which has been found to negatively correlate with networking, an action that limits a firm's visibility and access to critical resources (Grandi and Grimaldi, 2003). Scholars interested in team heterogeneity can benefit by studying whether self-sufficiency is a primary or only determinant of a founder's networking activity, or whether other effects play a role in hindering or facilitating networking efforts. While most studies on founding teams use static snapshots composed of cross-sectional data, some (Clarysse and Moray, 2004) analyze the dynamics of the founding teams, particularly in building a founding team's capability. In addition, intrateam dynamics and human capital may be other factors that affect how university technologies are transferred from universities to industry, and subsequently transformed into commercialized outcomes. Given the vibrant nature of research on new venture creation, future studies that address the dynamic and multifaceted aspects of founding teams should be welcome in additions to this literature. This may also be another entry point for microresearchers trained in psychology, a group currently conspicuously absent from this research stream.

Another significant issue in the literature on new firm creation concerns the founder's social network. Social networks have been identified as having implications on the type of spin-out, particularly to what extent technology and human resources are transferred into the newly created firms (Grandi and Grimaldi, 2003; Nicolaou and Birley, 2003a,b) as well as the spin-outs' performance (Shane and Stuart, 2002; Grandi and Grimaldi, 2003; Gubeli and Doloreux, 2005). Prior research, however, has not addressed what particular advantages a spin-out firm would gain from one type of spin-out versus alternative forms (e.g., "technology only" versus "personnel only" versus "technology and personnel"), given a founder's social network. Moreover, a founding teams' social ties, either formal or informal, linking different resources to generate distinctive advantages may constitute another area for organizational and strategy research.

In terms of research methods, most studies in this research stream rely on survey designs. The impact of these studies can be enhanced if the researchers were to develop and execute more effective surveys, through the use of multiple items per construct, pre-testing of items, factor analysis, etc. Many of the psychometric measurement advancements that are standard today in psychology and organizational behavior/human resource management research could be leveraged into the study of the entrepreneurial university system and its groups and actors within. Moreover, studies that track the performance of university ventures over time through the use of fine-grained longitudinal panel data are systematically missing in the area of new venture creation (exceptions Rothaermel and Thursby, 2005a,b). The question pertaining to an appropriate metric for proxying

the performance of university spin-offs and incubator firms is also far from resolved (for a discussion see Rothaermel and Thursby, 2005b). Finally, future avenues of research will need to move beyond the context of a single university in order to enhance the external validity of this research stream.

4.4 Environmental context including networks of innovation

The research stream on environmental context including networks of innovation emphasizes that university entrepreneurship is a result of being embedded in networks of innovation, which in turn are influenced by the larger environment. Measures of university entrepreneurship center around firm performance along several dimensions: growth, productivity, graduation from incubators, firm differential performance compared to those outside the specific environment, and competitive advantage (based on human capital or social capital). Scholars in this stream have identified four factors that directly influence university entrepreneurship: innovation networks, science parks, incubators, and geographic location. The underlying science and faculty involved are seen more as mediating factors in this line of research. Table 5 summarizes the studies pertaining to the environmental context of university entrepreneurship, including networks of innovation.

In understanding innovation networks, scholars have studied networks from two perspectives: (i) from the firm's perspective in which a firm makes decisions to create various linkages with universities and other parties; and (ii) from an overall network perspective in which the network is analyzed as a group of dyads and measured through the application of network-specific constructs (e.g., network density, network centrality, etc.). Fewer studies have assessed environments for innovation from the latter perspective (Owen-Smith *et al.*, 2002).

Research on innovation networks highlights the benefits of such networks to technology-based firms. Scholars have produced evidence that innovation networks are beneficial for overall firm productivity, R&D capability, and R&D output (Adams *et al.*, 2001; Zucker and Darby, 2001; Zucker *et al.*, 2002; Murray, 2004; Lofsten and Lindelof, 2005; Medda *et al.*, 2005). In addition, involvement in innovation networks enhances a firm's embeddedness in social networks and increases its survival (Lockett *et al.*, 2003; Murray, 2004). Scholars have also identified various means to develop innovation networks, ranging from informal to formal collaborations, from facility sharing to deep and reciprocal knowledge sharing (e.g., joint projects and recruitment of scientists) (Zucker and Darby, 2001; Zucker *et al.*, 2002; Perez Perez and Sanchez, 2003; Murray, 2004; Lofsten and Lindelof, 2005). Firm choice and behavior in the development of such networks have also been found to be dynamic and are contingent on the stage of firm's development (Perez Perez and Sanchez, 2003).

Table 5 Environmental context including networks of innovation

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Adams *et al*. (2001)	What drives an industrial lab to become a member in Industry University Cooperative Research Centers (IUCRCs)? What are the effects of IUCRCs on industrial R&D labs?	208 observations representing 220 industrial labs from a survey of 600 R&D labs owned by 200 publicly traded firms in the chemicals, machinery, electrical equipment, and transportation equipment industries.	Propensity to patents; R&D expenditures by R&D labs	Provide evidence on the influence that IUCRCs have on industrial R&D labs. There is an association between membership in IUCRCs and the importance of faculty consultants, co-authorship with faculty and hiring of graduate students into the lab. IUCRC membership contributes marginally to member industrial lab's patenting and R&D expenditures, but the effect is higher for NSF IUCRCs, likely due to their higher quality and larger size of labs.
Audretsch and Stephan (1996)	Why geography matters more in certain economic relationships than in others?	54 firms affiliated with 445 university scientists	Probability of scientist-firm contact being local	The importance of proximity is shaped by the role played by the scientists: (i) Proximity matters more in the case of founders and chairs of scientific advisory board (SABs); (ii) Proximity does not matter as much in the case of members of SABs; (iii) When knowledge is transmitted through formal ties, geographic proximity is not necessary.
Gans and Stern (2003)	What are the factors that affect strategic choice of technology entrepreneurs (TE)?	n/a	n/a	Competitive interaction between start-up innovators and established firms depends on the presence or absence of a "market for ideas." The drivers of start-up commercialization strategy are the excludability environment and the complementary asset environment. The interaction of these two environments determines the presence of a market for ideas and TE's strategic options.

Lee and Osteryoung (2004)	What contributes to the effectiveness of university business incubators (UBIs)? Are the factors different for US and Korean incubators?	39 Korean UBIs and 20 US UBIs	n/a	14 factors for the effectiveness of incubator systems, among them: goal/operations strategy, physical/human resources, incubator services, and networked program. There are no significant differences between US and Korean incubators, except for goal/operation strategy which were perceived to be more important to the directors of UBIs in the United States than those in Korea.
Lindelof and Lofsten (2003)	How do motivations of locations, strategies, collaborations and performance differ between new technology-based firms (NTBFs) in and off science parks?	10 Swedish science parks, 134 in-park firms, 139 off-park firms	n/a	There are differences but no clear pattern of differences in motivation and cooperation. No statistically significant differences for innovative performance. On-park firms collaborate less than off-park firms, but show no differences in economic performance.
Lindelof and Lofsten (2004)	Does proximity to university provide new technology-based firms (NTBFs) with competitive advantage?	In Sweden: 134 on-park NTBFs, 139 off-park NTBFs.	n/a	Park-based firms (i) put greater emphasis upon access to equipment, R&D and personal categories, (ii) are more involved in co-operation with universities, (iii) rate basic and applied research more highly, and (iv) have higher network activities. NTBF-specific co-operative resources will provide the firm with a competitive advantage.
Link and Scott (2003a)	How should we explain and model the growth of Research Triangle Park?	Research companies in Research Triangle Park from (1957–1998)	Number of research companies in Research Triangle Park from 1957 through 1998	Park's growth can be estimated in term of a simple model of diffusion. That is, park's growth equates to the adoption of innovation by companies and the park's innovative environment.

