ORGANIZATIONAL VICARIOUS LEARNING AND INTERNATIONAL PATTERNS IN UNIVERSITY START-UPS: A PRELIMINARY CONVERSATION AND RELATED EVIDENCE

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This paper represents work in progress. The authors welcome suggestions for additional research that would strengthen the paper's coverage of related work, alternative interpretations of findings reported, and suggestions to strengthen the paper's theoretical quality.

ABSTRACT

We use theories and prior research on organizational vicarious learning as a lens to review the literature on patterns in university linked start-ups, aiming to advance theories of organizational vicarious learning by probing their value and challenges in this context. We explore whether and how institutional context represents a crucial moderator of the nature and outcomes of vicarious organizational learning. We propose that in some institutional contexts repeated vicarious learning can increase, rather than decrease, the variation in outcomes of efforts to pursue a single vision. Further, we probed different aspects of contemporary international patterns in university-linked start-ups, while also suggesting some important but yet-to-be answered questions about the impact of efforts to promote them. In particular, we explore some of the potential unintended outcomes of well-intentioned programs to promote University linked new firms.

Many universities around the world have embraced the idea that facilitating university-linked start-up firms represents a crucial activity for the contemporary university. The popular press, government reports, reports and discussion in University policy publications, articles in policy journals such as the Journal of Technology Transfer and Research Policy, and scholarly articles that compare specific practices and outcomes across nations, taken together, highlight that many universities, regions and countries have concluded that creating university-linked firms can potentially play a powerful role in creating social good – and that this vision has increased in strength in the last decade.

In this paper, we envision the spread of the commitment to facilitating university start-ups as the outcome of a vicarious learning process by universities and in some instances, government bodies. Vicarious organizational learning occurs when organizations observe actions by other organizations and change their own behavior or beliefs as a result (Haunschild & Miner, 1997). Policy and press reports, along with exploratory interviews in several countries suggest that many universities observed the visible success of Silicon Valley, among other apparent successes, and concluded that creating university-linked start-ups represents an important – if not essential – activity.

We use theories and prior research on organizational vicarious learning as a lens to review the literature on patterns in university linked start-ups, with two goals. First, we hope to advance theories of organizational vicarious learning by probing their value and challenges in this context. Specifically we explore whether and how institutional context represents a crucial moderator of the nature and outcomes of vicarious organizational learning. We propose that in some institutional contexts repeated vicarious learning can increase, rather than decrease, the variation in outcomes of efforts to pursue a single vision (Miner, Haunschild and Schwab, 2003).

Second, we hope to help understand some aspects of contemporary international patterns in university-linked start-ups, while also suggesting some important but yet-to-be answered questions about the impact of efforts to promote them. Among other things, we probe some of the potential unintended outcomes of well-intentioned programs to promote University linked new firms.

The motivation for this paper springs partly from a prior exploratory study that included interviews with university professionals involved in encouraging university start-ups in Canada, France, Germany, Singapore, Thailand, Japan and the United States (Miner et al. 2000). In that study, Miner and colleagues reported (2000) that many universities appeared to share three core assumptions about university start-ups: (1) that most universities could and should encourage them, (2) that such start-ups will produce economic prosperity through the creation of new jobs, and (3) that this prosperity will help the university's home region.

The evidence for these widespread beliefs was mixed at that time. Nonetheless, many universities showed a strong commitment to these assumptions, and along with a belief that fairly simple recipes of encouragement and resources would produce these outcomes. Responsible university officers often presented this vision with considerable commitment that seemed in many ways more similar to a social movement than to a management fad or simple promotion of a professional self-interest (Miner et al., 2000). In this paper, we update evidence regarding some patterns, and ground our review in the theoretical framework of vicarious learning.

To foreshadow our preliminary findings based our review of the literature, we focus here on four implications of contemporary evidence. First, there is considerable evidence that many universities around the world have adopted the vision of creating start-ups as an important activity, even in the presence of substantial internal dispute, *moving towards homogeneity in their formal goals.* Second, in spite of this movement to formal homogeneity in programs or goals, close observation reveals considerable *variability in the micro-activities* undertaken in the name of promoting university start-ups. In many cases this micro-variation appears to result from the interaction of pursuing the common vision but in the presence of local institutional constraints. For example, university or national rules about the obligations of faculty members can produce patterns in whether start-ups heavily involve research faulty or students and part-time faculty.

Third, accumulated evidence suggests that even if universities pursue similar programs, their efforts may produce *dramatic variability in their impact* in terms of stated goals. For example, in some settings they may lead to local regional impact, and not in others (Zucker & Darby, 2001). Finally, evidence indicates that university linked start-ups *generate highly varied collateral impact, with the potential for both* negative and positive surprises. For example, some developing countries have experimented with aggressive forms of promoting university start-ups. In some cases, these all-out efforts have contributed to highly visible national tragedies when universities started firms with massive government support and were later discovered to have failed to live up to scientific standards. In other cases, it appears that the effort to promote university start-ups for economic reasons, may have a collateral impact on university and government efforts to encourage creativity, autonomy and personal responsibility. That is, the effort to pursue economic goals appears to sometimes generate intended and unintended changes in capabilities that may spill over into other regimes.

RESEARCH SETTING AND THEORETICAL FRAMEWORK

University Start-Ups

Deliberate efforts to promote university linked start-ups can be seen as the most recent in a series of institutions that have developed over the last century, through which universities facilitate the creation of economic value from research. Universities and colleges have long contributed useful knowledge and skills to society in several ways and for varied purposes. The largest and most diffuse contributions comes through providing society with trained students who offer knowledge and capabilities, and through ongoing streams of papers, reports, conferences and presentations offered freely to society as a whole (Wiley, 1999). Some parts of many educational systems -- such as the Land Grant universities in the United States -- long ago initiated programs to actively take university generated knowledge to specific groups of reach out to potential users such as farmers or manufacturing firms. With some exceptions, deliberate programs to license university inventions have been more recent, along with the creation of research consortia, science parks and other programs that promote the use of university knowledge by specific organizations (Di Gregorio and Shane, 2003; O’Shea, Allen, and Arnaud, 2004; Lockett and Wright, 2004).

Although seen in the light, programs to promote university start-ups appear a simple extension of prior university micro-institutions, their creation and goals have been and remain highly contested, and are a relatively novel activity for many university citizens. The direct involvement of universities in new ventures designed to harvest the value of university inventions represents a significant institutional redefinition for many university participants, the public and policy makers (Kleinman, 2003; Stuart and Ding, 2006)

New ventures may be linked to universities through three distinct paths, as illustrated by Figure 1. New ventures may be initiated by faculty, staff or students who have also generated the inventions, as shown in Segment A in Figure 1 (people and inventions). New ventures may also form that formally license university inventions but do not necessarily involve any students or faculty, Segment B of Figure 1 (inventions only). Finally new ventures can arise that employ students or previous university employees who bring their personal skills and acquired knowledge but do not draw on university inventions, indicated by Segment C of Figure 1 (people only).

For the purpose of this study, we will use the term university startup to refer to any new firm that exploits a university invention, whether it is founded by faculty or students or by others using an invention made in the university. The focal invention may or may not be formally licensed from the university. Much contemporary discussion focuses on segments A and B, especially on whether universities should hold equity in such firms. While we consider any firm grounded in university-created knowledge to be a university startup, we focus here mainly on segments A in which the key science behind the firm springs from university research, and there is some involvement of university faculty, staff or students.

Insert Figure 1 about here

Organizational Vicarious Learning and University Start-up Programs

We approached our review of evidence regarding international patterns in university start-ups using the lens of contemporary research on vicarious organizational learning. This literature is part of a broader domain or work on learning within and by organizations that has moved from primarily descriptive and simulation studies to a substantial body of theory-driven empirical research in the past fifteen years. Scholarly research has examined learning by individuals within organizations, by small groups and by whole organizations (Argote, 1999). Although the initial "learning curve" studies many decades ago focused on efficiency gains in production through experience (a learning outcome) (Yelle, 1999), contemporary research embraces two major types of learning processes and many specific sub-processes in learning. For example, organizations may engage in search, may experiment, may engage in trial and error learning, may store knowledge in memory, create new knowledge, or imitate others (Levitt & March, 1988). We focus on learning as a process not an outcome, and define learning as occurring when experience systematically alters behavior or knowledge (Argote, 1999; Miner & Mezias, 1996). This can occur when organizations observe and react to their own experience, or to that of others, defined as vicarious learning (Beckman & Haunschild, 2002; Greve, 1996; Levitt & March, 1988; Zahra & George, 2002).

Taken as a whole, descriptions of the increasing number of university programs to foster start-ups clearly suggest that over the past twenty years, many universities have observed other universities or regions and drawn on these observations to motivate and design their own programs to encourage start-ups. University officers routinely describe visits to the technology transfer offices of Stanford University -- often seen as at the center of a region that prospered due in part to university start-ups, -- along with TTO's at MIT and other schools seen as 'hot-spots' of university fostered start-ups (Miner et al., 2000). In some cases vicarious learning about these programs occurs through such direct visits; in others it occurs through learning about the programs of other schools through conferences and publications related to professional associations such as AUTM, and international associations such as the Association of European Science and Technology Transfer Professionals or Knowledge Commercialization Australasia.

Importantly, learning refers to the process of changing behavior or ideas based on experience, and can produce both good and bad outcomes. An organization can learn something that is actually incorrect, known as superstitious learning (Denrell & March, 2001; Levinthal & March, 1993; Levitt et al., 1988). It can learn things that are factually valid but not particularly helpful (Carley, 1999; Greve, 1996, 1999; Kim & Miner, 2000; Van de Ven & Polley, 1992). Many fields present models of organizational change that fit our definition of learning, including sociology, communications, economics and geography, but focus primarily on organization theory's body of theory and research on organizational learning.

Vicarious learning and homogeneity. Intuitively, one might assume that if many organizations imitate the practices that led to an apparently exceptionally good outcome for some other organization, this repeated vicarious learning should produce homogeneity in practices and outcomes themselves over time. This intuition resembles predictions from neo-institutional theory that over time, organizations will adopt practices that tend to make them look and act the same (Tolbert & Zucker, 1983). More recent work on vicarious organizational learning has emphasized barriers to vicarious learning – organizations may not be aware of what other organizations are doing, may sample other organizations in ways that hurt the value of learning from their experience, may make mistakes in imitation, may fail to completely implement practices, may have trouble making useful inferences from the observation of others (Miner & Haunschild, 1995; Greve, 1998).

One important implication of these obstacles is that instead of growing more alike in actions and outcomes, organizations all trying to achieve the same goal with apparently the same means, can actually generate a mix of growing homogeneity at one level, yet increasing variability in behavior and outcomes in other domains (Miner et al., 2001).

We recognize that general observation that implementing the 'same' program in many different settings can and will produce different micro-activities and different outcomes represents almost a cliché in the context of many careful historical and descriptive studies of economic development. Many studies of efforts to transplant programs and policies across regions and nations have revealed that they do not produce consistent behavior or outcomes. In further work, we hope to draw on these rich literatures to deepen our theoretical framework, and compare the patterns in this context to other instances of this well-known phenomenon. In this paper, we have the more modest goal of drawing on some of the most basic research on vicarious organizational learning to help us begin to assess evidence and descriptive theory about university start-ups.

We sketch four generic predictions based on contemporary vicarious learning research, and present findings about university start-ups in the following section using this as a structuring device. We emphasize for this paper the claim that high levels of interaction between the causal factors in a give organizational activity will produce certain patterns when repeated vicarious learning occurs.

