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Research Policy 36 (2007) 768–788
research policy
www.elsevier.com/locate/respol

Entrepreneurs from technology-based universities: Evidence from MIT

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Received 13 March 2006; received in revised form 4 December 2006; accepted 6 March 2007
Available online 19 April 2007

Abstract

This paper analyzes major patterns and trends in entrepreneurship among technology-based university alumni since the 1930s by asking two related research questions: (1) Who enters entrepreneurship, and has this changed over time? (2) How does the rate of entrepreneurship vary with changes in the entrepreneurial business environment? We describe findings based on data from two linked datasets joining Massachusetts Institute of Technology (MIT) alumni and founder information. New company formation rates by MIT alumni have grown dramatically over seven decades, and the median age of first time entrepreneurs has gradually declined from about age 40 (1950s) to about age 30 (1990s). Women alumnae lag their male counterparts in the rate at which they become entrepreneurs, and alumni who are not U.S. citizens enter entrepreneurship at different (usually higher) rates relative to their American classmates. New venture foundings over time are correlated with measures of the changing external entrepreneurial and business environment, suggesting that future research in this domain may wish to more carefully examine such factors.

Keywords: Entrepreneurship; University alumni

1. Introduction

This paper analyzes major patterns and trends in entrepreneurship among technology-based university alumni since the 1930s by asking two related research questions: (1) Who enters entrepreneurship, and has this changed over time? and (2) How does the rate of entrepreneurship vary with changes in the entrepreneurial business environment? We examine these questions in the context of alumni[1] and founder records from the Massachusetts Institute of Technology (MIT), thereby introducing several facts about the entrepreneurial activity of MIT alumni. We find that new company formation rates by MIT alumni have grown dramatically over seven decades, and the median age of first time entrepreneurs has gradually declined from about age 40 (1950s) to about age 30 (1990s). Women alumnae lag their male counterparts in the rate at which they become entrepreneurs, and alumni who are not U.S. citizens enter entrepreneurship at different (often higher) rates relative to their American classmates. These results therefore suggest that differences in individual characteristics shape the transition to entrepreneurship, both within and across time periods. The number of new venture foundings over time is correlated with measures of the changing external entrepreneurial and business environment, suggesting that future research in

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[1] We use the term "alumni" throughout to include both male alumni and female alumnae.

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doi:10.1016/j.respol.2007.03.001

this domain may wish to more carefully examine such factors.

Research universities are important institutions for educating world-class technologists. But, among many other roles, they also provide an important social setting for students and faculty to exchange ideas, including ideas on commercial entrepreneurial opportunities. We do not address in this paper the considerable challenge of disentangling the marginal impact of one life experience (albeit an important one, graduating from an institution of higher learning) from other experiences in contributing to the necessary skills and preferences for founding an entrepreneurial venture (though in the concluding section we offer some indicative evidence on this). Our goal is to present an exploratory analysis of the proclivity of MIT alumni to become entrepreneurs instead of examining issues of causality and policy—which we largely leave for future research. Nonetheless, establishing basic facts regarding technically trained entrepreneurs via analysis of a population from a university with a remarkable reputation for innovation and entrepreneurship is important.

Alumni from leading research universities are responsible for a host of important new ventures. For example, the Stanford website asserts that the university's "entrepreneurial spirit . . . has helped spawn an estimated 1200 companies in high technology and other fields."[2] Companies listed include Charles Schwab & Company, Cisco Systems, Dolby Laboratories, eBay, Excite, Gap, Google, Netflix, Nike, Silicon Graphics, Sun Microsystems and Yahoo!. For its part, the MIT website claims 150 new MIT-related firms founded per year, a total of 5000 companies, employing 1.1 million and with aggregate annual sales over $230 billion.[3] Companies founded by MIT alumni and faculty include Analog Devices, Arthur D. Little, Inc. (1886), Campbell Soup (1900), Bose, DEC, IDG, Intel, Raytheon, Rockwell, Texas Instruments, Teradyne and 3Com. Both universities claim E*Trade and Hewlett-Packard.

While the recent literature on the "entrepreneurial university" and academic entrepreneurship has focused on university technology transfer, university spin-off firms, and faculty entrepreneurs (e.g., Dahlstrand, 1997; DiGregorio and Shane, 2003; Etzkowitz, 1998, 2003; Nicolaou and Birley, 2003; Vohora et al., 2004), the university's entrepreneurial influence can be seen as extending to its students as well. While academic studies of technology-based entrepreneurship began in earnest in the 1960s (Roberts, 2004), the role of universities in fostering entrepreneurship via students and alumni still needs much systematic analysis, particularly as related to changes over time.

We have a more modest goal here. The purpose of this study is to provide an initial and rare view of entrepreneurship patterns among graduates of MIT over several decades. This research serves to advance our knowledge of how founders have changed over time. To that end, instead of deriving empirical predictions from the extant literature (which is limited in this domain), we devote our attention to describing what we found in the data on the evolution of entrepreneurship over time and discuss implications for future research in this domain.

The first of our two main research questions is: Who enters entrepreneurship? While this is not a new question to the literature, we offer three enhancements in our empirical approach. First, the long time horizon of our data allows us to observe entrepreneurial patterns over multiple decades and examine temporal effects. Second, our focus on alumni from a leading technical university allows us to examine the entrepreneurial choices of technically savvy individuals (and so there is desirable relative uniformity in individuals' technical skill sets in the sample).[4] These individuals likely represent individuals with the luxury of choosing among a wide spectrum of alternate career paths, and so the choice of an entrepreneurial career is notable. Finally, our data comprise a representative sample of MIT alumni not selected based on entry (or successful entry) into entrepreneurship. The second research question we address is how the rate of entrepreneurship changes with the business environment. This question has been relatively less explored in the literature, especially in connecting individual-level entrepreneurial entry decisions with macro-level business environment factors.

Our emphasis is on new venture creation as distinguished from small professional service partnerships and consulting groups. While it may be tempting to differentiate technology-based firms from others by the amount of initial capital raised or patents awarded, these criteria

[2] http://www.stanford.edu/home/stanford/facts/innovation.html (accessed 1 September 2005).

[3] http://entrepreneurship.mit.edu/mit_spinoffs.php (accessed 1 September 2005).

[4] The fact that the founders in our study are all graduates of MIT imposes some degree of uniformity on the sample of entrepreneurial ventures, which is attractive since entrepreneurs and new ventures in general are quite heterogeneous. While such a sample is not necessarily representative of the entire spectrum of self-employment (e.g., Blau, 1987; Carroll and Mosakowski, 1987; Parhankangas and Arenius, 2003), our focus is on the changing nature of entrepreneurship among technically trained graduates.

would eliminate those using bootstrapped financing or those situations in which patents are less useful for value appropriation. Likewise, using industrial classifications may not be satisfactory (e.g., even financial services firms could have developed new software solutions). Absent a clear conceptual consensus on the boundaries between new venture creation and self-employment, we adopt one concrete measure in our empirical analyses: we operationalize new ventures as those that employed 10 or more individuals.[5]

The list of some of the more well-known companies founded from research universities previously mentioned suggests that studying entrepreneurs emanating from MIT and comparable institutions is an important undertaking, as such firms are responsible for considerable value creation. In ongoing research (unpublished), we examine the firms formed by the set of MIT-alumni entrepreneurs in our dataset, which includes a great deal of variety across both industry sectors (spanning service and manufacturing industries, with varying degrees of technological reliance) and venture sizes.