(continued)

Table 5 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Link and Scott (2003b)	What are the influences of science parks on the academic missions of universities?	88 US academic institutions	Outcomes of university's involvement with organizations in science park	A formal relationship between the university and the science park increases publication, patenting, extramural funding, ability to hire preeminent scholars, and placement of doctoral students. The closer the distance, the greater the influence of park tenants on the university's curriculum.
Loftsen and Lindelof (2002)	Are there any differences between new technology based firms (NTBFs) that locate on science parks and those that locate elsewhere?	273 firms (on and off science parks) in Sweden	Sales, number of employees	There are some differences between on- and off-park NTBFs in terms of innovation and marketing. On-park NBTFs are more likely to have linkages with universities. There is no statistically significant difference in the profitability between on- and off-park firms.
Loftsen and Lindelof (2005)	Do academic new technology-based firms (NTBFs) benefit from a Science Park location differently than those in the private sector in terms of R&D networks and product innovation?	Sweden: 134 NTBFs in science parks, 74 USOs, 60 CSOs.	n/a	University spin-off firms will use academic facility for R&D networks with university more than corporate spin-offs (CSO).
Medda *et al*. (2005)	What is the impact of joint R&D projects with universities on firm's productivity growth?	2222 Italian firms with more than 500 employees	Growth of firm's total factor productivity	Both internal and external R&D is positively associated with productivity growth. External R&D generates higher returns than internal R&D. However, investment in external R&D with universities does not appear to directly enhance firms' productivity.

Mian (1994)	What is the value-added of university business incubators?	Six incubators in the United States: three from private universities, three public universities	n/a	University business incubators provide a conducive environment for the development of new technology-based firms.
Mian (1996a)	What are the contributions of university's incubators to new technology-based firms (NTBF)?	Six university incubators in the United States: three from private universities, three from public university	n/a	There is a significant relationship between "frequency of use" and "perceived value added". Exception: cafeteria use, assistance in legal/government regulation, personal recruiting, and tax matters. All university-related services are significantly correlated. Thus, university incubators provide a nurturing environment for NTBFs.
Mian (1996b)	How do university relationships provide a nurturing environment for the survival and growth of small research technology-based firms?	Two established university business incubator programs – the Enterprise Development Inc. at Case Western Research University, and the Ben Craig Center at University of North Carolina at Charlotte.	n/a	University-based incubators provide the necessary resources and environment that help the survival and growth of research technology based firms (as measured by jobs created and sales).
Mian (1997)	How can we assess the performance of university technology-based incubators (UTBIs)?	Four UTBIs and their 29 tenant firms	n/a	UTBIs are assessed in three categories: (i) Performance outcomes - program sustainability and growth, tenant firm's sustainability and growth, and contributions to the sponsoring university's mission; (ii) management policies and their effectiveness; (iii) services to tenants and their value-added.

(continued)

Table 5 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Mowery and Sampat (2001a)	What the history of the Research Corporation can tell about the trend and challenges of managing universities' licensing?	Costs associated with the operation of the Research Corporation, among other data.	n/a	The paper discusses the history of the Research Corporation (a technology intermediary originated from UC Berkeley). The evidence suggests that the decline of the Corporation's role as a manager of patent licensing for US universities has its root before 1980 when the Corporation had growing deficits during 1970s, and also was attributed to Bayh-Dole Act, and factors in universities' licensing offices. The history reflects many contemporary challenges faced by US universities in managing licensing and research relationships with industry.
Murray (2004)	How does academic inventors' social capital contribute to the embeddedness of entrepreneurial firms?	25 interviews, patent and publication data of 23 biotechnology firms (US East Coast)	n/a	Elements of social capital can be translated by the firm into embeddedness: (i) Academic's local laboratory network, (ii) Cosmopolitan network of colleagues, collaborators and members of invisible college.
Owen-Smith *et al*. (2002)	How do the US research organization-industry innovation networks differ from those of European?	1026 links (public research organizations and biotech firms); 4358 collaborative R&D projects; 8031 patents	Cross-national network of R&D projects involving PROs and commercial entities; Organizational level patent co-assignment network for PROs; Co-location of prolific European patentees and therapeutic classes; Co-location of prolific US patentees	In the United States, public research organizations (PROs) and small firms conduct R&D across multiple therapeutic areas and stages. In Europe, innovative networks are characterized by sparser, more specialized relationship among a more limited set of organizational participants. Alterations in the scale of patenting activity alone without corresponding shifts in the division of labor will not make the European system resemble its American counterpart.

Palmai (2004)	What is the nature of and opportunity for a university research and incubation park?	One science park in Hungary	n/a	The scientific/innovation park was conceived as a spin-off from university. It created virtual research teams, virtual firms, and university spin-off firms. It can create a wider market for technological development if adapting to the specific external condition.
Perez Perez and Sanchez (2003)	How active in network development and technology transfer are university spin-offs during their early years?	Spanish university spin-offs (1990–2000)	n/a	University spin-offs are more dynamic in technology transfer and network formation during their early years. But over time both activities decreased while the relationships with customers increased.
Peters *et al*. (2004)	Do incubators facilitate the entrepreneurial process and if they do, how?	48 incubators: 19 non-profit, 14 universities-based, and 15 for profits incubators.	n/a	There is a significant difference in the number of companies graduating among the three types of incubators (non-profit, for-profit, and university-based). The success of incubators relates mostly to the presence of coaching and access to networks. Characteristics and quality of networking also varied by incubator types.
Phan *et al*. (2005)	How can we better understand science parks and incubators?	n/a	n/a	There is no systematic framework to understand science parks and incubators. There is a failure to understand their dynamic nature as well as that of the companies located in them. There is a lack of clarity regarding the performance of science parks and incubators which is associated with problems in identifying the nature of performance.

(continued)

Table 5 Continued

Study	Research question(s)	Data	Dependent variable(s)	Key findings
Quintas *et al.* (1992)	How do science parks link academic research with industrial activity?	UK science parks from UKSPA data	n/a	Link mechanism: spin-off firms and research collaboration. Deficiency of science park model: (i) Mismatches between academic research output and R&D needs of science park firms, (ii) Science parks' restriction on manufacturing activity.
Rothaermel and Thursby (2005b)	How does knowledge flow from universities to incubator firms? How do these flows affect the performance of the new technology ventures?	79 tech ventures incubated at Georgia Tech	Firm performance proxied by: revenues, total funds raised, VC funding, failure/graduation/ remain in incubator	Knowledge flows from university to incubator firms through contractual and non-contractual ways. The knowledge flows increased firms' absorptive capacity which positively related to firm performance.
Siegel *et al.* (2003c)	What are the impacts of park's technological spillover on firm's research productivity? Are in-park firms more efficient in R&D?	89 firms in-park and 88 firms out-park in the UK	The number of new products/services, the number of patents applied or awarded, the number of copyrights, and relative productivity	In-park firms have slightly higher research productivity than that off-park firms. This difference is not so strong after controlling for endogeneity bias.
Siegel *et al.* (2003d)	What are the performance differentials between firms located in the science parks and those outside science parks? Why do the differences exist?	n/a	n/a	The "returns" to being located on a science park are negligible. These results may be due to imprecise estimates of these returns to different types of science parks.
Vedovello (1997)	What is the extent to which a science park facilitates the university-firm links?	One British science park	n/a	Science park can facilitate the establishment of informal and human resources links. Yet, links related to research activity is not substantially facilitated.