We note that research on vicarious learning has also shown that while many modern organizations emphasize learning from best practices of others, learning both successful and unsuccessful outcomes has been shown to produce more useful learning (Haunschild & Beckman, 2002). In fact, (Kim & Miner, 2006) have shown that organizations can learn from patterns of organizational near-failure (recovery) and failure in their local industry or setting. One interesting challenge to the organizations attempting to pursue the vision of university start-ups is that information on the potential impact of university start-ups is extremely difficult to find. Universities increasingly report the number of university start-ups.

However, very few observers can find information about the impact of the start-ups on key goals such as university or regional economic growth in jobs or general prosperity. Indeed, the fact that these programs may require years to develop their positive value, makes it difficult even for implementing organizations to know the long run impact of their efforts. Coupled with the pressure on both universities and sponsoring government groups to appear successful, this ambiguity means that for the most part, we believe universities do not really have available the information that would permit them to use outcomes to make choices in what programs to implement. One might expect that in this setting, we would see strong convergence to whatever activities and outcomes are most common (frequency imitation) or to the actual replication of the program of very high status organizations (trait imitation). Our framework implies however, that even in this context, repeated vicarious learning should generate surprises – at least to participants in the patterns of actions and outcomes.

Homogeneity in goals and general programs. Vicarious organizational learning research emphasizes that organizations have considerable difficulty in even becoming aware of the activities and outcomes of other organizations, so that the visibility and salience of the experience of others plays a crucial role (Levinthal & March 1993; Kim & Miner, 2006). Organizations struggle with the fact that attention represents a scarce resource and that the external world presents an extreme array of changing data about multiple domains (Ocasio, 1997). Accordingly, theorists predict that exceptionally vivid outcomes are often necessary to generate widespread vicarious learning about a particular practice or program (Ingram, 1997). Networks and channels of communication enhance the chances that a focal organization will become aware of a given practice and outcome (Greve, 1998; Ingram 1997). These general claims are consistent with the vast literature on the diffusion of innovation.

Recent empirical studies have underscored that in some cases only extreme outcomes produce action by other organizations (Haunschild & Miner, 1997) with outcomes near the mean not generating any imitation at all. Imitation, here, refers to replicating the action taken by another organization. It may represent simple behavioral learning, with the imitator acting but not developing a causal model of the situation; it could also involve imitating while developing an informal theory about why the actions by others had good or bad outcomes, or even changing aspiration levels (Ingram, 2002). When such vivid and salient outcomes do occur, they can trigger cascades of imitation by observing organizations' trying to replicate the action and harvest the outcomes, as revealed in the vast literature on the diffusion of innovations.

In the context of university start-ups, the most visible icon of the potential impact of university linked start-ups appears to be Silicon Valley and Stanford University, even though to some degree other universities took earlier and more aggressive steps to deliberately encourage start-ups and take equity in them (Kenney, 1998). Perusal of magazine articles and web-site rationales for university start-up programs along with informal interviews in Miner et al. (2000) are consistent with this speculation. The success of the United States in generating innovation and the visible role of high-tech new firms in many key industries contributed to the image of a system of innovation and start-up development of university technology that had potential for creating jobs and economic prosperity on a completely new scale. This contrasted with the previously dominant view that the most effective way to encourage such growth was through enticing very large firms into a region to promote employment as seen in prior efforts such as France's Technopoles and regional science parks around the world (Miner et al., 2001). Emerging associations of university officers concerned with the licensing of technology (not start-ups) provided an important set of networks through which beliefs and programs to encourage start-ups could occur.

These factors imply that repeated vicarious learning should lead to the following simple proposition.

> *Proposition 1: Universities will seek to implement programs to enhance the numbers of university start-ups, inspired in part the apparent exceptional success of highly visible other universities.*

Variability in modes of implementation. International research in many domains regularly reveals how implementing the "same" program or practice in different cultures and institutions frequently generates unexpected and considerable variance in the micro-activities actually executed in practice. Important historical research has described nuances in the apparent cross-country implementation of the "American production system" following World War II, for example. Vicarious learning theory emphasizes least at two key drivers of this frequent outcome. First, the rules and constraints in a given context may limit or produce variation in activities, with no deliberate intention or sometimes even awareness of participants that the activities deviate from the original model. This may occur simply because some activities are filtered out in a given setting or when there is an interaction between levels of rules or constraints (Haunschild and Sullivan, 2003).

Second, some vicarious learning involves observing others, and then deliberately devising novel programs or actions, designed to deviate from the original programs. The learner may create new-to-the world actions in order to adjust activities to match perceived special features of the local setting. Or, the learner may seek to find a way to "leap-frog" over other implementers, with an eye to achieving new levels of results.

In the University start-up setting we expect both types of variation in the implementation modes, although we are especially interested in the first because of its link to institutional context. What universities can actually implement, we anticipate, is highly linked to their institutional setting, so that local constraints and taken-for-granted assumptions should produced considerable variety in how start-up programs end up being implemented in practice. Organizational learning research assumes that a good part of most organizational action consists of implementing organizational routines that often have been distilled from prior experience, and universities often have large and powerful repertoires of such routines that will persist in behavior regardless of formal programs. These existing routines will interact with the introduction of new programs. Accordingly,

> *Proposition 2: Implementation modes for programs to promote university start-ups will vary substantially within and across nations, even when they seek the same goals and appear similar in content*.

Variability in key performance outcomes. Insightful research on the actual implementation of programs from other nations and settings has long indicated that subtle institutional differences can produce important variation in the actual *impact* of apparently similar programs across settings (Whitehouse & Zeitlin, 1999). Vicarious and adaptive learning theories highlight that the degree of epistatis, or interaction between important causal factors will produce this effect (Levinthal, 1997). In a modular system, adjusting one element improves our reduces good outcomes, but the system can be changed one element at a time, and support "hill-climbing" learning processes in which a given program element works or does not work more or less on its own. In highly epistatic systems, the greater the number of elements that interact, the more it becomes possible that a small change in the combination of elements present can produce dramatically different outcomes. This violates our natural assumption that large effects arise from large differences in starting conditions although it is consistent with many contemporary models of adaptation and learning in complex systems (Levinthal, 1997; March, 1991).

Miner et al. (2002) point the presence of iterative rule systems at different levels of action as an important setting in which ongoing learning may produce more rather than less variation in outcomes. Haunschild and Sullivan (2003), for example, found that although airlines learned to reduce the number of accidents with more collective and organizational experience, the complexity of individual accidents increased rather than decreased. While there are several plausible sources of this pattern, Haunschild and Sullivan (2003) argue that the interaction of firm and industry level rules played a key role in creating this increasing rather than decreasing variation in actual accidents.

Reflection on the factors that determine the outcomes of university spin-offs suggests to us that they occur in highly epistatic contexts. Appendix 2 summarized factors proposed in published research or reports as elements that will influence whether university start-ups will occur and whether they will thrive.

Although many if not most of this work consists of experts' views or interviews of small numbers of observers, even a casual review of these candidate factors indicates that many of them depend on the presence or absence of other potential factors. A sense of needing to get a "critical mass" of interacting factors pervades the views of many professionals in the field, suggesting that at least for observers on the ground, it appears that the university start-up is highly epistatic. This in turn implies:

Proposition 3: Efforts to encourage university start-ups will generate highly variant results in different institutional contexts.

Variability in collateral outcomes. Vicarious learning theory implies that not only may results on key, known performance vary to surprising degrees, but that the presence of high epistatis will generate collateral effects not anticipated and often not monitored by enacting organizations. Again, studies of organizational implement in general and international interventions have long noted that change efforts often create collateral benefits and dangers (Gibson & Zellmer-Bruhn, 2001).

One reason for this is the same interaction outcomes described for varied outcomes for performance outcomes that organizations deliberately pursue: the impact of changing one behavior in two different settings may have much a different effect in each, because it impact depends on another local features. In these cases, the organization may be monitoring on the observed outcomes in terms of a specific goal, and even attempt to notice the causes behind unexpected outcomes and adjust them, attempting to learn from its own direct experience how to use what it first learned from others.

Collateral unexpected outcomes occur in areas that were not the focus of the original program, and may not even be noticed during implementation or efforts to monitor outcomes. In the area of university start-ups, many committed observers in the university community have outcome potentially harmful collateral or unintended outcomes of university start-up programs aside from whether these programs do meet the focal goals of creating jobs or local prosperity (Kleinman, 2003). Careful participants in these programs themselves note the dangers of possible collateral but important effects such as changes in tacit deep norms for the openness in science, gradual shifts toward more short term research projects, or the loss of research on issues with no clear potential economic value (Miner et al., 2001; Kleinman, 2003).

High variance in collateral outcomes implies that we might also expect to see unexpected or surprising positive impacts that do not match the intended goals of programs to enhance start-ups. One might anticipate that earlier, stronger efficiency norms would shape some research programs in useful ways, for example. Or, as we will suggest below, actions take in pursuit of generating start-ups may have effects somewhat unrelated to firm or job creation, but linked to broader social change not even desired by those initiating the start-up programs.

These considerations lead us to:

Proposition 4: Efforts to encourage university start-ups will produce both negative and positive collateral unanticipated outcomes.

METHODS

We structured our study in a combination of theoretical pilot exploration and literature review. The purpose of this paper is not for testing specific hypotheses, but rather proposing four important implications of university startups and weighing them with empirical evidence in existing literature. University startups and related supportive programs clearly offer an interesting context to explore with the theoretical framework of vicarious learning. The procedures of combining exploratory propositions with empirical evidence from literature review are especially appropriate when the research context is not thoroughly understood and the research themes are still at an early emergent stage. Our goal was to index the research inventory in university startup, and help advance theories of vicarious learning through intensive assessment of fragmented empirical evidence in existing literature. We first describe the literature review efforts from which the empirical evidence on university startups was drawn.

We drew the target research papers and reports on university startups primarily from three sources: (1) systematic research database search, (2) bibliographic tracking, and (3) Internet search. The goal was to compile a comprehensive literature base on university startup for the big "picture" of empirical studies in the field. Six project team members were involved in the whole search process, engaging in coordinated efforts of further processing and coding relevant empirical evidence. Overall the search process generated over 120 research papers and reports specialized in university startups. We also cross-checked our list of publications with the most recent working papers on university startup to avoid any accidental flaws during the intensive search process.

We started the process with systematic research database search, applying the following search terms to a selected group of research journals: (1) universit* AND start ups, (2) universit* AND incubators, (3) universit* AND technology transfer, (4) universit* AND spin, and (5) universit* AND new ventures. Search terms were created on the basis of pilot literature review and group discussion, and were further iteratively modified with pilot search results. The final cross-checking procedure corroborated the sensitivity of the search terms adopted, as there was a high level of alignment between our paper list and references in recent working papers in the subject by established scholars. The targeted journals in the search process cover multiple disciplines which may directly or indirectly associated with university startups, including Economics, Management, Sociology and Entrepreneurship. We selected journals based on two criteria: (1) the academic impact of the journal in the relevant field, and (2) relevancy of the journal to the context of university startups. Based on the two criteria, a preliminary journal list was developed and modified with the pilot search results. Table 1 presents the final list of academic journals categorized in terms of academic disciples. Since in their earlier review, Miner et al. (2001) cataloged most prior university start-up studies up to the time of publication (Miner et al., 2001), we directed our attention to articles published between 1996 and February 2006 (inclusive).

Insert Table 1 about here

Based on the systematic step of research database search, it generated 105 publications related to university startups. We tabulated these 105 publications into an online-sharing spreadsheet document to index the major information with regard to the papers. This list was randomly sorted based on document source. After sorting, one project member assigned the documents in sets of twenty-one (5 sets) among five team members (first readers), in numerical order, for the first round of coding on the quality and relevancy of these papers.