The remainder of the paper is organized as follows: Section 2 reviews the prior literature on individuals and entrepreneurship, Section 3 discusses the data and presents results on characteristics and rates of those entering entrepreneurship over time. Section 4 examines the changing entrepreneurial business environment. Section 5 discusses the study's findings and limitations, together with areas for future research. A final section concludes.

2. Transition to entrepreneurship

Entrepreneurial action has been identified as both vital to economic growth and an important efficiency-inducing mechanism in the economy (Schumpeter, 1943). Shane (1995) shows that the national growth in the prevalence of entrepreneurial firms between 1947 and 1990 enhanced real economic growth in the U.S. economy as a whole. For these reasons, the innovation and entrepreneurship literatures have long been interested in the question: What causes some people to start companies when most do not? The literature analyzing this question has examined four categories of explanations: (1) basic demographic factors such as age, ethnicity and gender, (2) training and experience effects, (3) cognitive differences among individuals, and (4) financial and opportunity cost-based rationales. Our purpose here is to briefly review these explanations (in the order listed) to provide context for interpreting the facts established from the MIT dataset (though we will not be able to empirically adjudicate among some of these explanations). Clearly, this literature covers a large terrain; however, the literature does not provide analysis over a long time span, which may be necessary to better understand factors that drive changes in the rate of entrepreneurship.

The first class of explanations for entering into entrepreneurship emphasizes demographic factors, and spans areas such as religious background (McClelland, 1961) and the presence of self-employed parents (Dunn and Holtz-Eakin, 2000; Roberts, 1991; Sorensen, 2007). A number of studies have suggested that age may play a role in the decision to start a new venture as well, with an "aging out" phenomenon affecting those in their upper 40s and later years if they had not earlier started a company (Levesque and Minniti, 2006). Empirical evidence appears to support this assertion (Roberts, 1991).

Ethnic and immigration status may also play a role in entrepreneurship. Entrepreneurship participation rates appear to be high among members of some immigrant communities, including Swedish technological entrepreneurs and recent Silicon Valley high-tech start-ups (Saxenian, 1999, 2002; Utterback et al., 1988). More generally, the overall rate of entry into self-employment among members of immigrant communities depends on the size of the ethnic market, as well as on human capital characteristics such as language skills (Evans, 1989).

The literature on gender and entrepreneurship, while limited, highlights two areas. One group of studies suggests that women entrepreneurs tend to concentrate in certain industries, typically personal services and small-scale retail (e.g., Bates, 2002). A second group of studies examines differential motivations for entering entrepreneurship according to gender. These studies suggest that men tend to be more motivated by wealth creation, whereas women have family-oriented motivation and desire the flexibility that entrepreneurship offers, though these differences are less apparent among women and men who do not have children (DeMartino and Barbato, 2003). The differences across gender also appear to be conditioned on several environmental influences. Career advancement obstacles may induce women to go into business for themselves at a disproportionately high rate (Buttner and Moore, 1997), the presence of children and the provision of child care by the husband increases self-employment among women (Caputo and Dolinsky, 1998), and the effect of parental self-employment on one's likelihood

[5] This size threshold follows that used by the Stanford Project on Emerging Companies studies (e.g., Baron et al., 1996).

to enter entrepreneurship runs primarily along gender lines (Dunn and Holtz-Eakin, 2000).

A second class of explanations for transitioning into entrepreneurship has emphasized training, career histories, and other experience. Exposure to entrepreneurial experience through household or personal experience increases the likelihood of entrepreneurship (Carroll and Mosakowski, 1987; Roberts, 1991; Sorensen, 2007). The recent spin-off literature has emphasized both the characteristics of the parent firms (e.g., Gompers et al., 2005) as well as characteristics of the individuals (e.g., Shane and Khurana, 2003) as important determinants of the likelihood to spin off new ventures. While Dahlstrand (1997) shows that a minority of spin-offs come from universities, even for start-up firms that do not spin-off from academia there is a likely role that university training plays for entrepreneurs from private firms. Universities are an important source of knowledge spillovers (Jaffe, 1989; Zucker et al., 1998). These spillovers are not limited to university technology, but also include knowledge, norms, and attitudes about technology-based entrepreneurship. This is an important mechanism not well captured in the existing literature on the impact of universities on new venture creation. Recent work has noted that much of the university-developed knowledge received by the private sector is transferred through non-commercial mechanisms (Mowery and Shane, 2002). Yet these mechanisms have been under-explored in the literature on university entrepreneurship, and so we emphasize the transfer of knowledge related to technical entrepreneurship to students/alumni in this paper.

Recent studies have connected educational training with entrepreneurship, a plausible explanation as countries with a higher proportion of engineering college majors experience faster economic growth (Murphy et al., 1991).[6] Baumol (2004) suggests that the type of education appropriate for technical knowledge mastery may be significantly different from the type of creative thinking needed for entrepreneurial opportunity recognition and exploitation. In a related effort, Lazear (2004) developed a theoretical model and tested it on a data set of Stanford business school alumni, showing that an important determinant of entrepreneurship is the breadth of an individual's curriculum background, suggesting that entrepreneurs tend to be generalists rather than specialists. Lazear (2004) uses data on Stanford alumni and is the closest work to our study. However, the dataset is limited to Stanford's Graduate School of Business alumni whereas our dataset includes alumni across all schools at MIT.

The Lazear (2004) study raises the question of whether it is the higher number of different roles that induces entrepreneurship by providing a necessary balance of skills and knowledge. Alternatively, the generalist training mechanism for entrepreneurship may instead reduce the payoff to a traditional career based on building a specific skill set. As well, these payoffs may be importantly affected by regional labor market conditions. For example, Roberts (1991) finds that MIT-based technical entrepreneurs (who tended to exhibit more stable employment patterns in the East Coast) were quite different from Stanford-based technical entrepreneurs (who tended to "job-hop" in the West Coast labor market).

A third set of explanations for individual differences in transitioning into entrepreneurship emphasizes cognitive factors (e.g., Mitchell et al., 2000). For example, Douglas and Shepherd (2000) propose a model in which individual attitudes toward risk-aversion, independence and work determine entrepreneurial entry based on utility comparisons. Empirical evidence has been offered in this domain to support the extent of counterfactual thinking and regret (Baron, 2000) and controlling perceived risk versus perceived outcomes (Sarasvathy et al., 1998). In addition, Roberts (1991) finds that those with "moderate" needs for achievement and power, as well as heavy orientation toward independence, were more likely to become entrepreneurs.

The final set of explanations for individual differences in transitioning to entrepreneurship deals with opportunity costs and financial access. Both theory and empirical evidence have supported the claim that the lower the opportunity costs of individuals, the more likely they are to start a new firm (Amit et al., 1995; Iyigun and Owen, 1998). Gimeno et al. (1997) demonstrate that those with higher switching costs into other occupations are more likely to remain in entrepreneurship, even with low performing firms. Additionally, employees are more likely to leave their existing organization to start a new firm when there has been a slowdown in sales growth in the existing firm (Gompers et al., 2005).

The financial capital of parents and, to an extent, the income of the potential entrepreneur have also been linked with entrepreneurship (Dunn and Holtz-Eakin, 2000). The effects of financial constraints on the formation of new firms are also seen in the negative correlation of tax rates and self-employment in lower tax brackets (Blau, 1987) as well as in the increased propensity to be self-employed follow-

[6] The direction of causality may be reversed here, however: countries with faster growth may provide more engineering jobs and may support more engineering education, a possibility these authors acknowledge.

ing an inheritance or gift (Blanchflower and Oswald, 1998). More generally, in a model of the supply of employees becoming entrepreneurs, Hellmann (in press) shows that the munificence of funding for new ventures determines the transition rate from employee to entrepreneur.