Westhead and Storey (1995)	Is there any evidence that the development of HEI (Higher Education Institution)—industry links encourages wealth creation and job generation?	UK data. In 1986: 284 interviews (183 in-park firms, and 101 off-park firms). In 1992: 119 in-park firms and 72 off-park firms.	Company status (survival or failure)	Link to HEI increases the likelihood of survival regardless of the location (in or off park).
Zucker and Darby (2001)	What are the effects of star scientists on the success of biotechnology industry in Japan?	327 star scientists	The numbers of US biotechnology patents granted, number of products in development, number of products in the market	Collaboration between university star scientists and firms increase firms' research productivity, biotech patents, products in development, and products on the market. There is little evidence of geographically localized knowledge spillovers.
Zucker *et al*. (2002)	What is the value of knowledge, especially tacit knowledge, at the time of commercially relevant scientific breakthroughs?	Stars scientists and scientists at top 112 US universities, joint articles, venture capital funding, and patents	Cumulative patents granted, cumulative citation-weighted patents granted, total products in development, total human therapies and vaccines development, total products on the market, total human therapies and vaccines on the market, total employees	Working jointly is a crucial transfer mechanism when knowledge has a large tacit dimension. The study also shows that tacit knowledge is embodied by individuals.

The second element of environmental contexts of innovation concerns science parks. Studies of science parks attempt to answer questions pertaining to the nature of science parks and their impact. Insights here include an understanding of science parks as novel innovative environments, which in turn allows their growth to be modeled using an adoption of the innovation model (Link and Scott, 2003a,b). Other insights pertain to the purpose of science parks as links of technology transfer through spin-offs, research collaborations, and informal points of accessibility to various resources, including human resources (Quintas *et al.*, 1992; Vedovello, 1997; Siegel *et al.*, 2003c).

Research on science parks also attempts to answer questions related to their impact on firm members as well as on academic missions of affiliated universities. Scholars studying the impact of science parks on member firms have not found convincing evidence that membership in science parks is effective in contributing to a firm's economic performance (Westhead and Storey, 1995; Lofsten and Lindelof, 2002; Lindelof and Lofsten, 2003), although they have found differences in underlying factors that lead to higher economic performance, such as motivation of founders, cooperation, and networking opportunities with universities (Westhead and Storey, 1995; Lindelof and Lofsten, 2003; Lofsten and Lindelof, 2005). Unlike the numerous studies on member firms' performance, research on the impact of science parks on university missions is limited. Contributing to the ongoing debate surrounding the mission and identity of university systems, the few current studies show that universities are able to effectively perform in both their research and teaching capacities (e.g., increase in publications and ability to hire and retain prominent scholars), as well as their entrepreneurial capacities (e.g., increase in patenting, placement of doctoral students, and extramural funding) (Link and Scott, 2003b). Phan *et al.* (2005) provide an insightful review of the literature on science parks and incubators.

In addition to innovation networks and science parks, another aspect of the environmental context for entrepreneurial activities is a university's technology business incubator (UTBI). Current studies have contributed to our understanding of key success factors of UTBIs (Peters *et al.*, 2004; Link and Scott, 2003b), their value added (Mian, 1994, 1996a), and how best to assess their performance (Mian, 1997; Peters *et al.*, 2004). Studies on UTBIs have also attempted to answer questions pertaining to their impact on firm members' performance (Mian 1996b, 1997; Peters *et al.*, 2004; Rothaermel and Thursby, 2005a,b). Moreover, scholars have identified sources of UTBI impact, including general as well as specific UTBI services (e.g., coaching and networking), and the strength of ties between member firms with UTBIs and their sponsoring universities (Mian, 1997; Peters *et al.*, 2004; Rothaermel and Thursby, 2005a).

The geographic location of universities has also been of interest to researchers. One important issue is whether universities are part of a regional technology cluster (Audretsch and Stephan, 1996). Research on geographical locations has

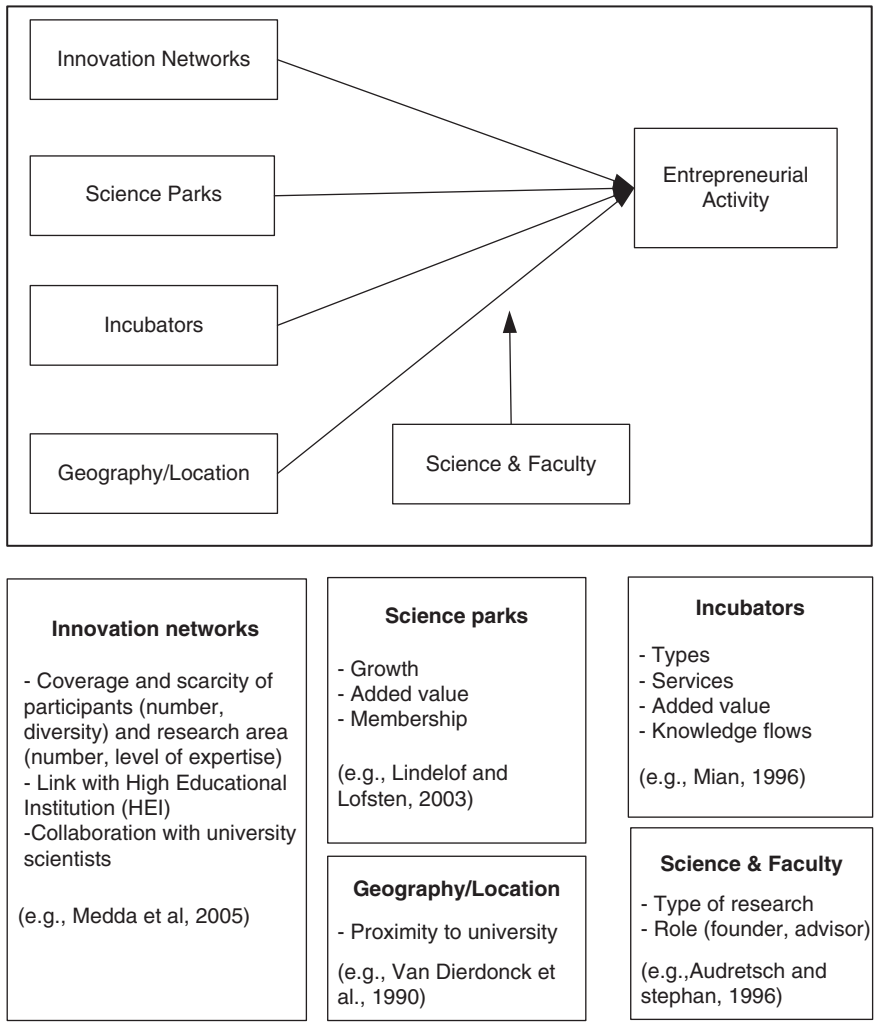

Figure 8 Environmental context including networks of innovation.

provided us with an understanding that geographical proximity of start-up firms to universities can be both an antecedent and a consequence of entrepreneurial efforts. For instance, scholars have found that geographical proximity of start-ups to universities is determined by the need to transfer tacit knowledge (Audretsch and Stephan, 1996; Vedovello, 1997). There is also evidence pointing to the impact of proximity to universities on the competitive advantages of new technology-based firms (Lindelof and Lofsten, 2004). Table 5 presents the relevant studies in this research stream, while Figure 8 provides a schematic overview of this research stream, with representative articles that focus on certain key aspects in the boxes below the figure.

A closer look at this rich research allows us to note some conflicting findings. While some studies on innovation networks have informed us that there is no evidence on the impact of such networks on a firm's R&D output (Lofsten and Lindelof, 2005), other studies have shown that R&D networks in the form of joint projects do increase a firm's R&D output (Zucker and Darby, 2001). This discrepancy begs for future studies to address how R&D network activities differ in their impact on a firm's R&D output. Do some network activities require certain conditions in order to have a positive effect on a firm's R&D output?