With the initial coding process, we sought to narrow the original list of publications to include only those that had a clear connection to university start-ups and came with rigorous empirical data. We employed a set of coding heuristics to exclude those technology transfer studies that did not examine start-ups based on university knowledge. The five first readers read their assigned publications and coded them, when applicable, based on data quality (A= strong data set; B= marginal data quality; or C= poor data quality), whether the article addressed antecedents and/or consequences of university start-ups, and overall grade (A= must read; B= of interest, or C= not directly relevant). Readers had the option of using the comments field to record other relevant information.

After the first readers read and coded their respective articles, one project member sorted the document by overall grade. Those articles that received overall grades of A's were selected for further review. This resulted in a list of 35 articles. Each team member was assigned to carefully review all 35 articles. In addition to focusing on antecedents and consequences of university start-ups, we were also tasked with focusing on variations and distinctions of university start-ups across different institutional environments.

The systematic search and coding step above was complemented by bibliographic tracking and Internet search. Specifically, for those most widely cited papers on the topic we tracked the reference items one by one, and made efforts to locate those items that were not included in our list of papers from search step 1. This step yielded few supplementary publications, as a result of the robustness of the search terms we have adopted in step 1. As an effort of locating the most recent working papers and reports by different countries, we engaged in complementary Internet search at the Website scholar.google.com. The search terms used in this – university spin AND country name. Due to the rarity of emerging economies in the current university startup literature, we put particular emphasis on a number of developing countries, including China, Singapore, South Africa, Burma etc. The Internet search process generated another 20 or so papers and reports, which brings the total number of papers and reports to over 130.

EVIDENCE FORM LITERATURE REVIEW

To explore the propositions of vicarious international learning, we examined descriptive empirical evidence on university startups based on existing literature. Our goal was to see if university-linked new ventures are developing similar patterns across different institutional environments as a result of vicarious international learning.

Evidence of Proposition 1: Homogeneity of University Startup Patterns across Different Countries

Proposition 1 anticipates that university startup as a new form of institutional activity will expand across different countries, as countries observe each other and imitate related university venture creation routines, procedures and institutional arrangements. The interactive vicarious learning process leads to the homogeneity of university startup activity along certain dimensions. In particular, based on literature review we have found that the homogeneity of university startup has been evident in two aspects: (a) University startup as a general institutional format has emerged across different countries, and university-linked new ventures are common events internationally; and (b) University startup activities have been prevalent in the two scientific fields, biotechnology and information technology, compared to the other scientific areas.

University startup as an emerging institutional format internationally. In 1991, the Association of University Technology Managers (AUTM) started to conduct annual licensing surveys of its member institutions. AUTM's membership consists mainly of university technology licensing officers-individuals charged with facilitating technology transfer-who represent more than 300 U.S. and Canadian universities and research institutes. In the 1993 survey, AUTM began querying its members on new ventures. The recent AUTM survey indicated that 462 new startups formed as a result of licensing an invention from universities and research institutions in fiscal year 2004. According to this survey, 128 universities, or 67% of the 191 responding institutions, reported at least one startup company in fiscal year 2004. Eight institutions reported 10 or more startup companies formed in fiscal year 2004. Figure 2 shows the distribution of startup companies formed by U.S. universities.

Insert Figure 2 about here

While this evidence clearly indicates that universities are creating new ventures, the numbers are not large – an average of 2.42 firms per university per year. For several reasons, the actual number of university-linked new ventures is higher than the totals the AUTM reports. The data were collected retrospectively which may result in sample selection bias. Furthermore, new ventures that were built on university inventions but did not involve a formal licensing agreement with the university were not counted in this particular survey. Reports by individual U.S. universities provide complementary data on the creation of new ventures. For example, Shane (2003) reported that MIT engaged in the creation of 99 university startups between 1980 and 1996. A recent study at the University of Wisconsin-Madison counted 172 new firms linked to university inventions over a forty-year period (Sobocinski, 1991). Thus, even with few formal efforts to stimulate new ventures, university inventions have been associated with new firms for a long time.

University startup as an emerging institutional format has been documented in a number of other countries, including but not limited to Canada, Europe, and emerging economies such as Singapore and South Africa.

In Canada, educational institutions develop similar patterns to generate startup companies, based on a recent AUTM survey. In 2002, the 33 Canadian institution respondents generated 56 startup companies – an average of 1.70 firms per university per year. Table 2 lays out the number of startup companies associated with each institution.

Insert Table 2 about here

In Europe, a similar pilot survey, ProTon Europe Annual Survey (PEAS), has been conducted to collect information on knowledge transfer performance of public research organizations. In its second year, the ProTon Europe Annual Survey FY 2004 aggregated information from 172 Knowledge Transfer Offices (KTOs) in Spain, Italy, Deutschlan, Portugal, Polan, UK, Belgium, Czech Republic, Ireland, Austria, Demark, Finland, Greece, Hungary, Israel, Switzerland, and The Netherlands. According to the survey, startup companies are being developed in Europeans KTOs. About 50% of those 103 KTO providing startup services report the creation of 1 or more startup companies in 2004. Figure 3 illustrates the distribution of the startup companies among the KTOs. Table 3 presents the comparison of startup activities of public research organizations in U.S., Canada and Europe.

Insert Table 3 and Figure 3 about here

Some more focused studies targeting individual universities provide more fine-grained data on the creation of new ventures in countries other than U.S. For example, Lockett and Wright (2005) conducted a questionnaire survey to 122 universities in the UK as ranked by research income, of which 48 universities provided complete university startup data. They found that the 48 universities generated a mean of 1.98 startups and 3.04 startups with equity investments. As illustrated in Table 4, of the 48 universities, 18 generated no university startups in the financial year 2002 while one university generated 10 startups in the same period.

Insert Table 4 about here

In emerging economies, Wong, Ho and Singh (2005) documented the startup activities by the two major universities in Singapore, National University of Singapore (NUS) and Nanyang Technology University (NTU), as can be seen in Table 5. Both NUS and NTU have been engaged in startup activities. By 2003 the cumulative number of startups at NUS reached 30 compared to 12 at NTU. University startup activities have also been reported in South Africa. According to the National Biotech Survey 2003 of South Africa's biotechnology industry, there are 47 “core” biotechnology companies, and 29% of them were spinoffs from research institutions (Motari et al., 2004).

Insert Table 5 about here

Scientific fields of university startups. Varied data sources suggest that some scientific fields are more likely than others to generate new ventures. Studies based on university startups in U.S. and other countries yielded surprisingly similar patterns on the concentration of academic entrepreneurial activities in two scientific areas, biotechnology and information technology. Previous studies looked into the dominance of the two fields and proposed that the intrinsic nature of some sciences alters the likelihood of university-linked new ventures (e.g., Zucker, Darby and Armstrong, 1998; Argyres and Liebeskind, 1998). They argue that biotechnology has a “collapsed” discovery process, in which basic research is more likely to yield directly commercializable discoveries than the traditional sciences. Argyres and Liebeskind (1998) argued that the work at the frontier of biotechnology can move more quickly than other sciences to commercially valuable knowledge. While the nature of the scientific fields may partly explain the homogeneity of university startups along the two fields, some indicators suggest that there may also be a vicarious learning effect. Many universities set agenda of spin-off activities in biotechnology and information technology even though they lacked adequate technology reservoir in these fields, which is not consistent with the fundamental argument.

The current dominance of these fields is evident in a wide range of studies and reports internationally. According to the AUTM survey, for the surviving U.S. university startups in 1996, 647 (57%) were in the life sciences (biology, medicine, chemistry, medical devices, etc.), and 496 (43%) were in the physical sciences (engineering, software, business systems, etc.), as illustrated in Table 6. Consistent with the AUTM survey, in a more recent study, Zhang (2006) found a similar pattern of university startups in areas of biotechnology and information technology. Based on a sample of 903 venture-backed academic entrepreneurs from 1992 to 2001, he reported that the biopharmaceutical industry attracted 252 academic entrepreneurs, followed by 226 academic entrepreneurs in the software industry, as presented in Table 7.

Insert Table 6 and 7 about here

At university level, some studies have verified the same pattern of scientific fields of university startups. For example, Shane (2004) reported that 54 out of 99 (54.5%) startup companies founded at MIT between 1980 and 1996 are biotechnology and software companies, as illustrated by Table 8.

Insert Table 8 about here

International data sources suggest similar patterns of scientific fields to generate new ventures, in both established economies and emerging economies. For example, in France Mustar (1997) documented that 28 percent of the startups were found in biotechnology, and 27 percent were found in computer science and software engineering. In a very recent study, Eun, Lee and Wu (2005) examined the trend of university startups in China. They reported a high concentration of information technology companies among university startups – almost 40% of university startups are information technology firms in year 2001. Similar pattern was revealed during the period of 1997 to 2000. In Singapore, Wong, Ho and Singh (2005) investigated the startup activities of the National University of Singapore (NUS). They reported that almost half (43.8%) of NUS startups are involved in IT business (Table 9), followed by a strong presence of biochemical/medical firms (31.3%), which echoes the NUS patenting strength on information technology and life sciences.

Insert Table 9 about here

Proposition 2: Variability in Implementation of Start-Up Efforts

Our review of the literature showed that there is significant variance of university people involvement in startups, which suggests that vicarious learning across countries can generate variance under certain conditions. Many universities held the implicit conviction that there is a recipe for combining the essential ingredients that will lead to success on university startups in their own countries or regions. The key, following this logic, was to follow the right recipe by vicarious learning. However, vicarious learning can be biased in the way that they inferred the wrong recipe when observing the success stories in other campuses or in other countries. Further, the barriers during various learning could drive significant variance in university entrepreneurial outcomes, due to the different executions of the same 'recipe' by university people.

Variability in the roles of people involved across nations. There is a growing body of studies that provide suggestive evidence on the variant patterns of how different university roles influence the creation of new ventures. This work suggests that the involvement of university people in startups may be more complex than often assumed and begins to delineate the contours shaping the creation of university-linked new ventures. One general and widely assumed pattern of university people involvement is that they may serve as founders or advisors to the university startup, while the startup itself stands as a separate independent entity from the university. For example, in a recent study of academic entrepreneurs in life sciences, Stuart and Ding (2006) reported the total number of university-employed biotechnology company principals that are employed by the 10 universities that appear most frequently in their dataset of academic founders and advisors, as can seen by Table 10. In this model, university people have separate roles in the university and the startup, and these two roles are independent from each other with different responsibilities.

Insert Table 10 about here

In contrast, some recent studies documented different paths of university participant involvement in university startup in some emerging economies such as China. Since China's open policy around three decades ago, universities have been actively engaged in not only generating startups, but also running these companies on a daily basis (Eun, Lee and Wu, 2005). University startups often are affiliated with the university, either in the form of subsidiary or fully controlled entity. University people involved in startups are typically directly appointed by the university, shouldering an intertwined role of university-designated-entrepreneur. Based on the statistics of the Chinese Ministry of Education, by 2001 there were 5,039 university-run enterprises (UREs) in China (Eun, Lee and Wu, 2005), as can be seen in Table 11. UREs play an important role in China's economy – about 40 UREs are public traded companies, including the top three PC makers Lenovo, Founder and Tongfang operated by Peking University and Tsinghua University (Eun, Lee and Wu, 2005). In 2002, 14 out of the top 100 Chinese IT Firms of 2002 were UREs, as evaluated by Chinese Ministry of Information Technology (see Table 12).