3. The MIT data and transitions to entrepreneurship

To shed light on the transition to entrepreneurship at the individual level for a sample of technically trained individuals, we present a new dataset composed of 43,668 records of MIT alumni who responded to a 2001 survey of all living alumni (105,928 surveys were sent out for a response rate of 41.2%). These records contain basic demographic information on respondents' date of birth, country of citizenship, gender, major at MIT, highest attained degree and new venture founding history. Of the respondents to the 2001 survey, 7798 individuals (17.9% of the respondents) indicated that they had founded at least one company. These individuals were then mailed a second survey in 2003 that asked detailed questions about the formation of their firms. Two thousand one hundred and eleven founder surveys were completed, representing a response rate of 27.1%.[7] One of the key features of this interlinked dataset is its long time horizon in the cross section (1930–2003) that allows us to analyze trends over several decades.

3.1. What can be examined and what cannot?

The advantages of the MIT alumni founder dataset are the number of decades covered, the very large number of observations, as well as the ability to compare the founders' characteristics along a number of dimensions with their classmates who had largely the same educational experience while at MIT but did not become entrepreneurs. We also observe wide variation in firm sizes, number of operating years, and outcomes so we do not necessarily share the limitation of other entrepreneur datasets in only sampling the most successful founders. One difficulty in interpreting these data is that there is temporal right-censoring in that we cannot know who of the more recent graduates will become entrepreneurs, especially given the frequently long lag from graduation to first firm founding. We use statistical methods in the regression analysis to adjust our estimates for this right-censoring.

Using these data, we can analyze and report on a number of the personal characteristics within the entrepreneurial dataset. These include the overall temporal pattern of change in the number and intensity of founder experiences among these alumni. We can determine the age at which individuals' first entrepreneurial acts occurred, and how long they delayed after graduation from MIT and/or other universities before beginning their venture. In addition, the data permit separation by gender, country of origin, and academic field of study while at MIT.

However, we lack data that the literature has presented as important. For example, we do not have parental or family background information, including parental careers, religion or wealth. We do not have good measures of the skills or variety of roles played by the alumni prior to their becoming entrepreneurs. We also lack information on cognitive characteristics of the entrepreneurs, opportunity costs they might have perceived in becoming entrepreneurs, and information on their motivations in starting their firms. These deficiencies constrain our areas of current analyses while providing good opportunities for future research direction. For the present study, we regard these factors as unobserved, and to the extent that they are randomly distributed between founders and non-founders, our regression estimates are consistent. Before turning to the regression analyses, we first present a series of figures that illustrate the basic trends in the data.

[7] Appendix A shows *t*-tests of the null hypothesis that the average (observed) characteristics of the responders and non-responders are the same statistically, for both the 2001 and 2003 surveys. Due to the volume of data, even small differences in means across the responding and non-responding sub-samples can be statistically significant. On an absolute basis, the means between the two sub-samples appear to be very well matched by observable characteristics. In only a few instances do the differences between the sub-samples vary by three percentage points or more in absolute value. For the 2001 survey, only the variables *male*, *European citizen*, and *Middle Eastern citizen* meet these criteria. To foreshadow our statistical results, the regressions reveal only the first and third of these variables as statistically significant after controlling for the remaining factors. We therefore further confine our discussion of possible bias to those variables. For both *male* and *Middle Eastern citizen*, a smaller fraction of individuals relative to the underlying population responded to the survey. Our estimates imply that belonging to each of these groups increases the hazard of becoming an entrepreneur, and so we are likely being conservative in our estimation (assuming a proportionate likelihood of entering entrepreneurship). While there is no reason to believe that the small percentage difference in these two groups systematically did not engage in entrepreneurship, even if this were the case, the reported statistical results would likely not be overturned. For the 2003 survey only two variables have statistically significant differences between responders and non-responders, *engineering major* and *management major*. Because we do not report our results concerning venture characteristics in this article (leaving that description to an ongoing project), we defer the associated discussion.

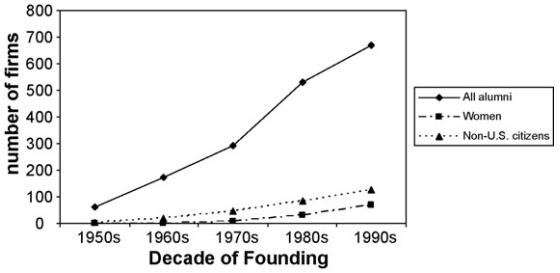

Fig. 1. First firm foundings by decade.

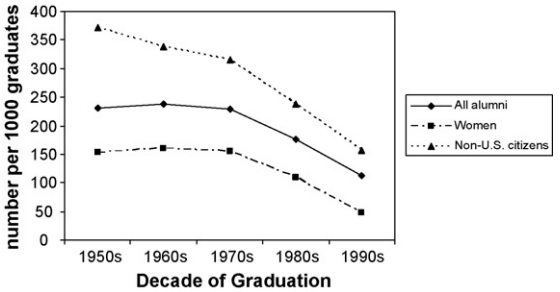

Fig. 2. First firm foundings per 1000 alumni within category.

3.2. Founder characteristics

3.2.1. Incidence and demography of entrepreneurship

Fig. 1 shows dramatic growth over the past seven decades in the number of MIT alumni founding their first companies, including additional curves for the firms founded by women and those founded by alumni who were not U.S. citizens. Clearly, males and U.S citizens account for the vast bulk of the MIT alumni entrepreneurs over this entire period. A total of 747 MIT alumni report starting their first firms during the decade of the 1990s. Women founders started appearing in the 1950s and grow to about 10.1% of the sample by the 1990s. Non-U.S. citizens as entrepreneurs begin slight visibility in the 1940s and grow steadily to about 17.2% of the new firm formations during the decade of the 1990s. Fig. 2 shows normalized data (from the 2001 survey), which portrays the number of founders by decade of graduation per thousand alumni overall, per thousand women alumnae, and per thousand non-US citizens.[8] The intensity of new entrepreneurial start-up formation by women is considerably below the male rate of firm formation. Relative to their numbers, non-U.S. citizens become entrepreneurs even more rapidly than their U.S. alumni counterparts, to a rate of about 250 new companies being formed per 1000 alumni in the decade of the 1980s, with a slight turndown in the 1990s (due to right-side censoring). The differences within decade among constituent groups is roughly similar though appears to be narrowing over time in this simple tabulation. In Section 3.2.4 we provide data that indicate that most of the non-U.S. alumni entrepreneurs have been coming from Asia, Europe and Latin America, with these continents in recent decades accounting together for approximately 14% of the entire sample of MIT alumni first-time start-ups.

The overall results here mirror those by Gartner and Shane (1995), who observe an acceleration of new venture foundings between 1957 and 1992, particularly after 1980, and by Blau (1987), who shows that in the early 1970s the general trend toward decreasing self-employment in the nonagricultural sector reversed and has continued to rise since then. Dunne et al. (1988) use the Census of Manufactures and find that the average rate of new firm entry increases from 0.15 for 1963–1967 to 0.25 in 1967–1972 before returning to about 0.23 through 1982. The overall results are also consistent with Evans and Leighton (1989) who find self-employment increasing from 1966 to 1981.