Mixed findings in the studies of science parks also pertain to their impact on a firm's R&D productivity. Some scholars find no evidence that science park membership has any effect on R&D productivity (Lindelof and Lofsten 2003; Lofsten and Lindelof, 2005), while others find that members have slightly higher research productivity (Siegel *et al.*, 2003c). Although the contradicting results are based on different methods (Lindelof and Lofsten (2003) and Lofsten and Lindelof (2005) employ F-tests to find differences between members and non-members, while Siegel *et al.* (2003c) uses regression models based on Griliches (1994)'s R&D production function), these findings point to the need for further study, and possibly the need to consider mediating or moderating factors. In addition, current research has not addressed why the potential for economic returns, a result of membership in science parks, has not been translated into documented higher economic returns.

Other future areas for study in this research stream pertain to a deeper understanding of diverse linkages in networks of innovation. That is, most studies to date have focused on only one particular linkage: recruitment of human capital (i.e., scientists) (Zucker and Darby, 2001; Zucker *et al.*, 2002; Murray, 2004, exception Medda *et al.*, 2005). Moreover, there is a notable absence of studies comparing the effectiveness of various types of linkages that a firm can employ in connecting with a university (exception Rothaermel and Thursby, 2005a). For example, how do different types of linkages affect firm performance and growth? Are different types of linkages complements or substitutes? What types of linkages are more critical at different stages of firm development?

Other important avenues for future research should examine factors that make a network of innovation, science parks, and incubators more productive than others (exceptions Peters *et al.*, 2004; Link and Scott, 2003b). In addition, because most research has treated networks of innovation, science parks, and incubators as external and thus given, future research can contribute by addressing the challenge of how to effectively build and manage necessary institutions within the system of university entrepreneurship.

4.5 Contextual issues of university entrepreneurship studies

Although the field is quite international, most studies to date focus on university entrepreneurship in the United States and selected European countries.

Only a few studies compare or contrast university commercialization activities across countries (Roberts and Malone, 1996; Jones-Evans and Klofsten, 1999; Collins and Wakoh, 2000; Etzkowitz *et al.*, 2000; Klofsten and Jones-Evans, 2000; Owen-Smith *et al.*, 2002; Goldfarb and Henrekson, 2003; Mowery and Sampat, 2005). Because of this, it is far from clear whether universities rooted in other cultures or situated in different economic contexts (e.g., transitional economies) are likely to show the same patterns of entrepreneurial activities or the same dynamics as described in the framework developed herein (Figure 4). Research on the process of technology transfer and technology diffusion has identified different levels of difficulty in the United States (Siegel *et al.*, 2003a,b, 2004), Japan (Collins and Wakoh, 2000) and various European countries [e.g., Sweden and Ireland, see Jones-Evans and Klofsten (1999), Goldfarb and Henrekson (2003), United Kingdom Franklin *et al.* (2001)]. It seems a plausible working hypothesis that each entrepreneurial university system needs to incorporate respective local institutional and cultural dimensions (Collins and Wakoh, 2000), and that differences in economic development and culture may significantly impact the necessary redesign and incentives for a university system to become more entrepreneurial. A promising avenue exists for scholars to test the validity of prior findings and to generate new insights pertaining to the evolution of university innovation systems across the world.

In addition to cultural differences across countries, studies on entrepreneurial universities need to address differences across institutions (i.e., academic institutions versus business institutions). In contrast to the large body of knowledge on business institutions, our understanding of academic institutions from an organizational perspective is quite limited. A fairly large number of publications on the university system have contributed mainly to the identification of different factors in the system's black box, such as the university's incentive structures, entrepreneurial culture, and university policies. A few pioneering studies (Etzkowitz, 2003; Etzkowitz and Klofsten, 2005) have moved further in their attempt to reveal what resides inside the black box, and identify university organizational designs as a key construct of interest. Again, initiating and facilitating change in a university system is a challenging task, as universities are bureaucratic organizations traditionally designed to primarily advance their teaching and research missions.

Our review also reveals that a university's past experience in technology transfer is a consistent antecedent to university entrepreneurship, implying that an organizational learning framework can be a useful lens in future studies. Other research streams in organizational theory, such as organizational design or politics and power, may also be useful in the study of university systems and networks of innovation. As more universities become entrepreneurial, future studies should more deeply investigate the balance between a university system's academic and entrepreneurial roles in the global innovation systems.

5. Conclusion

We submit that the collective scholarship on university entrepreneurship has created a critical mass over the last 25 years that can not only provide guidance to policy makers and other practitioners, but has also progressed and evolved to a point where it is ready to be published in many of the premier academic journals, and thus move beyond a niche field into the mainstream of scholarly debate.

When synthesizing the results of this literature review, it becomes clear that questions pertaining to university entrepreneurship go to the heart of multidisciplinary areas of study. For example, the study of new firm creation based on university inventions can be leveraged to address one of the most important and vexing questions in strategic management today: Where do capabilities come from? Another avenue for future contributions may be to focus on the network context of university inventions, and to leverage this focus into pursuing key issues such as the effects of social embeddedness on economic actions, with the help of theories rooted in sociology (Powell and Owen-Smith, 1998; Owen-Smith and Powell, 2003). Economists can examine the different incentive systems that explain certain behaviors and outcomes within the university entrepreneurial system (Jensen and Thursby, 2001). By addressing key disciplinary questions in the context of entrepreneurial universities, scholars can help to move this fascinating research stream into the premier mainstream journals in their respective disciplines, and in turn to enhance the visibility and build impact for this important new field of research.

Acknowledgements

We thank the co-guest editors Donald Siegel, Mike Wright, and Andy Lockett, the anonymous reviewers, as well as Gerry George, Sanjay Jain, Gideon Markman, Lesa Mitchell (of the Kauffman Foundation), Philippe Mustar, Phil Phan, and Scott Shane for helpful comments and suggestions. A prior version of this article was presented at the 2006 Technology Transfer Society Annual Conference. We thank the seminar participants for valuable comments and suggestions. We also thank Karyn Lu for expert copy editing.

Rothaermel gratefully acknowledges support for this research from the Kauffman Foundation, National Science Foundation (CAREER Award, NSF SES 0545544), and the Sloan Foundation (Industry Studies Fellowship). Rothaermel is an Affiliate of the Sloan Biotechnology Industry Center at the University of Maryland. All opinions expressed as well as all errors and omissions are entirely the authors'.

Addresses for correspondence

Frank T. Rothaermel, College of Management, Georgia Institute of Technology, Atlanta, GA 30332-0520, USA. e-mail: frank.rothaermel@mgt.gatech.edu
Shanti D. Agung, College of Management, Georgia Institute of Technology, Atlanta, GA 30332-0520, USA. e-mail: shanti.agung@mgt.gatech.edu
Lin Jiang, College of Management, Georgia Institute of Technology, Atlanta, GA 30332-0520, USA. e-mail: lin.jiang@mgt.gatech.edu

References

Adams, J. D., E. P. Chiang and K. Starkey (2001), 'Industry-University Cooperative Research Centers,' *Journal of Technology Transfer*, **26**(1–2), 73.

(*)Agrawal, A. (2006), 'Engaging the inventor: exploring licensing strategies for university inventions and the role of latent knowledge,' *Strategic Management Journal*, **21**(1), 63–79.

Agrawal, A. and R. Henderson (2002), 'Putting patents in context: exploring knowledge transfer from MIT,' *Management Science*, **48**(1), 44–60.

(*)Aldrich, H. E. and T. Baker (1997), 'Blinded by the cites? Has there been progress in entrepreneurship research?,' in D. L. Sexton and R. W. Smilor (eds), *Entrepreneurship 2000*. Upstart Publishing: Chicago, Ill, pp. 377–400.