Insert Table 11 and 12 about here

In a case study, Casper and Whitley (2002) provided further evidence that the university participant involvement patterns differ across different institutional environments. Casper and Whitley (2002) compared how particular institutional frameworks in Germany, Sweden and the United Kingdom affect their entrepreneurial activities in biotechnology and software industry. They suggest that Germany's technology failure in the biotechnology and software sectors can be partly attributed to its constrained university people involvement in startups. While the government has crafted supportive policies for university startups, including hiring consultants to persuade university professors or their students to commercialize their research findings and help them design business plans, there have been no major reforms to German labor or company laws. As a result, the long-term employment mindset and associated career structure, there is a high risk for researchers in moving from a prestigious professorship to a startup firm (Casper and Whitley, 2002).

Variability e of university participant involvement across universities. At university level, a high level of variance of university people involvement in startups has been documented. In a focused study on department of electrical engineering and computer science at UC Berkeley and Stanford, Kenney and Goe (2004) identified 168 corporate affiliations for UCB professors and 253 for Stanford professors. They found significant differences between UCB and Stanford faculty in regard to startup involvement.
EE&CS faculty at Stanford were more extensively involved in founding new startups compared to the

faculty at UCB – on average, UCB faculty founded 0.39 firms per faculty member compared to 0.67 firms per faculty member for the Stanford faculty (see Table 13). This works underscores cultural embeddedness as Stanford represents a university environment loaden with a history of success and high level of support for entrepreneurship.

Insert Table 13 about here

Variability of university participant involvement within universities. The variance of university people involvement startup can also be traced back to different patterns of startup involvement within the university. While the major focus of university startup literature lies in university professors, a significant portion of university startups is connected with university people beyond professors, such as academic staff, administrators and even students. The varied patterns of people involvement within university greatly expanded the cross-level vicarious learning, and contributed to the variance of university people involvement at higher levels. With a venture capital dataset including 903 VC-backed academic founders, Zhang (2006) investigated their positions in academic institutions. The 903 individuals founded or co-founded 744 VC-backed firms from 1992 to 2001, and 35 of them founded more than one firm. As Table 14 shows, nearly two thirds of the entrepreneurs from universities are professors, and the second largest group (16%) is research scientists at universities. There are 23 entrepreneurs who identified themselves as "research assistants," "Ph.D. students," or "post-doc fellows" and did not hold formal job positions at universities.

Insert Table 14 about here

Proposition 3: Variability in the Impact of University Startup Programs

Proposition 3 predicts the heterogeneity of the localization effect of university startups across different regions and countries. Economic geographers and economists have long argued that agglomeration effects can enhance the local impact of new firms in a particular area, which implies that university-linked new ventures will have a positive local effect as they cluster together for promoting growth. However, recent research on university startups indicate a high level of variance of localization effect across different countries, suggesting that such agglomeration effects may involve combinations of deliberate and accidental factors not easily captured by vicarious learning.

Variability in localization of university startups across regions. In U.S., a major study by Zucker, Darby and Brewer (1998) provides some of the first systematic evidence about specific processes that link university research to new ventures. They collected 14 years of panel data for 183 economic regions in the United States, consisting of 751 firms, 511 of them new ventures. They also gathered data on 327 "star" scientists who were exceptionally productive in their field of biotechnology and linked new firm births in the biotech industry to these star scientists. In a subsequent study, Zucker, Darby, and Armstrong (1998) looked at relationships between "star" scientists and new venture development. Using a sample of 110 biotech firms and 55 "star" scientists in California, they examined the link between the "star" scientists' involvement and the number of products in development. The result contrasts a vision in which knowledge diffuses in a broad way through general spillover and underscores the role of a select group of individual scientists who play a key role in the process of generating university-linked new ventures. Audrestch and Stephan (1996)

Based on a sample of the entire population of biotechnology firms that prepared that prepared an initial public offering (IPO) in the early 1990's, Audretsch and Stephan (1996) further provided some fine-grained localization patterns in the U.S. They found that while a substantial number of university-based scientists participated in geographically bounded networks, about 40 percent of the university-based founders establishing firms outside of the region of their university, as can be seen in Table 15. This study implies that even if university-linked new ventures create local growth initially, the effect may rapidly disappear over time in some areas. In a more recent study Zhang (2006) further investigated the location of university startups in U.S. Consistent with Audretsch and Stephan (1996), Zhang (2006) suggests that not all the academic entrepreneurs stayed close to their academic institutions. About one third of them ended up in different states. In addition, in the same location the number of startups varies significantly across different universities. Table 16 illustrates the distribution of academic entrepreneurs and startups by location.

Insert Table 15 and 16 about here

Variability in localization of university startups across countries. The heterogeneity of localization effect of university startup across countries was revealed in a number of studies. Germany has been documented with a strong tendency of localization. Based on 281 publicly listed, high-technology startup firms in Germany, Audretsch, Lehmann and Warning (2005) tested the localization effect of university on startup development. They reported that the mean distance between a high-technology startup and the closest university is about 16km, while the median distance is about 7km (Figure 4). Similarly, in China there is a strong pattern of localization of high-technology startup firms. In a recent survey, conducted by Zhongguancun Science Park Information Center and E-business Center of Peking University, it is reported that 10.04 percent (867 firms) of all firms registered with Zhongguancun District, Beijing are university-run enterprises (UREs), or firms affiliated with public research institutes (Eun, Lee and Wu, 2005).

Insert Figure 4 about here

In Japan it has shown a different pattern of localization effect. Zucker and Darby (2001) compared the localization effect of "star scientist" in the U.S. and Japan. In contrast to America, there is a little evidence of geographically localized knowledge spillovers. Star collaborations in Japan are less localized around their research universities. Table 17 details the pattern of publication collaborations between academic star scientists and firms. Tokyo firms account for about 76% of the collaborated articles, keeping all their local stars and attracting additional 65% of the remaining collaborations. The concentration of collaborations towards major areas depresses the expected localization effect associated with star scientists.

Insert Table 17 about here

Proposition 4: Variability in Collateral Outcomes of University Start-up Programs

Programs to encourage university start-ups typically deliberately tackle the specific goals of creating regional economic growth and local jobs, along with promoting university well being through eventual income to the university itself that will sustain more research and education (Miner et al. 2000; European Commission, 2002; Degroff & Roberts 2004; Plosila 2004). Since their early days, however, concerned observers nad participants have raised concerns questions about whether they will have collateral impact so that the price of even successful programs may be too high (Dasgupta & David, 1994; Nelson, 2002). By collateral impact, we refer to significant outcomes in domains not obviously related to the main goals of the programs. The failure to produce start-ups at all, or the failure of those start-ups to produce regional growth would be surprises and disappointments, but not collateral outcomes, since they related to the proposed purposes of the programs.

Collateral outcomes can occur in terms of individual researchers' patterns of behavior, university cultures and roles, regions, nations and the entire international community of higher education. One type of collateral outcome occurs as the proximate outcome of the university start-up activities. At the individual level, for example observers have expressed concerns that involvement in start-ups will change the nature of research conducted by involved faculty to be more applied, weaker, more short-term in perspective or simply less in volume (Louis, Jones, Anderson, Blumental & Campbell; Feller 1989). There is some evidence that in certain situations involvement in start-ups does lead to more applied research or to more secrecy (Louis, Jones, Anderson, Blumenthal & Campbell, 2001). On the other hand, Zucker and Darby's substantial body of work on star scientists early in the development of the U.S. bioech industry showed that in many cases top researchers seemed to become more productive, including in areas of basic research (Darby & Zucker, 2003).

Proximate collateral impact on universities might include a pattern in which resources are diverted to the start-up activity that might have had more fruitful impact if applied to other university goals. Here too, there is conflicting evidence but Darby & Zucker (2002) provide evidence conclude that rather than secrecy norms pervading the university, scientific norms of publishing are moving into the commercial domain. Researching possible collateral impact at the level of individual faculty requires research designs that will permit before and after comparisons controlling for individual faculty traits. Barham and Foltz (2006) at the University of Wisconsin have assembled data that will permit such nuanced testing of the impacts at the individual level of participation in start-ups on faculty productivity in varied areas. This work promises to provide deeper insight into short-term direct collateral impacts, if any.

A second type of potential collateral outcome will be more difficult to research, because typically involves long term impact and dynamic interactions of multiple processes. It is a cliché but nonetheless accurate to note that complex dynamic systems routinely produce nonlinear effects. Even simple issues offer the potential for nonobvious collateral or long-term effects; dynamics processes may include tipping points or endogenous interactions hard to predict in early phases. For example, small numbers of start-ups in major research universities may not harm the climate of open science, leaving no significant trace. At some critical point, however, heavy involvement of top scientists in start-ups (in contrast to licensing) may reduce the invisible open space of collaborative science past a critical value. At that point, system might not maintain a level of network interaction that can drive the collective scientific achievement (Dasgupta & David, 1994).

Normal science research testing predictions about possible dynamic collateral outcomes presents a challenge, yet in some ways these claims are the most important for scholars to explore. For the most part, suggestions about these possibilities appear in essays by close observers of science and universities (Nelson, 2001). Hints of the credibility of some speculated outcomes also can be seen in media reports of contemporary incidents that may reflect unfolding patterns. Reports of two such current events illustrate two important potential types of collateral impact of university start-ups, one negative and one presumably positive.

Miner et al. (2000) predicted that in countries seeking to leapfrog achievement in the area of university start-ups, starting from institutional settings without well developed routines and norms in research administration, we would see intended and unintended experiments in forms and processes involved in university start-ups with potential for extreme outcomes. Apparently consistent with this possibility, the May 15, 2005 New York Times described the difficult to read story of Jin Chen, a Chinese computer scientist now accused of fraud. The story recounts how the government provided exceptional resources, and Chen created a family of private companies, one of which was based in Texas and founded with a former Texas classmate. “The whistle blowers also gave details of an array of companies that Mr. .Chen operated to profit from the big government contracts he received….” (New York Times: p 6.).

The article reports that Reed Hundt, a seasoned observe4 of universities and science interprets this extreme outcome as the natural outcome of the lack of developed research policy and routines – that is, the institutional context of commercialization of science including start-ups. The collateral damage in this case is not just to the investigator but to national hopes and institutional reputations. In addition, students at this particular university express cynicism about whether professors have abandoned traditional scholarly values. Of course a single exemplar does not provide evidence on the net impact of the less constrained pursuit of start-ups in developing countries, which could still yield superior economic impact even in the presence of occasional disasters. Only systematic evidence, not really available now could answer that question.

Qualitative and persistent reports of contemporary events in some countries also points to the potential for collateral positive outcomes, at least from the viewpoint of western societies. In several countries with traditionally authoritarian regimes, efforts to encourage university start-ups for economic gain have led to curriculum and program innovations designed to promote entrepreneurial values and skills. These include giving status and value to notions of autonomy, creativity and independence. Programs designed to promote these values and skills are created in the university because of the anticipated value of university start-ups. Singapore, for example, began deliberately changing he nature of university instruction to encourage autonomy and creativity when prior programs to encourage start-ups and other entrepreneurship did not produce satisfactory results (A. Tang, 1999). In some politically authoritarian settings, it is possible that encouraging and developing such skills in the university setting will not only produce entrepreneurial people but legitimize values and activities that may challenge the nature of existing political institutions.