3.2.2. Age of first time entrepreneurs and lag from graduation

Along with the sheer increase in numbers has been the dramatic reduction beginning in the 1960s in the age at which "the entrepreneurial act" occurs, as shown in Table 1 (panel A). The shift over the past six decades from starting a company in a founder's 40s to doing so at the age of 30 (at the median) implies career pattern shifts from entrepreneurship as a mid-life career change to becoming an initial choice near the beginning of one's working career. Differences in organizational work experience, network accumulation, wealth accumulation and family responsibility situation, among other changes, likely accompany this shift in the age of founding. The distribution of entrepreneurial ages at founders' times of first foundings also has changed over the past 40 years. Fig. 3 shows two frequency distributions of MIT alumni entrepreneur ages for firms founded in the 1980s and

[8] To construct each data point, only the number of alumni graduating in that decade is taken into account. The MIT undergraduate class grew from about 900 per year in the 1950s to about 1100 in subsequent decades. Graduate school enrollments have grown considerably as well over the same time period, including in particular the institutionalization of the MIT Sloan School of Management in 1952. Taking these changes into account via normalization per 1000 alumni at each decade helps to clarify the underlying trends.

Table 1
Select trends in graduates becoming entrepreneurs

	Decade of graduation				
	1950s	1960s	1970s	1980s	1990s
Panel A: Median age at first firm founding (years)					
All	40.5	39	35	32	28
Non-U.S. citizens	38	35.5	36.5	32	29
Women	42	41	40	35	29

	Decade of first firm founding				
	1950s ($N=60$)	1960s ($N=167$)	1970s ($N=284$)	1980s ($N=507$)	1990s ($N=653$)
Panel B: Proportion of entrepreneurs by final degree (%)					
Bachelor's	53.2	44.0	41.3	46.8	25.3
Master's	36.4	36.0	40.3	38.4	56.2
Doctorate	10.4	20.0	18.4	14.9	18.5

	Decade of first firm founding				
	1950s ($N=54$)	1960s ($N=147$)	1970s ($N=252$	1980s ($N=448$)	1990s ($N=620$)
Panel C: Proportion of founders from certain academic departments (%)					
EE and CS degrees	20.4	26.5	18.7	25.4	22.7
Management degrees	16.7	14.3	13.5	13.8	15.8
Life sciences degrees	0.0	2.7	4.0	4.9	4.7

for those founded in the 1990s. Also added to the figure is the age distribution of entrepreneurs who came from several MIT laboratories and departments prior to 1970 (many were MIT alumni), documented earlier by Roberts (1991, Fig. 3-3 used with permission). Note the general shifts in the three curves over the years. The distributions show that the more recent entrepreneurs include more from the younger age brackets as well as more from the late 40s and 50s age brackets. Prior to the 1970s, 23% of the first-time entrepreneurs were under 30 years of age; during the 1980s that number grew to 31%; in the 1990s 36% of the founders were under 30. Prior to the 1970s 26% of the first-time founders were over 40 years of age; during the 1980s 28% were older than 40; and in the 1990s 35% were older than 40.

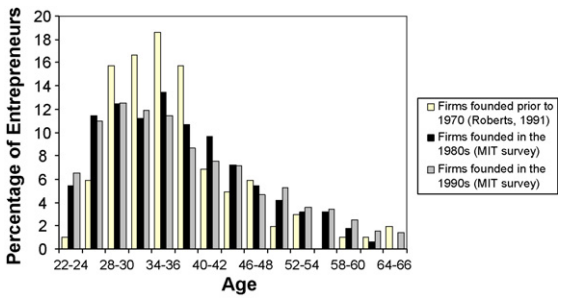

Fig. 3. Age distribution of entrepreneurs at first firm founding.

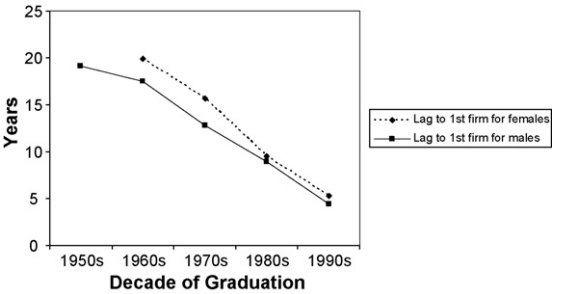

Fig. 4. Entrepreneurial time lag to first firm.

Related to the decline in age distribution is the delay from graduation to founding a first firm, as shown in Fig. 4. In this figure, the time lag for graduates from the more recent decades drops to as low as 4 years from graduation during the "bubble" years of the 1990s.[9] Interpreting Fig. 4 is challenging since lags in more

[9] To explore whether the drop in age at first founding is due to a recent trend for graduates to go into freelance information technology (IT) consulting, we examined the sub-sample of software firms. A *t*-test of means shows that founders of software firms with fewer than 10 employers (mean age = 48.9) were not significantly younger than founders with 10 employees or more (mean age 47.7). This result was unchanged by restricting the sample to firms founded in the 1990s. We conclude that the age result is not driven (solely) by entry into freelance IT consulting.

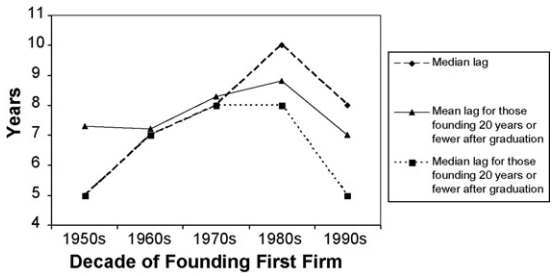

Fig. 5. Time lag to entrepreneurship from highest academic degree (excluding bachelor's).

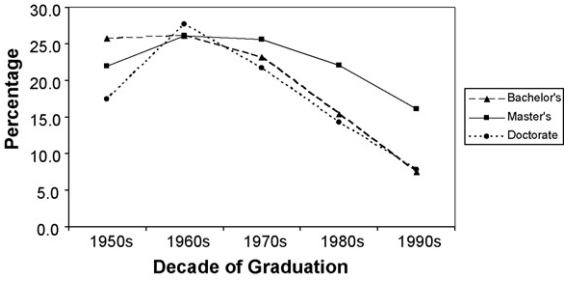

Fig. 6. Proportion entering entrepreneurship (normalized for number finishing with specified degree).

recent time periods do not account for those individuals who will become entrepreneurs in the future, i.e. right-side censoring of the data. Fig. 5 plots the median lags[10] and finds a consistent time pattern, while the regression analyses presented below will statistically adjust for the right censoring. Note that the drop in time lag for men is approximately the same as for women over the full duration that women entrepreneurs have meaningful numbers in the dataset.

3.2.3. Educational characteristics

Examination of the founder characteristics by educational degree attainment in Table 1 (panel B) shows gradual changes across the decades of new company formations from over 50% down to below 40% bachelor's degree recipients, a rise in percentage of master's degree holders to 40% and more, with doctoral recipients gradually moving upward toward 20%. These numbers changed in the post-World War II period with the rapid growth of graduate education at MIT in engineering and the sciences, especially at the doctoral level, and the later growth of those enrolled for the master's degree at the MIT Sloan School of Management.