(*)Ansoff, H. I. (1965), *Corporate Strategy. An Analytic approach to business policy for growth and expansion*. McGraw-Hill: New York.

Argyres, N. S. and J. P. Liebeskind (1998), 'Privatizing the intellectual commons: universities and the commercialization of biotechnology,' *Journal of Economic Behavior & Organization*, **35**(4), 427–454.

Audretsch, D. B. and E. E. Lehmann (2005), 'Do University policies make a difference?,' *Research Policy*, **34**(3), 343–347.

Audretsch, D. B. and P. E. Stephan (1996), 'Company-scientist locational links: the case of biotechnology,' *The American Economic Review*, **86**(3), 641–652.

Bains, W. (2005), 'How academics can make (extra) money out of their science,' *Journal of Commercial Biotechnology*, **11**(4), 353–363.

Bania, N., R. W. Eberts and M. S. Fogarty (1993), 'Universities and the startup of new companies: can we generalize from route 128 and Silicon valley?,' *The Review of Economics and Statistics*, **75**(4), 761–766.

Bell, E. R. J. (1993), 'Some Current issues in technology transfer and academic-industrial relations: a review,' *Technology Analysis & Strategic Management*, **5**(3), 307–321.

Bercovitz, J., M. Feldman, I. Feller and R. Burton (2001), 'Organizational structure as a determinant of academic patent and licensing behavior: an exploratory study of Duke, Johns Hopkins, and Pennsylvania state Universities,' *Journal of Technology Transfer*, **26**(1–2), 21–35.

Bray, M. J. and J. N. Lee (2000), 'University revenues from technology transfer: licensing fees versus equity positions,' *Journal of Business Venturing*, **15**(5–6), 385–392.

Brouwer, M. (2005), 'Entrepreneurship and university licensing,' *Journal of Technology Transfer*, **30**(3), 263–270.

(*)Busenitz, L. W., G. P. West III, D. Shepherd, T. Nelson and G. N. Chandler (2003), 'Entrepreneurship research in emergence: past trends and future directions,' *Journal of Management*, **29**(3), 285–308.

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.

(*)Chandler, A. D. (1962), *Strategy and Structure. Chapters in the History of the Industrial Enterprise*. MIT Press: Cambridge, MA.

Chapple, W., A. Lockett, D. S. Siegel and M. Wright (2005), 'Assessing the relative performance of U.K. University technology transfer offices: parametric and non-parametric evidence,' *Research Policy*, **34**(3), 369–384.

(*)Chesbrough, H. W. (2003), *Open Innovation. The New Imperative for Creating and Profiting from Technology*. Harvard Business School Press: Boston, MA.

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.

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.

(*)Christensen, C. M., P. Carlile, D. Sundahl (2002), The process of theory-building. *Working paper*, Harvard Business School, Boston, MA.

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.

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.

Cohen, W. M., R. R. Nelson and J. P. Walsh (2002), 'Links and impacts: the influence of public research on industrial R&D,' *Management Science*, **48**(1), 1–23.

Collins, S. and H. Wakoh (2000), 'Universities and technology transfer in Japan: recent reforms in historical perspective,' *Journal of Technology Transfer*, **25**(2), 213–222.

Colyvas, J., M. Crow, A. Gelijns, R. Mazzoleni, R. R. Nelson, N. Rosenberg *et al.* (2002), 'How do University inventions get into practice?,' *Management Science*, **48**(1), 61–72.

Conceicao, P., M. V. Heitor and P. Oliveira (1998), 'University-based technology licensing in the knowledge based economy,' *Technovation*, **18**(10), 615–625.

Coupe, T. (2003), 'Science is golden: academic R&D and university patents,' *Journal of Technology Transfer*, **28**(1), 31–46.

(*)Darby, M. R. and L. G. Zucker (2006), 'Grilichesian breakthroughs: inventions of methods of inventing and firm entry in nanotechnology,' *Annales d'Economie et Statistique*, in press.

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.

Debackere, K. and R. Veugelers (2005), 'The role of academic technology transfer organizations in improving industry science links,' *Research Policy*, **34**(3), 321–342.

Degroof, J.-J. and E. B. Roberts (2004), 'Overcoming weak entrepreneurial infrastructures for academic spin-off ventures,' *Journal of Technology Transfer*, **29**(3–4), 327–352.

Del Campo, A. A., A. Sparks, R. C. Hill and R. T. Keller (1999), 'The transfer and commercialization of University-developed Medical Imaging Technology: opportunities and problems,' *IEEE Transactions on Engineering Management*, **46**(3), 289–299.

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

Doutriaux, J. (1987), 'Growth pattern of academic entrepreneurial firms,' *Journal of Business Venturing*, **2**(4), 285.

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

(*)EIMS (European Innovation Monitoring System) (1995), *Good Practice in the Transfer of University Technology to Industry*. EIMS Publication No 26, http://cordis.europa.eu/eims/src/eims-r26.htm.

Ensley, M. D. and K. M. 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.

Etzkowitz, H. (1998), 'The norms of entrepreneurial science: cognitive effects of the new university-industry linkages,' *Research Policy*, **27**(8), 823–833.

Etzkowitz, H. (2003), 'Research groups as 'quasi-firms': the invention of the entrepreneurial university,' *Research Policy*, **32**(1), 109–121.

Etzkowitz, H. and M. Klofsten (2005), 'The innovating region: toward a theory of knowledge-based regional development,' *R & D Management*, **35**(3), 243–255.

Etzkowitz, H., A. Webster, C. Gebhardt and B. R. C. Terra (2000), 'The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm,' *Research Policy*, **29**(2), 313–330.

(*)Evans, D. S. and B. Jovanovic (1989), 'An estimated model of entrepreneurial choice under liquidity constraints,' *Journal of Political Economy*, **97**(4), 808–827.

Feldman, M. and P. Desrochers (2003), 'Research universities and local economic development: lessons from the history of Johns Hopkins University,' *Industry and Innovation*, **10**(1), 5–24.

Feldman, M., I. Feller, J. Bercovitz and R. Burton (2002), 'Equity and the technology transfer strategies of American Research Universities,' *Management Science*, **48**(1), 105–121.

Feller, I. (1990), 'Universities as engines of R&D-based economic growth: they think they can,' *Research Policy*, **19**(4), 335.

Fontes, M. (2005), 'The process of transformation of scientific and technological knowledge into economic value conducted by biotechnology spinoffs,' *Technovation*, **25**(4), 339–347.

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.

Freier, S. (1986), 'Parks of science-based industries in Israel,' *Technovation*, **4**(3), 183–187.

Friedman, J. and J. Silberman (2003), 'University technology transfer: do incentives, management, and location matter?,' *Journal of Technology Transfer*, **28**(1), 17–30.

Gans, J. S. and S. Stern (2003), 'The product market and the market for ideas: commercialization strategies for technology entrepreneurs,' *Research Policy*, **32**(2), 333–350.

George, G. (2005), 'Learning to be capable: patenting and licensing at the Wisconsin Alumni Research Foundation 1925–2002,' *Industrial and Corporate Change*, **14**(1), 119–151.

Geuna, A. (1998), 'Determinants of university participation in EU-funded R&D cooperative projects,' *Research Policy*, **26**(6), 677.

Goldfarb, B. and M. Henrekson (2003), 'Bottom-up versus top-down policies towards the commercialization of university intellectual property,' *Research Policy*, **32**(4), 639.

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

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

Grigg, T. (1994), 'Adopting an entrepreneurial approach in universities,' *Journal of Engineering and Technology Management*, **11**(3–4), 273–298.

(*)Griliches, Z. (1994), 'Productivity, R&D, and the data constraint,' *American Economic Review*, **84**(1), 1–23.

Gubeli, M. H. and D. Doloreux (2005), 'An empirical study of university spin-off development,' *European Journal of Innovation Management*, **8**(3), 269–282.