DISCUSSION

In this study, we drew on and seek to deepen research on organizational vicarious learning by using this framework to consider contemporary evidence concerning the important movement towards universities deliberately promoting and often investing in start-ups. We argued that universities represent complex institutions that are themselves nested within regional and national institutions with long histories, nuanced rules and action routines. Although we did not provide direct quantitative evidence of increasing implementation of such programs, observers generally agree that this movement towards the legitimacy and even glorification of university start-ups has grown in the past decade (Feller, 1989; Miner et al., 2001). We also accepted Miner et al's (2001) claim that many universities have actively sought to imitate and learn from others during this period and that the implementation of these programs resembled a social movement more than a management fad. That is, many such programs went beyond transient symbolic efforts to gain legitimacy or appear productive, drawing serious attention from informed faculty and university leaders..

We noted that within organization theory, there are two general and competing predictions about what happens over time when many organizations try to learn vicariously about a new way to generate value or behave. Under some conditions this should produce increased productivity or value, with convergence to similar activities and outcomes. This might be expected when an immediately and visibly better way to do something becomes available and organizations learn from each other about its value. Unambiguous outcomes, independence of effect from local context, and consistency of external forces would all imply that over time we would see increasingly similar organizational actions and outcomes as vicarious learning continued over time.

We made the case that under conditions of high epistatsis one would not expect to see such conference and in some cases would even see expanding variability rather than a stable menu of variants in actions or outcomes. Our review of current descriptive literature did not offer data that permits us to falsify this idea, but it did provide suggestive evidence consistent with our framework. We did see evidence of similarity in the general behavior and goals in creating start-ups. This was coupled with variation in specific implementation approaches closely tied to institutional setting and, we believe, a potentially increasing degree of variability. Some of he more rigorous research papers provided convincing evidence that for one major goal of such programs --- the regional impact of start-ups – institutional variation meant that sometimes the programs had regional impact and in other institutional setting they did not.

Prior research has shown that early in the development of the biotechnology industry firms developed close to the university while later locality had little effect (Darby & Zucker, 2002) We believe the contemporary evidence indicates that institutional conditions – not just timing – can also produce conditional regional effects, Fairly all institutional elements could facilitate or bock the regional value of university start-ups (Zucker & Darby, 2001).. Finally we noted that institutional factors that produce increasing variability in both the success or failure of intended performance outcomes, and may also generate variability in collateral outcomes over time.

The potential for effective vicarious learning in this context. At the present phase of implementation of these programs around the world, it is increasingly possible to assess how many start-ups many universities produce. It is typically very difficult, on the other hand, to assess their financial viability or long term impact. This makes it hard to find simple reliable bets in terms of what to do, and to develop valid causal theories about how to generate the high impact start-ups anticipated by many programs (Ingram, 2002).. Learning theory predicts that this setting will lead to considerable superstitious learning in which organizations will develop inaccurate models of causality (Levitt & March, 1988). It als predicts that under these conditions social factors such as status or social affiliations will have a stronger influence on what new practices are implemented (Haunchild & Miner, 1997).

Implications for the relationships between universities around the world. The strong case of our general arguments would predict that ongoing vicarious leaning under conditions of high hope coupled very difficult learning conditions will not only fail to produce convergence of outcomes, but will produce *increasingly* varied outcomes over time. We did not have evidence to distinguish between ongoing variability and increasing variability but if this prediction is valid it has interesting implications for the world-wide relationships between regions and universities.

For example, many of the plausible collateral outcomes of the pursuit of start-ups seem to occur differentially at strong and weak universities. The already-strong research universities should be able to harvest the value of start-ups, while weak ones will have lower chances of the rare home run that can produce major economic value. Weaker schools and regions will not overcome their relative standing but become hollowed out of their talent and resources in pursuit of a vision that is unlikely to pay off in large ways.

At the same time prior sociological research often finds that the more organizations experiment with radical versions of organizational innovations. As with most innovations on average these experiments will fail, but an occasional experiment will in fact represent a genuine improvement (March, 1991). This potential feature of repeated vicarious learning offers the possibility that while most weak institutions will decline, one or two rare marginal organizations will leapfrog to new levels of strength. Whether or not the experiments in university start- up programs we have described can generate such a radical re-ordering of university strength remains an open question but surely one of interest to universities around the world..

Limitations. This is a working paper designed to elicit discussion and its limitations are consistent with that status. Deeper reading of articles described may reveal subtle points or misinterpretations of data. We welcome suggestions for such opportunities to represent results more accurately. We also welcome suggest for research that should be included in our review but is not. Work in progress includes a review of related books on this topic, which we believe will offer rich and important qualitative data.

Conclusion. University start-ups represent an under theorized and emerging phenomenon with potentially powerful implications for universities, regions and society as a whole. They are not a simple extension of licensing activities that have become part of many contemporary universities, but can represent a dramatic shift in roles and institutional rules of the game. Theories of vicarious learning offer a promising framework for anticipating possible unanticipated outcomes of sensible of programs to enhance start-ups, probing their less obvious destructive and liberating potential for universities and society at large.

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TABLE 1: List of Academic Journals

Academic Field	Name of Journal
Economics	a. American Economic Review b. Review of Economic Studies c. Journal of Political Economy d. Econometrica e. Journal of Economic Theory f. Quarterly Journal of Economics
Management	a. Administrative Science Quarterly b. Academy of Management Journal c. Strategic Management Journal d. Organization Science e. Management Science f. Industrial and Corporate Change g. Research Policy
Sociology	a. American Journal of Sociology b. American Sociological Review c. Social Forces
Entrepreneurship	a. Journal of Business Venturing b. Entrepreneurship Theory & Practice

TABLE 2: Number of University Startups in Canada, 2003

Name of Institution	Startup Companies Formed
Univ. of British Columbia	4
McGill Univ.	5
Univ. de Montreal	3
Univ. of Toronto	7
Univ. of Alberta	4
Université Laval	3
UTI, Inc./Univ. of Calgary	3
Univ. of Western Ontario	0
Univ. Health Network	1
Queen's Univ.	0
The Hospital for Sick Children	0
Univ. of Saskatchewan	3
McMaster Univ.	0
Univ. of Guelph	0
Univ. of Ottawa	1
Univ. of Waterloo	13
Univ. of Manitoba	0
Univ. de Sherbrooke	1
Dalhousie Univ.	0
Memorial Univ. of Newfoundland	0
Simon Fraser Univ.	4
John P. Robarts Research Inst.	1
Univ. of New Brunswick	1
Ottawa Heart Inst. Research	0
Lakehead Univ.	0
Ryerson Univ.	0
Univ. of Northern British Columbia	0
CRESTech	2
Ecole De Technologie Superieure	0
Univ. of Prince Edward Island	0
TRIUMF	0
Bloorview MacMillan Children's	0
Mount Allison Univ.	N/A

Source: AUTM Canadian Licensing Survey, 2003

TABLE 3: University Startup Activities – U.S. vs. Canada vs. Europe

	U.S.	Canada	Europe
Source	AUTM survey	AUTM survey	ProTon Survey
Fiscal Year	2004	2003	2004
Number of Startups	462	56	174

Source: AUTM Survey & ProTon Survey

TABLE 4: Number of University Startups in U.K., 2002

Numbers of startups created by a university in 2002	Number and percentage of university creating each number of startups	Number and percentage of university creating each number of spin-outs with equity investment
0	18 (38)	17 (36)
1	7 (15)	8 (17)
2	7 (15)	4 (8)
3	5 (10)	4 (8)
4	5 (10)	2 (4)
5	1 (2)	3 (7)
6	4 (8)	1 (2)
7	-	-
8	-	2 (4)
9	-	4 (8)
10	1 (2)	1 (2)
11	-	1 (2)
16	-	1 (2)
Total	48(100)	48(100)

Source: Lockett & Wright, 2005

TABLE 5: Comparison of NUS versus NTU in Singapore

	NUS	NTU
Manpower • Research • Academic	 1,151 2,055	 652 1,361
Research Funding, 2001/2002	$ 210 million	$ 44 million
Number of Spin-offs formed 2001/2002	5	3
Cumulative Number of Spin Offs as at March 2003	30	12

Source: Wong, Ho and Singh (2005)

TABLE 6: University Startups in U.S. by Industry, 1996

	FY 1980 to FY 1995 (N=152)	Data on Start-Ups Formed FY 1980 to FY 1995 (N=121)	Operational Start-Ups: Life Science (N=120)	Operational Start-Ups: Physical Science (N=120)	Equity in Start-Ups Formed FY 1980 to FY 1995 (N=103)
Start-Ups Formed	1,633	1,516			557
Operational Start-Ups		1,166			
Operational Start-Ups: by Science		1,143	647	496	

Source: AUTM Survey, 1996

TABLE 7: VC-Backed Academic Entrepreneurs by Industry

Industry	No. of Entrepreneurs in Sample	No. of Academic Entrepreneurs	% of Academic Entrepreneurs in Each Industry
Advance/special material and chemical	39	11	28.21
Agriculture	11	0	0
Biopharmaceutical	618[a]	270	43.69
Communication	1,442	91	6.31
Consumer/business products	71	10	14.08
Consumer/business services	2,467	79	3.20
Electronics	279	20	7.17
Energy	12	2	16.67
Health care	138	7	5.07
Information services	1,159	41	3.54
Medical devices	347	54	15.56
Medical information services	302	51	16.89
Retailing	228	3	1.32
Semiconductor	442	43	9.73
Software	2,966	220	7.42
Other	9	1	11.11
Total	10,530	903	8.58

Source: Zhang (2006)

TABLE 8: The Industry Distribution of MIT Startups from 1980 to 1997

Technology	Percentage of Startups
Biotechnology	31
Software	23
Materials	11
Medical devices	10
Mechanical devices	7
Computer hardware	6
Robotics	4
Semiconductors	4
Optics/lasers	3
Total	99

Source: Shane (2004), p. 140

TABLE 9: NUS Startups by Nature of Business

Nature of Business	No.	%
Information Technology	14	43.8
Biochemical/ Medical	10	31.3
Electrical and Electronic	3	9.4
Mechanical and Machines	3	9.4
Chemicals	1	3.1
Geotechnical	1	3.1
Total	32	100

Source: Wong, Ho and Singh (2005)

TABLE 10: University People Involvement in Life Science Startups in Top 10 Universities, 2002

	Founders	***Scientific Advisors***	***Total***
Harvard University	25	159	184
University of California-San Diego	34	83	117
Stanford University	21	67	88
University of California-San Francisco	12	74	86
University of Washington	8	47	55
Massachusetts Institute of Technology	16	37	53
Johns Hopkins University	7	32	39
Yale University	6	31	37
Columbia University	4	32	36
Cornell University	3	28	31

Source: Stuart and Ding (2006)

TABLE 11: University-Run Enterprises in China (1992-2001)

	Number of total UREs
1992	n.a
1996	n.a
1997	6634
1998	5928
1999	5444
2000	5451
2001	5039

Source: Eun, Lee and Wu (2005)

TABLE 12: UREs in the Chinese Top-100 S&T Firms (2002)

Ranking	Abbreviated Firm Title	Mother Institution
3	Tsinghua Tongfang	Tsinghua Univ.
12	Zheda Wangxin	Zhejiang Univ.
15	Dongruan Gufen	Dongbei Univ.
18	Qingdao Tianqiao	Peking Univ.
25	Fangzheng Keji	Peking Univ.
38	Nankai Gede	Nankai Univ.
41	Qingdao Huaguang	Peking Univ.
46	Tianda Tiancai	Tianjin Univ.
48	Yunnan Keji	Yunnan Univ.
59	Huagong Keji	Huazhong S&T Univ.
88	Beida Gaoke	Peking Univ.
89	Tsinghua Ziguang	Tsinghua Univ.
95	Jiaoda Angli	Shanghai Jiaotong Univ.
98	Fudan Fuhua	Fudan Univ.