In Fig. 6, we show the educational characteristics differently, by plotting the proportion of those entering entrepreneurship normalized by the number finishing with each specified degree in each decade. This figure is again right-side censored in that we do not know who of the recent decade graduates will start first firms after 2003, the last date for which we have founding data. While the rate of entrepreneurship across the three degree categories is essentially the same in the 1960s and 1970s, in the part of the data unlikely to be materially affected by right time censoring (the entrepreneurship patterns from the 1960s to 1970s), it appears that masters students are two percentage points more likely to enter entrepreneurship relative to bachelor and doctorate degree holders, but it is possible these differences are due to Master's students from recent years starting firms sooner after graduation. If this were true, then we could be seeing less right side censoring for the Master's students compared to the others.[11]

A final educational aspect is the general area of MIT study of these alumni entrepreneurs. In Fig. 7 we show by decade of firm founding the percentage breakdown by field of study of the MIT alumni founders. MIT is organized by academic departments within five schools. The departments have had some small number of changes over the years, but the five schools have remained relatively stable as Architecture and Urban Studies, Engineering, Humanities and Social Sciences, Management, and Science, with the MIT Sloan School of Management becoming MIT's fifth school in 1951 (it had been a department since 1914). The data show that while

[10] Bachelor's degree graduates were excluded from this calculation to eliminate the effect of the major trend of an increasing percentage of them going directly to graduate school rather than into a job. As an illustrative example of the right censoring issue, consider the graduates from 1965 who by the 2003 survey have an average age of at least 64. These individuals are unlikely to start any new firms after that age, so they are likely to constitute a complete sample. By 12 years after graduation just over 50% of the individuals who will eventually start a firm have founded a firm. If this statistic were constant over time, that would mean that by the 2001 survey, only about 50% of the graduates from 1990 who might eventually become entrepreneurs would have founded a firm and been included in the 2003 survey.

[11] Bachelor's degree recipients decline in becoming entrepreneurs, at least in their early years post-degree. This may be in part due to the increased fraction of bachelor's graduates going on for advanced degrees. Fewer and fewer MIT bachelor's degree holders enter the labor market (including new firm formation) immediately following their undergraduate studies. For the period 1994–1996 approximately half of MIT graduates with an SB entered industry and half entered graduate school directly (http://web.archive.org/web/*/web.mit.edu). The number entering graduate school directly hit a low of 38% in 2001–2002 and has since increased to 67% for the 2003–2005 period (http://web.mit.edu/facts/graduation.shtml) (Web sites accessed 1 September 2005).

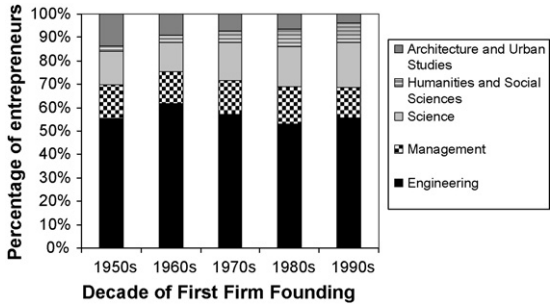

Fig. 7. Proportion of MIT entrepreneurs from each school.

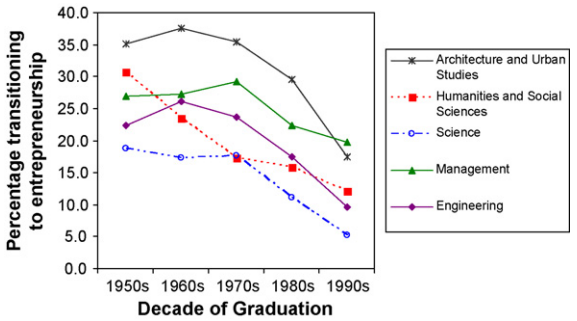

Fig. 8. Proportion entering entrepreneurship from each school.

engineering graduates represent the bulk of those entering entrepreneurship over the time period of the sample, science graduates have increased their representation in recent decades.

In Fig. 8 we show the normalized percentages of entrepreneurs by school, again using the numbers graduating in each decade as our bases for normalization. We face the same right-side censoring as observed previously, but we presume that the overall trends in areas of study are not affected by this censoring. Despite increased participation over time from science graduates, the percentage of them who become entrepreneurs is still the smallest of all background areas of study, over essentially the entire period of time studied.[12] Proportionately from 50 to 100% more MIT engineering graduates than science alumni have eventually become entrepreneurs. Management graduates overall seem to be as inclined proportionately to become entrepreneurs as MIT engineering graduates. Architecture alumni are the most likely among graduates of all the MIT schools to strike out on their own (on a proportional basis). This no doubt reflects a dominant "industry" structure of large numbers of small architectural practices, with relatively frequent changes in partnerships.

Table 1 (panel C) highlights some specifics of the educational backgrounds of the MIT alumni, showing for comparison the percent of all alumni founders by decade for three select MIT departments: electrical engineering and computer science (EECS), biology/life sciences, and management. EECS has by tradition been the largest department at MIT and the most evident home of its entrepreneurial offshoots. Biology/life sciences is an up-and-coming "technology change area" and we wish to portray its entrepreneurial inclinations. Management appears to have established itself as a common ground for entrepreneurial interest development and we want to examine how deeply rooted are these indicators. The data show that the percentage of founders graduating with degrees in biology/life sciences has indeed increased over the years, but appears to have leveled off in recent decades at around 5%. The percentage of EECS majors represented among founders remains the highest at slightly more than 20% and those with management degrees hover around 15%. Both EECS and management appear to be relatively stable in their supply of entrepreneurs over the decades.

3.2.4. *Geographic origins*

Fig. 1 shows an increase in number of those MIT alumni entrepreneurs who held non-U.S. citizenships. These data are impressive but still understate the number whose country of origin is not the United States.[13] Some percentage of the alumni who had been born elsewhere remained in the U.S. and had become U.S. citizens by the time they formed their first firm. Fig. 9 shows the time trends in the proportion of founders by non-U.S. global geographic region at the time they formed their first companies. Within each decade, alumni coming to MIT from South America and the Middle East are consistently more likely to become entrepreneurs. Fur-

[12] The overall social welfare implications of the finding that science graduates enter entrepreneurship at lower rates than their classmates is ambiguous in that it is difficult (or not possible) to know how productive and socially useful such individuals would have been had they decided to undertake an entrepreneurial venture instead of the career that they chose. In order to understand policy choices on this issue, future studies may wish to conduct a comprehensive analysis of the costs and benefits to encouraging science graduates to pursue entrepreneurial careers instead of science careers.

[13] Technically, we use responses for country of citizenship since only 182 of the founders provided information on country of origin, compared to 366 with information on country of citizenship. In only 14 cases does the information on country of origin differ from the corresponding country of citizenship data.

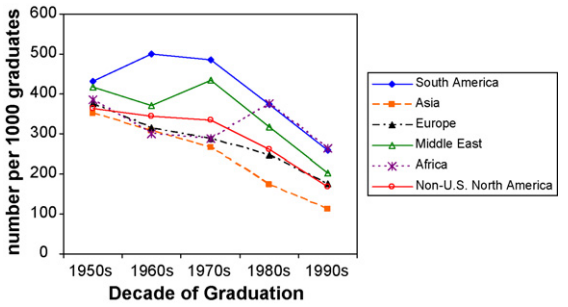

Fig. 9. Founders per 1000 graduates from the geographic region.

ther, their increased relative likelihood of firm founding has remained at similar levels above alumni from other regions. While U.S. citizens still account for about 85% of the new start-up alumni entrepreneurs, proportional to their graduating numbers at MIT, the alumni from almost every other region of the world have a higher likelihood of firm formation.