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

Hall, B. H., A. N. Link and J. T. Scott (2001), 'Barriers inhibiting industry from partnering with universities: evidence from the advanced technology program,' *Journal of Technology Transfer*, **26**(1–2), 87.

Hall, B. H., A. N. Link and J. T. Scott (2003), 'Universities as research partners,' *Review of Economics & Statistics*, **85**(2), 485–491.

Harmon, B., A. Ardishvili, R. Cardozo, T. Elder, J. Leuthold, J. Parshall *et al.* (1997), 'Mapping the university technology transfer process,' *Journal of Business Venturing*, **12**(6), 423–434.

Henderson, R., A. B. Jaffe and M. Trajtenberg (1998), 'Universities as a source of commercial technology: a detailed analysis of university patenting, 1965–1988,' *Review of Economics and Statistics*, **80**(1), 119–127.

Henrekson, M. and N. Rosenberg (2001), 'Designing efficient institutions for science-based entrepreneurship: lesson from the US and Sweden,' *Journal of Technology Transfer*, **26**(3), 207–231.

Hicks, D., T. Breitzman, D. Olivastro and K. Hamilton (2001), 'The changing composition of innovative activity in the US - a portrait based on patent analysis,' *Research Policy*, **30**(4), 681.

(*)Ireland, D. R., C. R. Reutzel and J. W. Webb (2005), 'From the editors: entrepreneurship research in *AMJ*: What has been published, and what might the future hold?,' *Academy of Management*, **48**(4), 556–564.

Jackson, S. and D. B. Audretsch (2004), 'The Indiana University Advanced Research and Technology Institute: a case study,' *Journal of Technology Transfer*, **29**(2), 119.

Jacob, M., M. Lundqvist and H. Hellsmark (2003), 'Entrepreneurial transformations in the swedish university system: the case of Chalmers University of Technology,' *Research Policy*, **32**(9), 1555–1568.

Jensen, R. A. and M. C. Thursby (2001), 'Proofs and prototypes for sale: the licensing of university inventions,' *American Economic Review*, **91**(1), 240–259.

Jensen, R. A., J. G. Thursby and M. C. Thursby (2003), 'Disclosure and licensing of university inventions: 'the best we can do with the S**T we get to work with?,' *International Journal of Industrial Organization*, **21**(9), 1271–1300.

Johansson, M., M. Jacob and T. Hellstrom (2005), 'The strength of strong ties: university spin-offs and the significance of historical relations,' *Journal of Technology Transfer*, **30**(3), 271–286.

Jones-Evans, D. and M. Klofsten (1999), 'Creating a bridge between university and industry in small European Countries: the role of the industrial liaison office,' *R & D Management*, **29**(1), 47–56.

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.

Kinsella, R. and V. McBrierty (1997), 'Campus companies and the emerging techno-academic paradigm: the Irish experience,' *Technovation*, **17**(5), 245–251.

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.

(*)Kuhn, T. S. (1962), *The Structure of Scientific Revolutions*. University of Chicago Press: Chicago, IL.

Laukkanen, M. (2003), 'Exploring academic entrepreneurship: drivers and tensions of university-based business,' *Journal of Small Business and Enterprise Development*, **10**(4), 372–382.

Lee, S. S. and J. S. Osteryoung (2004), 'A comparison of critical success factors for effective operations of university business incubators in the United States and Korea,' *Journal of Small Business Management*, **42**(4), 418–426.

Lee, Y. S. (1996), 'Technology transfer and the research university: a search for the boundaries of university-industry collaboration,' *Research Policy*, **25**, 843–863.

Lee, Y. S. (2000), 'The sustainability of university-industry research collaboration: an empirical assessment,' *Journal of Technology Transfer*, **25**(2), 111.

Lee, Y. S. and R. Gaertner (1994), 'Technology transfer from university to industry: a large-scale experiment with technology development and commercialization,' *Policy Studies Journal*, **22**(2), 384–399.

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.

(*)Lerner, J. (1995), 'Venture capitalists and the oversight of private firms,' *Journal of Finance*, **50**(1), 301–318.

Lerner, J. (2005), 'The university and the start-up: lessons from the past two decades,' *Journal of Technology Transfer*, **30**(1–2), 49–56.

Lindelof, P. and H. Lofsten (2003), 'Science park location and new technology-based firms in Sweden - implications for strategy and performance,' *Small Business Economics*, **20**(3), 245–258.

Lindelof, P. and H. Lofsten (2004), 'Proximity as a resource base for competitive advantage: university-industry links for technology transfer,' *Journal of Technology Transfer*, **29**(3–4), 311–326.

Link, A. N. and J. T. Scott (2003a), 'The growth of research triangle park,' *Small Business Economics*, **20**(2), 167–175.

Link, A. N. and J. T. Scott (2003b), 'U.S. science parks: the diffusion of an innovation and its effects on the academic mission of universities,' *International Journal of Industrial Organization*, **21**(9), 1323–1356.

Link, A. N. and J. T. Scott (2005a), 'Opening the Ivory tower's door: an analysis of the determinants of the formation of U.S. university spin-off companies,' *Research Policy*, **34**(7), 1106–1112.

Link, A. N. and J. T. Scott (2005b), 'Universities as partners in U.S. research joint ventures,' *Research Policy*, **34**(3), 385–393.

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

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

(*)Lockett, A., J. Moon and W. Visser (2006), 'Corporate social responsibility in management research: focus, nature, salience and sources of influence,' *Journal of Management Studies*, **43**(1), 115–135.

Lockett, A., M. Wright and S. J. Franklin (2003), 'Technology transfer and universities' spin-out strategies,' *Small Business Economics*, **20**(2), 185–200.

Lofsten, H. and P. Lindelof (2002), 'Science parks and the growth of new technology-based firms - academic-industry links, innovation and markets,' *Research Policy*, **31**(6), 859.

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.

Louis, K. S., D. Blumenthal, M. E. Gluck and M. A. Stoto (1989), 'Entrepreneurs in academe: an exploration of behaviors among life scientists,' *Administrative Science Quarterly*, **34**(1), 110–131.

Louis, K. S., L. M. Jones, M. S. Anderson, D. Blumenthal and E. G. Campbell (2001), 'Entrepreneurship, secrecy, and productivity: a comparison of clinical and non-clinical life sciences faculty,' *Journal of Technology Transfer*, **26**(3), 233–245.

Lowe, J. (1993), 'Commercialization of university research: a policy perspective,' *Technology Analysis & Strategic Management*, **5**(1), 27–37.

Mansfield, E. (1991), 'Academic research and industrial innovation,' *Research Policy*, **20**(1), 1–12.

Mansfield, E. (1995), 'Academic research underlying industrial innovations: sources, characteristics, and financing,' *Review of Economics and Statistics*, **77**(1), 55–65.

Mansfield, E. (1998), 'Academic research and industrial innovation: an update of empirical findings,' *Research Policy*, **26**(7–8), 773–776.

Markman, G. D., P. T. Gianiodis, P. H. Phan and D. B. Balkin (2004), 'Entrepreneurship from the Ivory tower: do incentive systems matter?,' *Journal of Technology Transfer*, **29**(3–4), 353–364.

Markman, G. D., P. T. Gianiodis, P. H. Phan and D. B. Balkin (2005a), 'Innovation speed: transferring university technology to market,' *Research Policy*, **34**(7), 1058–1075.

Markman, G. D., P. H. Phan, D. B. Balkin and P. T. Gianiodis (2005b), 'Entrepreneurship and university-based technology transfer,' *Journal of Business Venturing*, **20**(2), 241–263.