Source: Eun, Lee and Wu (2005)

TABLE 13: Corporate Affiliations by UC Berkeley and Stanford EE/CS Professors

Title	UCB (n = 92)	Stanford (n = 88)
Advisory Board, Member	54	77
Advisory Board, Chair	0	2
Founder	28	60
Board of Directors, Member	18	34
Advisor[1]	13	14
Chief Scientist	6	11
Board of Directors, Chair	5	7
Chief Technical Officer	5	6
President, CEO, Vice President	7	3
Miscellaneous affiliations	6	5
Total	143	220

Source: Kenney and Goe (2003)

TABLE 14: Positions of Academic Entrepreneurs Held in Academic Institutions

Position	Number	Percentage	Academic Disciple	Number	Percentage
Professor	563	68.49%	Engineering	304	45.44%
Research Scientist	143	17.40%	Medical Sciences	175	26.16%
Director	71	8.64%	Biosciences	96	14.35%
Executive	69	8.40%	Business	29	4.33%
Lecturer/Instructor	17	2.07%	Chemistry	23	3.44%
Research Assistant	23	2.80%	Other	42	6.28%
Ph.D. Student					
Postdoc Fellow					
Total	822	100%	Total	669	100%

Source: Zhang (2006)

TABLE 15: Localization of University Scientists in Startups

	Founder	SAB	SAB chair	Majorstock
Nonlocal	16	249	7	20
$n = 307$	(42.1)	(68.2)	(33.3)	(50.0)
Local	22	116	14	20
$n = 138$	(57.9)	(31.8)	(66.7)	(50.0)
Total	38	365	21	40
χ^2	14.04[a]	0.56	13.10[a]	7.41[b]

Source: Audretsch and Stephan (1996)

TABLE 16: Distribution of Academic Entrepreneurs by Location

	By Academic Location				By Business Location		
State	Moved Out	Stayed	Total (a)	Net Gain (b) – (a)	Total (b)	Stayed	Moved In
California	16	73	89	29	118	73	45
Massachusetts	9	33	42	12	54	33	21
North Carolina	4	15	19	–2	17	15	2
Maryland	12	1	13	–8	5	1	4
New York	7	4	11	–7	4	4	0
Connecticut	4	6	10	–1	9	6	3
Illinois	4	6	10	–4	6	6	0
Texas	5	4	9	–1	8	4	4
Washington	3	4	7	2	9	4	5
Michigan	2	4	6	–1	5	4	1
Missouri	3	3	6	–3	3	3	0
Pennsylvania	1	5	6	3	9	5	4
Colorado	0	5	5	3	8	5	3
Georgia	2	3	5	0	5	3	2
Arkansas	4	0	4	–4	0	0	0
Rhode Island	0	4	4	0	4	4	0
Tennessee	4	0	4	–3	1	0	1
Utah	2	2	4	–2	2	2	0
Wisconsin	0	4	4	0	4	4	0
Alabama	2	1	3	2	5	1	4
New Jersey	3	0	3	1	4	0	4
Indiana	1	1	2	–1	1	1	0
Kentucky	2	0	2	–2	0	0	0
Ohio	1	1	2	1	3	1	2
Oklahoma	1	1	2	–1	1	1	0
Virginia	2	0	2	2	4	0	4
Washington, D.C.	1	0	1	–1	0	0	0
Florida	1	0	1	0	1	0	1
Iowa	1	0	1	1	2	0	2
Kansas	1	0	1	–1	0	0	0
Maine	1	0	1	–1	0	0	0
Minnesota	0	1	1	1	2	1	1
Oregon	1	0	1	–1	0	0	0
Vermont	1	0	1	–1	0	0	0
Arizona	0	0	0	1	1	0	1
New Mexico	0	0	0	1	1	0	1
Total	101	181	282	14[a]	296	181	115

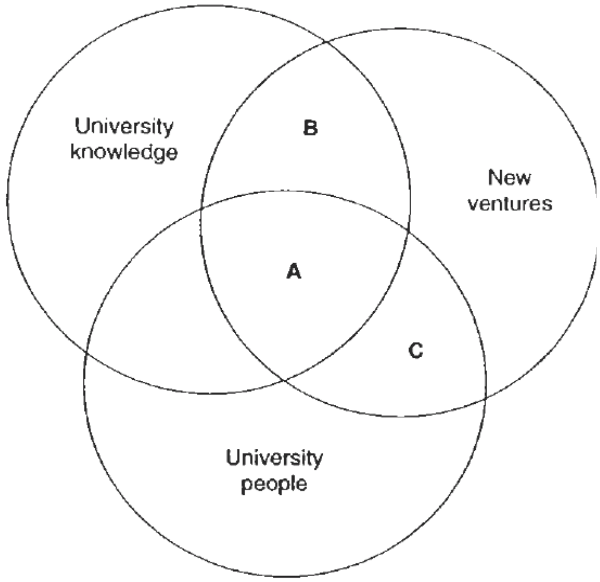
Source: Zhang (2006)

TABLE 17: Collaborations by Academic Stars and Firm Scientists by Region in Japan, 1975-1989

	Percentage of linked articles by regional location of star								
Region of firm	Northern Honshu	Tokyo area	West-Cen. Honshu	Kansai area	Western Honshu	Shikoku	Kyushu & Nansei S.I.	Other[a]	Total
Northern Honshu	0	0	0	0	0	0	0	0	0
Tokyo area	3	32	21	18	0	0	3	0	76
West-Cent. Honshu	0	0	0	0	0	0	0	0	0
Kansai area	0	0	6	12	0	0	0	0	18
Western Honshu	0	0	3	0	0	0	0	0	3
Shikoku	0	0	0	3	0	0	0	0	3
Kyushu & N.S.I.	0	0	0	0	0	0	0	0	0
Other[a]	0	0	0	0	0	0	0	0	0
Total	3	32	29	32	0	0	3	0	100

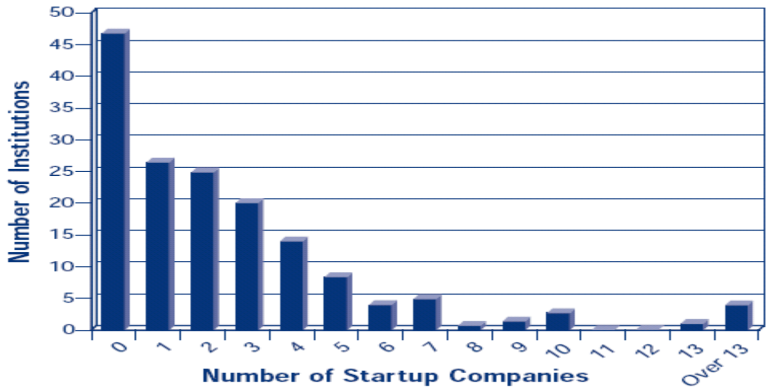
Source: Zucker and Darby (2001)

FIGURE 1: Categories of University Startups



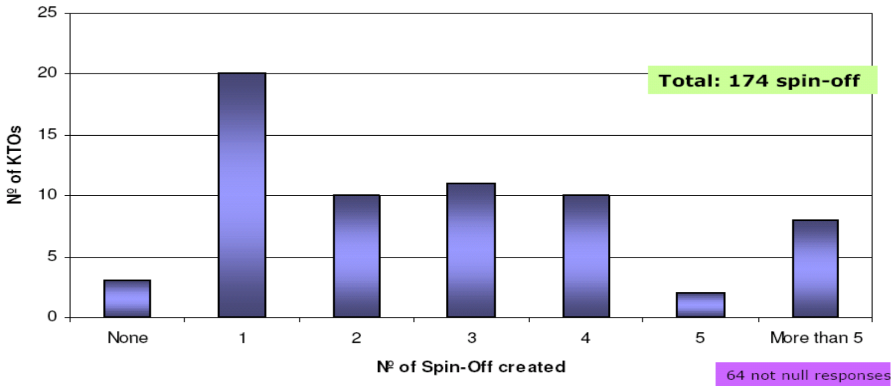
Source: Miner, Eesley, DeVaughn, and Rura-Polley (2000)

FIGURE 2: Startup Companies Formed by U.S. Universities, 2004



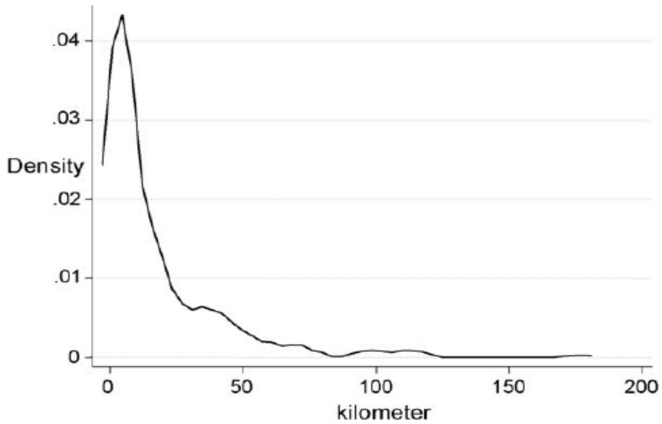
Source: AUTM licensing survey, 2004

FIGURE 3: Number of University Startups in Europe, 2004



Source: ProTon Europe Annual Survey FY04

FIGURE 4: Kernel Density Estimation of Kilometer (Epanechnikow)



Source: Audretsch, Lehmann and Warning (2005)

APPENDIX 1: ANTECEDENTS OF UNIVERSITY STARTUPS

The data on patterns in university start ups shows that universities in many countries apparently seek to promote the creation of university spin-offs. Observers have claimed, however, that the ability to successfully create new firms linked to university knowledge does not occur evenly across countries, regions or universities. Table below summarizes results from studies that (1) directly tested the impact of factors hypothesized to influence the chances of creating spin-offs, (2) aggregated the views of experts and participants about key factors or (3) generate from other theory or expertise lists of factors likely to influence the successful creation of start-ups.

Individual Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
Spin-out Formation	Perception of risk of equity		Feldman et al. 2002	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Values and interests of faculty		Bird et al., 1993	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Pre-formation networks (academic entreprenuer's embeddedness)		Nicolaou and Birley, 2003	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Individual gains supplemental income	40 U.S. universities with 778 administrator and faculty / OLS / Self-report		Louis et al., 1989. Paper # 27
Spin-Out Formation	Industry funding for individual	40 U.S. universities with 778 administrator and faculty / OLS / Self-report		Louis et al., 1989. Paper # 27
Spin-Out Formation	Individual holds a patent	40 U.S. universities with 778 administrator and faculty / OLS / Self-report		Louis et al., 1989. Paper # 27
Academic Leaves for Spin-Out	Professor or senior lecturer	89 inventors in 45 Imperial College spin-outs / Logit / Self-report		Nicolaou and Birley, 2003. Paper #28. Academic less likely to leave for start-up.
Academic Leaves for Spin-Out	Non-redundancy of business contacts	89 inventors in 45 Imperial College spin-outs / Logit / Self-report		Nicolaou and Birley, 2003. Paper #28. Increases likelihood of academic exodus.
Academic Leaves for Spin-Out	Tie strength business	89 inventors in 45 Imperial College spin-outs / Logit / Self-report		Nicolaou and Birley, 2003. Paper #28. Increases likelihood of academic exodus.
Engage in start-up	Clinical or non-clinical life scientist	847 clinical and non-clinical faculty at 49 U.S. universities / Chi square test / self-report		Louis et al., 2001. Paper #39. NOTE: there is NO significance to t-test stat in this instance, which suggests no meaningful differences in

				populations.
Start-up Time Until VC	Founder's start-up experience	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55. Reduces likelihood of VC.
Start-up Time Until VC	Direct and indirect ties to investors	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55. Increase likelihood of VC.
Academic Scientist Involved in Advising or Founding Biotech	Cumulative publication count (lagged)	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59.
Academic Scientist Involved in Advising or Founding Biotech	Patents (lagged)	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59.
Academic Scientist Involved in Advising or Founding Biotech	Number of jobs held	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59. Presumes more offers = better scientist
Academic Scientist Involved in Advising or Founding Biotech	PhD university prestige	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59.
Academic Scientist Involved in Advising or Founding Biotech	Count of co-worker transitions at emplying university (lagged)	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59.