3.3. Testing the founder characteristics' influence on firm formation

The information provided in Section 3.2 clearly reveals that the MIT founder data across 70 years strongly show overall and impressive increases in the entrepreneurship phenomenon by absolute number, by youthfulness, by gender and by non-U.S. citizens coming to MIT. In order to better understand the comparative importance of these factors in firm formation, as well as to account for the right-censoring of the data, we turn to a multivariate regression analysis. We employ Cox (1972) hazard regression models for two reasons. First, the model is semi-parametric, so that we can estimate the impact of independent variables on the hazard of founding a firm while being agnostic about the baseline hazard function. Second, the model explicitly takes the timing of events into account (by estimating the probability of founding a firm in a given year conditional on not having founded a firm up until that time period), and adjusts for the right-censoring of the data. In these regressions subjects start being "at risk" of founding a firm at the time of their graduation, and a "failure" event occurs the year the individual founds a firm (otherwise, the founding year is considered censored for that individual as of the year 2003).[14] Reported coefficients are hazard ratios, with values above 1.0 representing increases in the hazard of founding a firm and vice versa for values below 1.0. Statistically significant estimates are indicated through asterisks. We employ a stratified random sample of the underlying alumni dataset since founding a firm is a relatively rare event in the overall data. First, all 1631 individuals with complete data responses who are known ex post to have founded a firm were selected.[15] We then matched these individuals in a five to one ratio with randomly selected alumni who had not founded a firm as of 2001, conditioning only on birth year. The statistics literature (e.g., Breslow et al., 1983) suggests little loss of efficiency so long as approximately 20% of a sample has experienced the event of interest.

Panel A of Table 2 presents variable definitions and summary statistics. Table 3 shows the results of four models: 3-1, gender; 3-2, area of study at MIT; 3-3, geographic region of citizenship; 3-4, a combined model with all the above factors included. Model 3-1 shows that across the time span covered in the data, male alumni were 65% more likely to found a firm relative to their female counterparts. Model 3-2 shows that, relative to natural science graduates, engineering, management and architecture graduates were more likely to start firms (social science majors did not statistically differ from natural science graduates over the time period in their hazard rates of becoming entrepreneurs). Model 3-3 indicates that relative to U.S. citizen alumni, alumni hailing from Latin America or from the Middle East were significantly more likely to be firm founders. Finally, model 3-4 simultaneously examines all the prior effects. The basic patterns and estimates of gender, disciplinary background, and country of citizenship effects remain stable in their economic and statistical significance. These basic results are also robust to stratifying the baseline hazard according to disciplinary background (i.e., allowing engineering, management, architecture, social science,

[14] We have also run these analyses with individuals becoming at risk of founding a firm at their birth. The results are robust to that entry time. To address the distinction between self-employment and new ventures, absent a consensus in the literature on implied measurement differences, we define new ventures as those employing 10 or more individuals. All of the reported results are also robust to this venture size threshold.

[15] We only know founding dates for entrepreneurs responding to the 2003 survey rather than the broader sample of respondents to the 2001 survey. While we report results for hazard models, which rely on the timing of founding for the analysis (we are mainly interested in such models since they can accommodate right censoring), robustness checks on the full 2001 data employing simple logit models predicting entrepreneurial entry (regardless of timing) are consistent. Appendix A suggests that the 2003 survey respondents are statistically similar to the non-responders on most observables, and so the magnitude of bias from using these data is likely to be small or zero.

Table 2
Summary Statistics and Variable Definitions

Variable	Definition	Mean	S.D.
Panel A: Individual-level measures			
First start-up founded	Year in which first firm was founded (censored if not observed by 2003)	1985.10	12.30
Graduation year	Year of MIT graduation	1975.67	16.87
Male	Dummy = 1 if the individual is male	0.84	0.36
Academic major	Set of dummies for academic major: engineering (53%), management (14%), social science (5%), architecture (4%), and natural science (the excluded category)		
Country of origin	Set of dummies for country of citizenship: Latin America (2%), Asia (7%), Europe (6%), Middle East (1%), Africa (1%) or North America (the excluded category)		
Panel B: Year-level measures			
First firm foundings	Number of first firms founded	25.53	25.94
Number of graduates (t-1)	Number of individuals in the MIT graduating class in the prior year	567.04	315.92
Patents issued (t-1)	Number of U.S. patents issued in the prior year ('000s)	63.80	31.56
Venture capital disbursements (t-1)	Total disbursements made by venture capital firms in the prior year ($B)	5.51	15.71
Recessionary economy (t-1)	Dummy = 1 if the U.S. economy was in recession in the prior year as determined by the NBER	0.28	0.45
Gross domestic product (t-1)	Gross domestic product of the U.S. economy in the prior year ($B)	3925.37	2625.58
Inflation rate (t-1)	Inflation rate of the U.S. economy in the prior year (%)	3.46	4.14
NY stock exchange market cap. (t-1)	Total market capitalization of the New York Stock Exchange in the prior year ($)	1.63	2.86

and natural science majors to have their own unspecified baseline hazard functions).

Since we are interested in temporal changes in entrepreneurship, the analysis in Table 4 divides the sample into quartiles of birth year cohorts and estimates fully specified models (mirroring the final specification of Table 3) for these four time sub-samples. Being male and studying either engineering, management, or architecture retains significance in (almost) all these birth periods. Note that the hazard for male relative to female alumni has increased dramatically for the later birth cohorts (a comparison of these results with the visual patterns from Fig. 2 is interesting). Non-U.S. alumni over time in general show the same general directional pat-

Table 3
Entrepreneurship Cox hazard rate regressions (individual level of analysis)

Independent variables	Dependent variable = first start-up founded (subjects start being at risk upon graduation)[a]			
	(3-1)	(3-2)	(3-3)	(3-4)
Male	1.648*** (0.164)			1.675*** (0.168)
Engineering major		1.490*** (0.100)		1.548*** (0.098)
Management major		1.410*** (0.131)		1.384*** (0.129)
Social science major		1.110 (0.158)		1.133 (0.161)
Architecture major		2.422*** (0.270)		2.578*** (0.289)
Latin American citizen			1.920*** (0.302)	1.893*** (0.297)
Asian citizen			0.888 (0.108)	0.886 (0.108)
European citizen			1.035 (0.111)	1.027 (0.110)
Middle Eastern citizen			1.670** (0.421)	1.533* (0.386)
African citizen			1.399 (0.468)	1.183 (0.396)
Log likelihood	−13353.31	−13315.79	−13358.07	−13291.51
Number of observations	10,632	10,632	10,632	10,632

Note: 1482 failures; 312,039 total years at risk; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.
[a] Reported coefficients are hazard ratios.

Table 4
Entrepreneurship Cox hazard rate regressions by birth cohort (individual level of analysis)

Independent variables	Dependent variable = first start-up founded (subjects start being at risk upon graduation) Note: reported coefficients are hazard ratios			
	Birth year: 1912–1937 (4-1)	Birth year: 1938–1952 (4-2)	Birth year: 1953–1964 (4-3)	Birth year: 1965–1979 (4-4)
Male	1.791 (0.911)	1.678*** (0.324)	1.752*** (0.263)	4.024*** (0.876)
Engineering major	1.325* (0.197)	1.510*** (0.159)	1.393** (0.187)	1.625*** (0.302)
Management major	1.344 (0.268)	1.430** (0.210)	1.615*** (0.294)	1.067 (0.305)
Social science major	1.031 (0.369)	1.070 (0.234)	1.329 (0.348)	0.980 (0.406)
Architecture major	3.517*** (0.700)	2.941*** (0.579)	2.624*** (0.561)	0.985 (0.413)
Latin American citizen	1.801 (0.817)	2.488*** (0.583)	1.395 (0.398)	0.836 (0.382)
Asian citizen	0.601 (0.305)	0.895 (0.188)	0.634** (0.133)	0.742 (0.180)
European citizen	1.207 (0.246)	0.985 (0.176)	0.877 (0.204)	0.875 (0.245)
Middle Eastern citizen	4.342** (3.110)	1.081 (0.543)	1.928* (0.693)	0.468 (0.334)
African citizen	0.683 (0.685)	0.330 (0.331)	1.944 (0.693)	1.444 (1.028)
Log likelihood	−2719.43	−4345.07	−2836.40	−1538.00
Number of observations	2,529	3,756	2,636	1,711
Failure events	354	541	371	216
Time at risk (years)	118,188	120,574	53,546	19,731

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

terns as shown in Table 3, though it is clear that there is heterogeneity across the cohorts.