McQueen, D. H. and J. T. Wallmark (1982), 'Spin-off companies from chalmers university of technology,' *Technovation*, **1**(4), 305–315.

(*)McWilliams, A., D. S. Siegel and P. M. Wright (2006), 'Corporate social responsibility: strategic implications,' *Journal of Management Studies*, **43**(1), 2–17.

Medda, G., C. Piga and D. S. Siegel (2005), 'University R&D and firm productivity: evidence from Italy,' *Journal of Technology Transfer*, **30**(1–2), 199–205.

Meseri, O. and S. Maital (2001), 'A survey analysis of university-technology transfer in Israel: evaluation of projects and determinants of success,' *Journal of Technology Transfer*, **26**(1–2), 115.

Mian, S. A. (1994), 'US university-sponsored technology incubators: an overview of management, policies and performance,' *Technovation*, **14**(8), 515–528.

Mian, S. A. (1996a), 'Assessing value-added contributions of university technology business incubators to tenant firms,' *Research Policy*, **25**(3), 325–335.

Mian, S. A. (1996b), 'The university business incubator: a strategy for developing new research/technology-based firms,' *Journal of High Technology Management Research*, **7**(2), 191–208.

Mian, S. A. (1997), 'Assessing and managing the university technology business incubator: an integrative framework,' *Journal of Business Venturing*, **12**(4), 251–285.

(*)Mintzberg, H. and J. A. Waters (1985), 'Of strategies, deliberate and emergent,' *Strategic Management Journal*, **6**(3), 257.

Mok, K. H. (2005), 'Fostering entrepreneurship: changing role of government and higher education governance in Hong Kong,' *Research Policy*, **34**(4), 537.

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

Morgan, R. P., C. Kruytbosch and N. Kannankutty (2001), 'Patenting and invention activity of U.S. scientists and engineers in the academic sector: comparisons with industry,' *Journal of Technology Transfer*, **26**(1–2), 173.

Mowery, D. C., R. R. Nelson, B. N. Sampat and A. A. Ziedonis (2001), 'The growth of patenting and licensing by the U.S. universities: an assessment of the effects of the Bayh-Dole act of 1980,' *Research Policy*, **30**(1), 99–119.

Mowery, D. C. and B. N. Sampat (2001a), 'Patenting and licensing university inventions: lessons from the history of the research corporation,' *Industrial and Corporate Change*, **10**(2), 317–355.

Mowery, D. C. and B. N. Sampat (2001b), 'University patents and patent policy debates in the USA, 1925–1980,' *Industrial and Corporate Change*, **10**(3), 781–814.

Mowery, D. C. and B. N. Sampat (2005), 'The Bayh-Dole act of 1980 and university-industry technology transfer: a model for other OECD governments?,' *Journal of Technology Transfer*, **30**(1–2), 115.

Mowery, D. C., B. N. Sampat and A. A. Ziedonis (2002), 'Learning to patent: institutional experience, learning, and the characteristics of U.S. university patents after the Bayh-Dole act, 1981–1992,' *Management Science*, **48**(1), 73–89.

Mowery, D. C. and A. A. Ziedonis (2002), 'Academic patent quality and quantity before and after the Bayh-Dole act in the United States,' *Research Policy*, **31**, 399–418.

(*)Mowery, D. C., R. R. Nelson, B. N. Sampat and A. A. Ziedonis (2004), *Ivory Tower and Industrial Innovation. University-Industry Technology Transfer Before and After the Bayh-Dole Act.* Stanford University Press: Palo Alto, CA.

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

(*)Mustar, P., M. Renault, M. G. Colombo, E. Piva, M. Fontes, Lockett *et al.* (2006), 'Conceptualising the heterogeneity of research-based spin-offs: a multi-dimensional taxonomy,' *Research Policy*, **35**(2), 289–308.

Narin, F., S. Kimberley, S. Hamilton and D. Olivastro (1997), 'The increasing linkage between U.S. technology and public science,' *Research Policy*, **26**(3), 317–330.

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

Nelson, A. J. (2005), 'Cacophony or harmony? multivocal logics and technology licensing by the Stanford University Department of Music,' *Industrial and Corporate Change*, **14**(1), 93–118.

Nelson, R. R. (2001), 'Observations on the post-Bayh-Dole rise of patenting at American universities,' *Journal of Technology Transfer*, **26**(1–2), 13.

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.

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

Nicolaou, N. and S. Birley (2003b), 'Social networks in organizational emergence: the university spinout phenomenon,' *Management Science*, **49**(12), 1702–1725.

Oliver, L. A. (2004), 'Biotechnology entrepreneurial scientists and their collaborations,' *Research Policy*, **33**(4), 583.

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

O'Shea, R. P., T. J. Allen, C. O'Gorman and F. Roche (2004), 'Universities and technology transfer: a review of academic entrepreneurship literature,' *Irish Journal of Management*, **25**(2), 11–29.

Owen-Smith, J. (2003), 'From separate systems to a hybrid order: accumulative advantage across public and private science at research one universities,' *Research Policy*, **32**(6), 1081.

Owen-Smith, J. and W. W. Powell (2001), 'To patent or not: faculty decisions and institutional success at technology transfer,' *Journal of Technology Transfer*, **26**(1–2), 99–114.

Owen-Smith, J. and W. W. Powell (2003), 'The expanding role of university patenting in the life sciences: assessing the importance of experience and connectivity,' *Research Policy*, **32**(9), 1695–1711.

Owen-Smith, J., M. Riccaboni, F. Pammolli and W. W. Powell (2002), 'A comparison of U.S. and European University-industry relations in the life sciences,' *Management Science*, **48**(1), 24–43.

Palmai, Z. (2004), 'An innovation park in Hungary: innotech of the Budapest university of technology and economics,' *Technovation*, **24**(5), 421–432.

(*)Penrose, E. T. (1959), *The Theory of the Growth of the Firm*. Blackwell: Oxford, UK.

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

Peters, L., M. Rice and M. Sundararajan (2004), 'The role of incubators in the entrepreneurial process,' *Journal of Technology Transfer*, **29**(1), 83–91.

(*)Phan, P. H. and D. S. Siegel (2006), 'The effectiveness of university technology transfer: lessons learned, managerial and policy implications, and the road forward,' *Foundations and Trends in Entrepreneurship*, **2**(2), 77–144.

Phan, P. H., D. S. Siegel and M. Wright (2005), 'Science parks and incubators: observations, synthesis and future research,' *Journal of Business Venturing*, **20**(2), 165–182.

(*)Porter, M. E. (1980), *Competitive Strategy. Techniques for Analyzing Industries and Competitors*. Free Press: New York.

Powell, W. W. and J. Owen-Smith (1998), 'Universities and the market for intellectual property in the life sciences,' *Journal of Policy Analysis and Management*, **17**(2), 253–277.

Powers, J. B. and P. P. McDougall (2005a), 'Policy orientation effects on performance with licensing to start-ups and small companies,' *Research Policy*, **34**(7), 1028–1042.

Powers, J. B. and P. P. McDougall (2005b), '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.

Poyago-Theotoky, J., J. Beath and D. S. Siegel (2002), 'Universities and fundamental research: reflections on the growth of university-industry partnerships,' *Oxford Review of Economic Policy*, **18**(1), 10–21.

Quintas, P., D. Wield and D. Massey (1992), 'Academic-industry links and innovation: questioning the science park model,' *Technovation*, **12**(3), 161–175.

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.

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

Roberts, E. B. (1991), 'The technological base of the new enterprise,' *Research Policy*, **20**(4), 283–297.

Roberts, E. B. and D. E. Malone (1996), 'Policies and structures for spinning off new companies from research and development organizations,' *R & D Management*, **26**(1), 17–48.

Roberts, E. B. and D. H. Peters (1981), 'Commercial innovation from university faculty,' *Research Policy*, **10**(2), 108–126.