Academic Scientist Involved in Advising or Founding Biotech	Employed at medical school	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59.
Academic Scientist Involved in Advising or Founding Biotech	Prestige of co-workers who have transitioned	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59.
Academic Scientist Involved in Advising or Founding Biotech	Cumulative count of academic entrepreneur co-authors (lagged)	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59.
Academic Scientist Involved in Advising or Founding Biotech	Co-author cumulative patents (lagged)	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59.
Academic Scientist Involved in Advising or Founding Biotech	Event count of most central academic entrepreneur co-author	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59.
Intention to Form Start-Up at Disclosure	Commercial goals	327 academic inventors at 10 prestigous U.S. universities / exploratory factor analysis, LOGIT / self-report survey		Villanueva et al., forthcoming. Paper #60.
Intention to Form	Societal goals	327 academic inventors at 10		Villanueva et al., forthcoming. Paper

Start-Up at Disclosure		prestigous U.S. universities / exploratory factor analysis, LOGIT / self-report survey		#60. NOTE: strongest indicator of intent to start-up.
Intention to Form Start-Up at Disclosure	Experience	327 academic inventors at 10 prestigous U.S. universities / exploratory factor analysis, LOGIT / self-report survey		Villanueva et al., forthcoming. Paper #60.
Intention to Form Start-Up at Disclosure	Inventor is in food industry	327 academic inventors at 10 prestigous U.S. universities / exploratory factor analysis, LOGIT / self-report survey		Villanueva et al., forthcoming. Paper #60. Reduces intent to start up a company.

Technology Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
Spin-Out Formation	Complementary assets are highly available		Lowe, 1993	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Technology is under strong protection		Lowe, 1993	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Radical innovation		Lowe, 1993	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Licensed to Inventor-Founder	Invention cites higher proportion of scientific literature	488 inventions and 65 inventor founders in U.C. system / binomial and multinomial logits / TTO data		Lowe, 2002. Paper #63.
Licensed to Inventor-Founder	Age of technology	488 inventions and 65 inventor founders in U.C. system / binomial and multinomial logits / TTO data		Lowe, 2002. Paper #63. Technologies based on older art go to start-ups.
Licensed to Inventor-Founder	Tacit knowledge	488 inventions and 65 inventor founders in U.C. system / binomial and multinomial logits / TTO data		Lowe, 2002. Paper #63. Means more forward citations within a 100 hundred mile radius of original inventor's location (?)

University Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
POLICY				
Spin-Out Formation	Incentives at universities		Henrekson and Rosenberg, 2001	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Courses, seminars and workshops at university		Birley, 2002	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Rules for spin-out creation established and clear		Birley, 2002	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Career-reward structure in Swedish universities		Klofsten and Dylan, 2000	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Equity investment in TLO start-ups	101 U.S. Universities / negative binomial / objective measures		DiGregorio and Shane, 2003. Paper #9. Self-reported from universities + AUTM data.
Spin-Out Formation	Low inventor share royalty	101 U.S. Universities / negative binomial / objective measures		DiGregorio and Shane, 2003. Paper #9. Self-reported from universities + AUTM data.
Intensity of equity involvement	Cumulative # licenses executed	67 U.S. universities / TOBIT / Self-report survey + AUTM		Feldman et al., 2002. Paper #14
Intensity of equity involvement	Industrial research support	67 U.S. universities / TOBIT / Self-report survey + AUTM		Feldman et al., 2002. Paper #14
Intensity of equity involvement	Expectation TTO will be self-sustaining	67 U.S. universities / TOBIT / Self-report survey + AUTM		Feldman et al., 2002. Paper #14. Sign here is negative but significant, suggesting that those wanting to be self-sufficient make less use of equity
Intensity of equity involvement	Maintain medical school	67 U.S. universities / TOBIT / Self-report survey + AUTM		Feldman et al., 2002. Paper #14
Number of spin-outs formed + University Equity Investment in Spin-out	IP expenditures	48 U.K. universities / Poisson regression / self-report by TLO to survey		Lockett and Wright, 2005. Paper #89. NOTE: Same variables significant and same sign for both dependent variables. IP expenses includes patent costs, legal fees and more.

Number of spin-outs formed + University Equity Investment in Spin-out	Business development capability	48 U.K. universities / Poisson regression / self-report by TLO to survey		Lockett and Wright, 2005. NOTE: Same variables significant and same sign for both dependent variables. Paper #89. Spending on marketing, negotiations, due diligence and commitment of staff to process
Number of spin-outs formed + University Equity Investment in Spin-out	Royalty rate	48 U.K. universities / Poisson regression / self-report by TLO to survey		Lockett and Wright, 2005. Paper #89. NOTE: Same variables significant and same sign for both dependent variables. Share that goes to inventor.
Tech Transfer Generally	Take industry funding	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100.
Tech Transfer Generally	TLO aligned with economic development agenda	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100.
Tech Transfer Generally	TLO has clear policies	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100.
Tech Transfer Generally	Experiential learning in curriculum	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100. Especially for engineers.
Tech Transfer Generally	Develop interdisciplinary research centers	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100. In the hard sciences.
Tech Transfer Generally	Faculty culture	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100. Faculty are expected to support themselves and their research (except new faculty), so outside consulting and start-ups and industry connections are good. Word of mouth culture that entrepreneurship is good, some shame if you haven't done it.
QUALITY				
Spin-Out Formation	Research and development intensity		Cohen and Levin, 1989; Orr, 1974; Scherer 1980	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	University reputation/intellectual eminence		Di Gregorio and Shane, 2003; Birley 2002	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out	University	101 U.S. Universities /		DiGregorio and Shane, 2003. Paper #9.

Formation	reputation/intellectual eminence	negative binomial / objective measures		Gourman reports
Intensity of equity involvement	Is Carnegie II	67 U.S. universities / TOBIT / Self-report survey + AUTM		Feldman et al., 2002. Paper #14. More use of equity than Carnegie I.
Intensity of equity involvement	Age of TTO	67 U.S. universities / TOBIT / Self-report survey + AUTM		Feldman et al., 2002. Paper #14
Spin-Out Formation	Percent of faculty that hold equity	40 U.S. universities with 778 administrator and faculty / OLS / Self-report		Louis et al., 1989. Paper # 27
Licensing to Start-Ups	Quality of engineering faculty	110 U.S. universities / binomial negative / AUTM, NRC and NVCA data		Chukumba and Jensen, 2005. Paper #53.
Licensing to Start-Ups	Age of TTO office	110 U.S. universities / binomial negative / AUTM, NRC and NVCA data		Chukumba and Jensen, 2005. Paper #53.
Licensing to Start-Ups	Number of disclosures	110 U.S. universities / binomial negative / AUTM, NRC and NVCA data		Chukumba and Jensen, 2005. Paper #53.
Licensing to Start-Ups	Ratio of industrial to federal research support	110 U.S. universities / binomial negative / AUTM, NRC and NVCA data		Chukumba and Jensen, 2005. Paper #53.
Academic Scientist Involved in Advising or Founding Biotech	Employer prestige	917 academic entrepreneurs at U.S. public biotechs and 5,120 U.S. life scientist career histories / WESML discrete time hazard / SEC, Web of Science + objective data		Stuart and Ding, forthcoming. Paper #59. Gouman data.
Number of Spin-Offs	Faculty quality	141 U.S. universities / binomial negative / AUTM, NRC, NSF + TLO survey		Shea at al., 2005. Paper #87. Faculty quality is NRC data. NOTE: quality turned out to be more powerful than # of postdocs and faculty
Number of Spin-Offs	Amount of federal funding for science and engineering	141 U.S. universities / binomial negative / AUTM, NRC, NSF + TLO survey		Shea at al., 2005. Paper #87. Computer science, chemistry and life sciences within this category showed significant, positive results.
Number of Spin-Offs	TTO size	141 U.S. universities / binomial negative / AUTM, NRC, NSF + TLO survey		Shea at al., 2005. Paper #87. NOTE: No other factors, such as incubators or being land grant, showed to be

				significant.
Number licenses to private companies that IPO	TTO age	134 U.S. research universities / factor analysis, regression / AUTM, NRC, NSF and other objective data		Power and McDougall, 2005. Paper #88.
Number licenses to private companies that IPO	Faculty quality	134 U.S. research universities / factor analysis, regression / AUTM, NRC, NSF and other objective data		Power and McDougall, 2005. Paper #88. Faculty quality from Gourman.
Number licenses to private companies that IPO	Medical School	134 U.S. research universities / factor analysis, regression / AUTM, NRC, NSF and other objective data		Power and McDougall, 2005. Paper #88. Presence is positive.
Tech Transfer Generally	Science and engineering resource base	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100.
Tech Transfer Generally	Quality of faculty	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100. Suggest "radical thinkers" are key ingredient along with 'academic steeples" and a "critical mass" of faculty in the right disciplines.
Tech Transfer Generally	University mission	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100. Land grants universities like MIT that serve industry are better
Tech Transfer Generally	History and tradition	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100. Prior examples and leadership from administration.

Start-Up Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
Hazard rate of VC investment	Age of firm (decreases)	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55. Longer without VC, less likely to receive.
Hazard rate of VC investment	Semi-conductors	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55. More likely to receive VC.
Hazard rate for VC investment	Log cumulative sales (decreases)	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55. Reduces likelihood of VC (less need of it to grow)

Regional Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
Spin-Out Formation	Capital availability, Firm size, Industry concentration		Shane 2001	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Formation	Venture capital	101 U.S. Universities / negative binomial / objective measures		DiGregorio and Shane, 2003. Paper #9. Venture Economics data.
Licensing to Start-Ups	Rolling average of Venture Capital Index	110 U.S. universities / binomial negative / AUTM, NRC and NVCA data		Chukumba and Jensen, 2005. Paper #53. Negative sign suggests VC's might invest in university start-ups as last resort.
Number licenses to private companies that IPO	Entrepreneurial density Composite of R&D activity, number of patents, amount of VC, number of SBIR/STTR, and population of PhD scientists and engineers	134 U.S. research universities / factor analysis, regression / AUTM, NRC, NSF and other objective data		Power and McDougall, 2005. Paper #88. Composite of R&D activity, number of patents, amount of VC, number of SBIR/STTR, and population of PhD scientists and engineers
Tech Transfer Generally	Region is conducive to entrepreneurial activity	MIT / interviews / no analysis		Shea and Allen, 2005. Paper #100. Boston has the right "soil" to grow firms. Incubator is "city of Cambridge."

* For this work, we sought to identify plausible candidates for factors that may influence the creation of university-based start-ups and their survival or success. Because of the scarcity of objective, formally designed studies, we include – but identify – studies that report systematic review of expert opinion. For items reported as results in original papers, we include results reported as statistically significant at or below the .10 level. Although we would typically report results only at the .05 level, for purposes of casting a wide net of candidates for factors influencing start-ups, we used this more lenient standard.