4. Changes in the entrepreneurial founding environment

The figures and tables from the prior section highlight interesting long term patterns of individual-level entrepreneurial entry among MIT alumni. While the rate of transition into entrepreneurship has increased overall, these rates differ by gender, academic major, and country of origin. In aggregate, however, what factors in the changing entrepreneurial environment are correlated with overall entrepreneurial entry over time? To address this question, we begin with an empirical analysis of yearly entrepreneurial entries among MIT graduates. The following sections discuss three plausible groups of explanations for the observed empirical patterns: (1) shifts in entrepreneurial opportunity through, for example, scientific and technical advances or changes in government policies, (2) shifts in values, preferences and attitudes toward entrepreneurship, and (3) changes in the entrepreneurial infrastructure, such as the availability of professional services and the strength of intellectual property protection. We are careful to note, however, that our empirical analysis cannot sharply distinguish among these explanations. Instead, our goal here is to present empirical evidence on observable factors and to discuss the category of explanations consistent with our data and other factors which may explain the results, but which are unmeasured in our analysis.

4.1. Statistical evidence

To analyze how the changing entrepreneurial environment may relate to inter-temporal variation in entrepreneurial entry, we examine yearly data in which the dependent variable is the annual *number of first firm foundings* by MIT alumni between 1930 and 2003. Using negative binomial regressions due to the count nature of the dependent variable, we examine how well various regressors that reflect annual changes in the business and economic environment explain the variation in yearly firm foundings. The summary statistics and variable definitions for this analysis are found in Panel B of Table 2, and the regression results are presented in Table 5. Each specification controls for the number of graduating students, and successively introduces measures of the entrepreneurial environment. In all of the specifications, the variable *number of graduates* is positive and statistically significant (which is highly correlated with the passage of time, as the MIT graduating class has been increasing over time).[16] Each of the independent variables is lagged by 1 year to account for adjustment times, though the results are largely insensitive to both contemporaneous specifications as well as lags of 2 and 3 years. Column 5-1 introduces a parsimonious regres-

[16] The high correlation between the number of graduating students and a time trend variable makes statistical identification of such a trend difficult, though when both *number of graduates* and *time* are entered into the regression, the latter variable is positive and statistically significant, while the former is not.

Table 5
First firm foundings negative binomial regressions, 1930–2003 (year level of analysis)

Independent variables	Dependent variable = number of first firm foundings			
	(5-1)	(5-2)	(5-3)	(5-4)
Number of graduates (t-1)	0.004*** (0.000)	0.004*** (0.000)	0.001** (0.000)	0.002*** (0.001)
Patents issued (t-1)	0.021*** (0.003)			0.017*** (0.007)
Venture capital disbursements (t-1)		0.060*** (0.013)		0.026*** (0.009)
Recessionary economy (t-1)			0.188 (0.159)	0.275* (0.148)
Gross domestic product (t-1)			6.26e−4*** (9.97e−5)	4.32e−4*** (9.98e−5)
Inflation rate (t-1)			−0.005 (0.023)	−0.010 (0.022)
NY stock exchange market cap. (t-1)			−0.199*** (0.062)	−0.368*** (0.070)
Constant	−0.925*** (0.302)	0.353 (0.286)	−0.241 (0.237)	−1.053*** (0.357)
Log likelihood	−242.02	−266.35	−234.43	−226.01
Number of observations	71	72	71	71
Pseudo *R*-squared	0.17	0.11	0.20	0.23

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

sion, with *number of graduates* and *patents issued* as the sole right hand side variables. While *patents issued* can proxy for several concepts such as technological inputs, outputs, or opportunity, the variable is positive and statistically significant, with a one standard deviation increase in the annual number of patents issued associated with a 71% increase in the number of new venture foundings (all reported magnitudes in this section draw on the fully specified model, 5-4). A second specification, column 5-2, examines the role of *venture capital disbursements* in the prior year. The estimated effect of this variable is positive and statistically significant, with a one standard deviation increase associated with a 50.4% increase in venture foundings. A third column examines the macroeconomic environment using measures for a *recessionary economy*, *gross domestic product* (GDP), *inflation rate*, and the *market capitalization of the New York Stock Exchange* (NYSE). The *GDP* and *NYSE* measures are estimated with statistically significant coefficients. Putting all of these entrepreneurial environment effects together in the final column does not overturn the main conclusions from the prior specifications.[17] Changing technological opportunity (patents), venture capital activity, and financial opportunity costs (recessionary economic environment) are empirically supported as explaining variation in new venture initiation.

Care should be used in interpreting these results, not only because of the limited sample size, but also because right-censoring may be an issue in these analyses. In addition, we are not able to statistically identify a number of other shifts in the entrepreneurial environment, for example the cluster of events at the end of the 1970s and beginning of the 1980s (such as the changes in the IPR and venture capital funding environment, as previously discussed).[18]

4.2. Changing entrepreneurial opportunities

Starting with this section, we discuss three categories of explanations for how the external entrepreneurial environment relates to overall entrepreneurial entry. Emerging technologies and the new industries that they sometimes generate are associated with bursts of entrepreneurial activity (Utterback, 1994). Thus, one reason for increases in entrepreneurship may be new technological opportunities. For example, the development of the biotechnology industry occurred physically and temporally alongside those developing the underlying science (e.g., Zucker et al., 1998).

If technological opportunities are behind the general increase in entrepreneurship, then we should see the increase concentrated in certain industries. Consistent with this proposition, we find in our ongoing research (unpublished) on ventures started by MIT alumni-entrepreneurs larger relative increases in new software and pharmaceutical, biotechnology and other medically related firms formed by MIT alumni.

[17] The implied effects of the statistically significant macroeconomic variables are as follows. A one standard deviation increase in *recessionary economy*, *gross domestic product*, and *New York Stock Exchange market capitalization*, are associated with a 13% increase, 211% increase, and 65% decline, respectively, in annual new venture foundings.

[18] We experimented with dummy variables separating these time periods, but found that due to multicollinearity and limited sample size reasons, the coefficient on such indicator variables did not tend to be stable across different yearly thresholds. Rather than report volatile results which depend on the date threshold, we chose to not include such a dummy variable in this analysis.

Some have argued that the discovery of opportunities for entrepreneurship is a function of the information distribution across society (Hayek, 1945; Shane, 2000). Since one must discover an opportunity before one can act on it and start a new firm, changes in the distribution of information may result in shifts in the level and type of entrepreneurship. While individuals will have different experiences and be exposed to different information (moreover, information processing takes place differently), the MIT alumni sample imposes some desirable homogeneity on this dimension (e.g., levels of human and social capital) relative to more heterogeneous samples. To the extent that patents proxy for technological opportunities, our empirical findings are consistent with this explanation.