Rosenberg, N. and R. R. Nelson (1994), 'American universities and technical advance in industry,' *Research Policy*, **23**(3), 323–348.

Rothaermel, F. T. and M. C. Thursby (2005a), 'Incubator firm failure or graduation?: the role of university linkages,' *Research Policy*, **34**(7), 1076–1090.

Rothaermel, F. T. and M. C. Thursby (2005b), 'University – incubator firm knowledge flows: assessing their impact on incubator firm performance,' *Research Policy*, **34**(3), 305–320.

Sampat, B. N., D. C. Mowery and A. A. Ziedonis (2003), 'Changes in university patent quality after the Bayh-Dole Act: a re-examination,' *International Journal of Industrial Organization*, **21**(9), 1371–1390.

Samson, K. J. and M. A. Gurdon (1993), 'University scientists as entrepreneurs: a special case of technology transfer and high-tech venturing,' *Technovation*, **13**(2), 63–71.

(*)Sapienza, H. J. and A. K. Gupta (1994), 'Impact of agency risks and task uncertainty on venture capitalist CEO interaction,' *Academy of Management Journal*, **37**(6), 1618–1632.

(*)Sapienza, H. J. and M. A. Korsgaard (1996), 'Procedural justice in entrepreneur-investor relations,' *Academy of Management Journal*, **39**(3), 544–574.

Saragossi, S. and B. van Pottelsberghe de la Potterie (2003), 'What patent data reveal about universities: the case of Belgium,' *Journal of Technology Transfer*, **28**(1), 47–51.

Schmiemann, M. and J.-N. Durvy (2003), 'New approaches to technology transfer from publicly funded research,' *Journal of Technology Transfer*, **28**(1), 9.

Segal, N. S. (1986), 'Universities and technological entrepreneurship in britain: some implications of the cambridge phenomenon,' *Technovation*, **4**(3), 189–204.

Shane, S. (2001), 'Technological opportunities and new firm creation,' *Management Science*, **47**(2), 205–220.

Shane, S. (2002a), 'Executive forum: university technology transfer to entrepreneurial companies,' *Journal of Business Venturing*, **17**(6), 537–552.

Shane, S. (2002b), 'Selling university technology: patterns from MIT,' *Management Science*, **48**(1), 122–137.

Shane, S. (2004), 'Encouraging university entrepreneurship? The effect of the Bayh-Dole act on university patenting in the United States,' *Journal of Business Venturing*, **19**(1), 127–151.

Shane, S. and T. Stuart (2002), 'Organizational endowments and the performance of university start-ups,' *Management Science*, **48**(1), 154–170.

(*)Siegel, D. S. (2006b), 'Quantitative, and qualitative studies of university technology transfer: synthesis and policy recommendations,' in D. Audretsch, I. Grilo and R. Thurik (eds), *Handbook of entrepreneurship policy*. Aldershot, Edgar Elgar Publishing: UK. (forthcoming).

(*)Siegel, D. S. (ed.), (2006a), *Technology Entrepreneurship: Institutions and Agents Involved in University Technology Transfer*, Vol. 1. Edgar Elgar: London.

(*)Siegel, D. S. and P. H. Phan (2005), 'Analyzing the effectiveness of university technology transfer: implications for entrepreneurship education,' in G. Liebcap (ed.), *Advances in the study of entrepreneurship, innovation, and economic growth*. Elsevier Science/JAI Press: Amsterdam, pp. 1–38.

Siegel, D. S., D. A. Waldman, L. E. Atwater and A. N. Link (2003a), 'Commercial knowledge transfers from universities to firms: improving the effectiveness of university-industry collaboration,' *Journal of High Technology Management Research*, **14**(1), 111–133.

Siegel, D. S., D. A. Waldman, L. E. Atwater and A. N. Link (2004), 'Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies,' *Journal of Engineering & Technology Management*, **21**(1/2), 115–142.

Siegel, D. S., D. A. Waldman and A. N. Link (2003b), 'Assessing the impact of organizational practices on the productivity of university technology transfer offices: an exploratory study,' *Research Policy*, **32**(1), 27–48.

Siegel, D. S., P. Westhead and M. Wright (2003c), 'Assessing the impact of university science parks on research productivity: exploratory firm-level evidence from the United Kingdom,' *International Journal of Industrial Organization*, **21**(9), 1357–1369.

Siegel, D. S., P. Westhead and M. Wright (2003d), 'Science parks and the performance of new technology-based firms: a review of recent U.K. evidence and an agenda for future research,' *Small Business Economics*, **20**, 177–184.

Sine, W. D., S. Shane and D. Di Gregorio (2003), 'The halo effect and technology licensing: the influence of institutional prestige on the licensing of university inventions,' *Management Science*, **49**(4), 478–496.

Smilor, R. W., D. V. Gibson and G. B. Dietrich (1990), 'University spin-out companies: technology start-ups from UT-Austin,' *Journal of Business Venturing*, **5**(1), 63–76.

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.

(*)Sutton, R. I. and B. M. Staw (1995), 'What theory is not,' *Administrative Science Quarterly*, **40**, 371–384.

Thursby, J. G., R. A. Jensen and M. C. Thursby (2001), 'Objectives, characteristics and outcomes of university licensing: a survey of major U.S. universities,' *Journal of Technology Transfer*, **26**(1–2), 59–70.

Thursby, J. G. and S. Kemp (2002), 'Growth and productive efficiency of university intellectual property licensing,' *Research Policy*, **31**(1), 109–124.

Thursby, J. G. and M. C. Thursby (2002), 'Who is selling the Ivory tower? Sources of growth in university licensing,' *Management Science*, **48**(1), 90–104.

Thursby, J. G. and M. C. Thursby (2004), 'Are faculty critical? their role in university-industry licensing,' *Contemporary Economic Policy*, **22**, 162–178.

Thursby, J. G. and M. C. Thursby (2005), 'Gender patterns of research and licensing activity of science and engineering faculty,' *Journal of Technology Transfer*, **30**(4), 343.

(*)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.

Van Dierdonck, R., K. Debackere and B. Engelen (1990), 'University-industry relationships: how does the Belgian academic community feel about it?,' *Research Policy*, **19**(6), 551–566.

Van Looy, B., M. Ranga, J. Callaert, K. Debackere and E. Zimmermann (2004), 'Combining entrepreneurial and scientific performance in academia: towards a compounded and reciprocal matthew-effect?,' *Research Policy*, **33**(3), 425–441.

Vedovello, C. (1997), 'Science parks and university-industry interaction: geographical proximity between the agents as a driving force,' *Technovation*, **17**(9), 491–502.

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.

(*)Von Hippel, E. (1988), *The Sources of Innovation*. Oxford University Press: New York.

Wallmark, J. T. (1997), 'Inventions and patents at universities: the case of chalmers university of technology,' *Technovation*, **17**(3), 127–139.

Westhead, P. and D. J. Storey (1995), 'Links between higher education institutions and high technology firms,' *Omega*, **23**(4), 345–360.

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

Wright, M., A. Vohora and A. Lockett (2004b), '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.

Zucker, L. G. and M. R. Darby (2001), 'Capturing technological opportunity via japan's star scientists: evidence from japanese firms' biotech patents and products,' *Journal of Technology Transfer*, **26**(1–2), 37–58.

Zucker, L. G., M. R. Darby and J. S. Armstrong (2002), 'Commercializing knowledge: university science, knowledge capture, and firm performance in biotechnology,' *Management Science*, **48**(1), 138–153.

Zucker, L. G., M. R. Darbyand and M. B. Brewer (1998), 'Intellectual human capital and the birth of US biotechnology enterprises,' *American Economic Review*, **88**(1), 290–306.