APPENDIX 2: ANTECEDENTS OF UNIVERSITY STARTUPS (SUCCESS/PROSPERITY)

The data on patterns in university start ups shows that universities in many countries apparently seek to promote the creation of university spin-offs. Observers have claimed, however, that the ability to successfully create new firms linked to university knowledge does not occur evenly across countries, regions or universities. Table below summarizes results from studies that (1) directly tested the impact of factors hypothesized to influence the chances of creating spin-offs, (2) aggregated the views of experts and participants about key factors or (3) generate from other theory or expertise lists of factors likely to influence the successful creation of start-ups.

Individual Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
Spin-Out Success	Academics left university for spin-out		Olofson and Wahlbin, 1984	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	Social capital endowments		Shane and Stuart, 2002	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	When company was formed, academic inventor had no equity stake	57 European Universities / Mann-Whitney non-parametric / Self-report survey*		Lockett et al., 2003. Paper #7. Negative effect. Stronger universities tend to see academics take equity position.
Spin-Out Success	When the company was formed, academic inventor had up to 20% stake (V10 stronger)	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Start-up Survivorship	Entrepreneur is inventor	128 MIT start-ups / Hazard function with Weibull distribution / Objective data		Nerkar and Shane, 2003. Paper # 48. This reduces likelihood of start-up failure.
Start-up Survivorship	Has prior knowledge of problem solved	128 MIT start-ups / Hazard function with Weibull distribution / Objective data		Nerkar and Shane, 2003. Paper # 48. This reduces likelihood of start-up failure.
Start-up to IPO	Founder's industry experience	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55.
Start-up Survival	Indirect tie to investor	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55. Reduces risk of failure

Technology Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
Spin-out Success	Appropriability		Arrow 1962; Levin et al. 1987; Winter 1982	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Start-up Survivorship	Product is invention	128 MIT start-ups / Hazard function with Weibull distribution / Objective data		Nerkar and Shane, 2003. Paper # 48. This reduces likelihood of start-up failure. (Invention vs. process)

University Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
POLICY				
Spin-out Success	Investment funds are semi-commercial (balanced between public subsidy to allow bold investment while not losing private partners and returns)	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Programs on path to sustainability have independent management systems	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Broad alumni network complements the faculty, business and financial partners	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Strong file records and notebooks	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Clear initial IP ownership rights	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Separate an incubator's financing of companies to ensure ability to reject technologies without undermining resident researchers	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Sell shares of companies early on at low valuations	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1

Spin-out Success	Use turnover-based royalty rates	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Performance bonuses for programme managers and staff	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Use nonprofit dollars to develop early stage technologies to achieve proof of concept and attract private investment	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Make sure each company has a business plan and IP sharing agreement	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-Out Success	University networking events		Mustar, 1997	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	University – VC linkages		Lockett et al., 2003	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	Clear strategy for tech company spin-out formation	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	Licensing is preferred by university	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Paper #7. Survey. Negative impact on start-ups
Spin-Out Success	Spin-out companies are preferred commercialization route	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	Strategy for using external managers	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	Experience founding a company with IP from more than one university	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	Has program highlighting technologies available	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out	In-house specialists available	57 European Universities /		Lockett et al., 2003. Paper #7

Success		Mann-Whitney non-parametric / Self-report survey		
Spin-Out Success	Database of individuals outside university with interest in managing a spin-out	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	Initiatives that tap into Business Schools	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	Strong working relationship with at least 1 other university company	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	Strong working relationship with VC	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	Prior to formation, university commercial company recognized opportunity for new company	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	When company formed, university had no stake	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003Paper #7. Survey. Negative.
Spin-Out Success	Barrier to using surrogate entrepreneur is that it's at odds with current strategy	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8. Universities with successful spinouts don't see this as an obstacle.
Spin-Out Success	Barrier to using surrogate entrepreneur is that there is uncertainty about how process would work	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8.
Spin-Out Success	Barrier to using surrogate entrepreneur is lack of evidence of success	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8. Universities with successful spinouts don't see this as an obstacle.
Spin-Out Success	Barrier to using surrogate entrepreneur is desire to keep new ventures in house	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8. Universities with successful spinouts don't see this as an obstacle.
Spin-Out Success	Barrier to using surrogate entrepreneur is distrust of external entities	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8. Universities with successful spinouts don't see this as an obstacle.
Spin-Out Success	Barrier to using surrogate entrepreneur is lack of seed funding	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8. More successful universities didn't perceive this to be as great a barrier.

Spin-Out Success	Barrier to using surrogate entrepreneur is marshalling financial resources to manage such a program	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8. More successful universities didn't perceive this to be as great a barrier.
Tech Transfer Success	Assignment of IP rights to individual or university	Sweden versus U.S.		Goldfarb and Henrekson, 2003. Paper #98. In Sweden, IP belongs to individual faculty (1949 law – laraundantaget) versus U.S. which often goes to university. Sweden presumed to be weaker.
Tech Transfer Success	Revenue sharing with faculty, department and university	Sweden versus U.S.		Goldfarb and Henrekson, 2003. Paper #98. Stronger U.S. system often reward inventors, departments and inventors.

Start-Up Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
Spin-out Success	Make sure each company has a business plan and IP sharing agreement	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Strong CEO with specialty advisors	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-Out Success	Mix of academic and outside entrepreneur in new venture promotes growth		Chrisman et al., 1995	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	Choice of “coach” over CEO		Clarysse, 2004	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	Combinatory and cumulative learning		Clarysse et al., 2000	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	Post-formation links with university (labs)		Steffenson et al., 2000	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	Post-formation links with university (intangibles)		Rappert et al., 1999; Roberts 1991	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	Inter-industry networks		Van de Ven, 1986	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	When company was formed, a commercial manager (external to university) had up to 20% stake	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Lockett et al., 2003. Paper #7
Spin-Out Success	Advantage of having an academic-inventor in lead role in spin-out in understanding technology and its potential application	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8.
Spin-Out Success	Disadvantage of having an academic-inventor in lead role in spin-out in that activity will mean they spend less time on	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8.

	basic departmental research (More of a risk for “lesser” universities)			
Spin-Out Success	Disadvantage of having an academic-inventor in lead role in spin-out in that they are less likely of being able to behave like an entrepreneur (More of a risk for lesser universities)	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8.
Spin-Out Success	Advantage of using surrogate entrepreneurs in leading role in that they have previous commercial experience	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8.
Spin-Out Success	Advantage of using surrogate entrepreneurs in leading role in that they are likely to be motivated by capital gain	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8.
Spin-Out Success	Advantage of using surrogate entrepreneurs in leading role in that they bring existing networks	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8.
Spin-Out Success	Disadvantage of using surrogate entrepreneurs in that risk to university in trusting asset to someone with no connection to campus (V10 do not think as important factor)	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8. Universities with successful spinouts don’t see this as an obstacle.
Spin-Out Success	Disadvantage of using surrogate entrepreneurs in that less committed to technology	57 European Universities / Mann-Whitney non-parametric / Self-report survey		Franklin et al., 2001. Paper #8. Universities with successful spinouts don’t see this as an obstacle.
Start-up Survivorship	In electronics industry	128 MIT start-ups / Hazard function with Weibull distribution / Objective data		Nerkar and Shane, 2003. Paper # 48. In this industry increases likelihood of failure.
Start-up Survivorship	Venture capital available in industry	128 MIT start-ups / Hazard function with Weibull distribution / Objective data		Nerkar and Shane, 2003. Paper # 48. VC in this industry increases likelihood of failure (presume more competition from other funded firm)
Start-up Survivorship	Start-up experience of founding team	128 MIT start-ups / Hazard function with Weibull distribution / Objective data		Nerka and Shane, 2003. Paper # 48. This increases likelihood of start-up failure. This is significant in one

				model, not all, at p<0.10
Start-up Survivorship	Industry concentration	128 MIT start-ups / Hazard function with Weibull distribution / Objective data		Nerka and Shane, 2003. Paper # 48. Increases likelihood of failure (looks at top 4 company concentration in SIC code)
Start-up Survivorship	Technological radicalness	128 MIT start-ups / Hazard function with Weibull distribution / Objective data		Nerka and Shane, 2003. Paper # 48. This reduces likelihood of start-up failure.
Start-up Survivorship	Patent scope	128 MIT start-ups / Hazard function with Weibull distribution / Objective data		Nerka and Shane, 2003. Paper # 48. This reduces likelihood of start-up failure.
Start-up to IPO	Age	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55. Most likely at 4 – 7 years
Start-up to IPO	Cumulative VC raised	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55.
Start-up Survival	Patent stock	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55. More patents reduces risk of failure
Start-up Survival	Not invested in by MIT	134 MIT start-ups / piecewise hazard / TLO data		Shane and Stuart, 2002. Paper #55. MIT investment increases risk of failure (possible explanation: MIT investment indicates scare resources for start-up that chose to capitalize licensing cost through giving university equity position)
Incubator Start-Up Risk of Failure or Graduation	# employees	79 start-ups in Georgia ATDC / multinomial logit / Incubator records		Rothaermel and Thursby, 2005. Paper #91. NOTE: Increases risk of failure AND graduation
Incubator Start-Up Risk of Failure or Graduation	Total funds	79 start-ups in Georgia ATDC / multinomial logit / Incubator records		Rothaermel and Thursby, 2005. Paper #91. NOTE: Reduces risk of failure AND retards graduation
Incubator Start-Up Risk of Failure or Graduation	Time in incubator	79 start-ups in Georgia ATDC / multinomial logit / Incubator records		Rothaermel and Thursby, 2005. Paper #91. NOTE: Reduces risk of failure AND retards graduation
Incubator Start-Up Risk of Failure or Graduation	No Georgia Tech link	79 start-ups in Georgia ATDC / multinomial logit / Incubator records		Rothaermel and Thursby, 2005. Paper #91. NOTE: Retards graduation

Incubator Start-Up Risk of Failure or Graduation	Gergia Tech license	79 start-ups in Georgia ATDC / multinomial logit / Incubator records		Rothaermel and Thursby, 2005. Paper #91. NOTE: Reduces risk of failure
Incubator Start-Up Risk of Failure or Graduation	Georgia Tech link senior management only	79 start-ups in Georgia ATDC / multinomial logit / Incubator records		Rothaermel and Thursby, 2005. Paper #91. NOTE: Retards graduation
Incubator Start-Up Risk of Failure or Graduation	Georgia Tech inventor involved in senior management	79 start-ups in Georgia ATDC / multinomial logit / Incubator records		Rothaermel and Thursby, 2005. Paper #91. NOTE: Reduces risk of failure AND retards graduation

Regional Traits				
Dependent Variable	Independent Variables	Data / Methodology / Type	Citations Within Paper	Source Paper and Comments
Spin-out Success	Strong investment and business community makes spin-offs more successful	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-out Success	Financing from grants and governments as well as the private sector while avoiding reliance on 1 donor	55 European universities and institutes in 14 countries / Interviews / Observation no stats		European Commission, 2002. Paper # 1
Spin-Out Success	Financial markets developed		Looy et al., 2003	Djokovic and Souitaris, 2004. Paper #4 – Lit review
Spin-Out Success	Incubators		Cooper, 1984; for questioning effectiveness, see: MacDonald, 1987; Miller & Cole, 1987; Massey at al., 1992	Djokovic and Souitaris, 2004. Paper #4 – Lit review

* For this work, we sought to identify plausible candidates for factors that may influence the creation of university-based start-ups and their survival or success. Because of the scarcity of objective, formally designed studies, we include – but identify – studies that report systematic review of expert opinion. For items reported as results in original papers, we include results reported as statistically significant at or below the .10 level. Although we would typically report results only at the .05 level, for purposes of casting a wide net of candidates for factors influencing start-ups, we used this more lenient standard.