Finally, the era of U.S. government deregulation, primarily between 1976 and 1990 in a number of significant industries (e.g., Jensen, 1993), represents another important entrepreneurial opportunity window. A study of the U.S. electric power industry, for example, shows that deregulation can cause a rapid increase in entrepreneurial activity (Sine and David, 2003). Unfortunately, we do not have such useable measures of government deregulation-led opportunity for our empirical analysis.

4.3. Changing attitudes toward entrepreneurship

A second possible explanation for the observed empirical patterns is shifting attitudes toward entrepreneurial careers. Such shifts may be tied to changing expected financial rewards and/or social attitudes.

In the realm of financial returns sparking entrepreneurial interest, the large number of new venture liquidity events, particularly in Silicon Valley and Massachusetts, during the late 1990s altered the benefits (actual and perceived) and incentives to enter entrepreneurship. Entrepreneurship decisions are also based on financial opportunity costs, which may be lowered during periods of high unemployment or economic recession, and may be affected by changes in public policy such as tax law.

The second aspect of changing perceptions of entrepreneurial careers is tied to social attitudes. Recent increases in university-industry interactions may have an impact not only on faculty entrepreneurship (Murray, 2004; Oliver, 2004; Powell et al., 1996), but on students' perceptions of norms and opportunities as well (Etzkowitz, 1998). This can lead to strong demonstration effects. New sets of norms appear to be spreading throughout the academic community leading to more favorable attitudes toward commercially oriented research (Owen-Smith and Powell, 2001), even in countries with little prior history of academic entrepreneurship (DeGroof and Roberts, 2004). One important way in which information and norms about academic technology commercialization is spread is through networks of academic co-authorship (Stuart and Ding, 2006).

Beyond academic community norms, the phenomenon of innovation arising from joining inventors and entrepreneurs with dispersed yet complementary skills and knowledge (such as in open source software development) may also contribute to changing the environment for entrepreneurship (von Hippel, 2005). In addition, supporting institutions, related firms, complementary services and prior precedents are likely to make subsequent new venture creation more probable and more successful, both in the academic and non-academic contexts (e.g., Owen-Smith and Powell, 2004; Stuart and Sorenson, 2003).

Finally, while this discussion of factors that shape attitudes toward entrepreneurship has been segmented into financial and social, each likely influences the other. For example, differences in the social stigma associated with entrepreneurial failure may impact levels of entrepreneurship across regions or over time, which can have real implications for the cost of financial capital (Landier, 2005).

Our data do not allow us to disentangle specific changes in values (an upgrade in the expectations and role of entrepreneurs in society or universities training individuals to think more entrepreneurially) in explaining the rise of entrepreneurship, though it is likely to be multifaceted. Respondents' opinions on their primary influences on engaging in entrepreneurship (Table 6) lends credence to this view. The responses in this table suggest that there are factors that are growing more important over time (the MIT business plan competition and the technology licensing office), factors that have been important across time (faculty and research), and factors that are both important across time and increasing in importance (the student body and the entrepreneurial network).

4.4. Changes in entrepreneurial infrastructure

While numerous important changes in the infrastructure for entrepreneurial activity are likely to have occurred over the past several decades, we found empirical support for two such factors in the analysis: (1) the rise of institutionalized venture capital and (2) the strengthening of intellectual property protection. The financial capital requirements associated with new venture founding and development can constrain the

Table 6
MIT-related factors reported to have played a role in venture founding

	Graduation decade				
	1950s ($N=207$)	1960s ($N=313$)	1970s ($N=373$)	1980s ($N=315$)	1990s $N=214$)
Panel A: Proportion of founders choosing MIT for the entrepreneurial environment					
Chose MIT for its entrepreneurial reputation	17%	12%	19%	26%	42%

	Graduation decade				
	1950s ($N=73$)	1960s ($N=111$)	1970s ($N=147$)	1980s ($N=144$)	1990s ($N=145$)
Panel B: Proportion rating university factors as important in venture founding[a]					
Students	26%	24%	38%	50%	66%
Faculty	48%	42%	37%	28%	37%
Research	32%	32%	30%	26%	33%
Entrepreneurial network	26%	25%	32%	40%	50%
MIT entrepreneurship center	3%	1%	2%	1%	12%
MIT enterprise forum	7%	16%	15%	22%	9%
Venture mentoring service	0%	1%	0%	0%	1%
MIT business plan competition	0%	1%	0%	3%	30%
Technology licensing office	1%	0%	2%	4%	11%
Alumni regional clubs	5%	5%	3%	12%	3%

[a] Respondents could check all that were relevant.

transition to entrepreneurship, and so academic work in entrepreneurial finance has focused on the economics of the venture capital industry (e.g., Gompers and Lerner, 1999). The rise and institutionalization of venture capital can be traced to the formation of Boston-based American Research and Development Corporation in 1946 (Hsu and Kenney, 2005), though the munificence of venture capital funding has ebbed and flowed since that time. Between 1946 and 1977 the creation of new venture funds amounted to less than a few hundred million dollars annually (Kortum and Lerner, 2000). Starting in the late 1970s and especially in the late 1990s, fundraising in the venture capital industry sharply increased (Kortum and Lerner, 2000; VentureOne, 2000).[19] In the years since 2000, following the bursting of the technology bubble and 11 September 2001, the levels of venture investment have dropped (from a peak of about $100B), though they still amount to about $20B in annual disbursements.[20]

A second component of the entrepreneurial infrastructure is the strength of formal intellectual property rights (IPR) through patent protection. As has been documented elsewhere (e.g., Gallini, 2002, and references therein), a series of policy changes starting in the 1980s extended and strengthened the relative protection that patents provide.[21] Stronger IPR protection increases the returns to innovation via a decrease in the risk of expropriation (Gans and Stern, 2003), which may act to encourage entrepreneurial entry. If patenting is becoming more important in some fields (or overall), this may indicate changes in what it means to engage in new venture creation for entrepreneurs in more recent decades who must now think clearly about the implications of IPR for innovation and for entry decisions.

5. Discussion

In this section, we summarize the main results and discuss possible future research directions based on our findings from the MIT alumni founder dataset.

[19] In 1979 an amendment to the "prudent man" rule by the Department of Labor allowed pension managers to invest in high-risk assets, including venture capital, thus sparking a rise in VC, while efforts at commercializing the Internet are largely responsible for the late 1990s spike in VC investments.

[20] National Venture Capital Association, http://www.nvca.org/ffax.html (accessed 1 September 2005).

[21] In 1980 the *Diamond versus Chakrabarty* decision allowed the patenting of life forms and similar decisions by the U.S. Supreme Court extended patenting to software (*Diamond versus Diehr*), financial services and business methods (*State Street Bank and Trust versus Signature Financial Group*) (Gallini, 2002). In 1982 the creation of the Court of Appeals of the Federal Circuit resulted in an increase in the percentage of patents upheld on appeal from 62% during 1953–1978 to 90% during 1982–1990 (Gallini, 2002). In addition, the Trade-Related Aspects of Intellectual Property (TRIPs) agreement extended the life of some patents from 17 to 20 years in 1994. Finally, in 1984 the Hatch-Waxman Act also extended the length of patent protection for drugs.

5.1. The decline in age and lag time of first-time entrepreneurs

Table 1 (panel A) shows the declining median age of entrepreneurs beginning their first company from about 40 years in the decade of the 1950s to about 30 years in the decade of the 1990s. The related decreasing lag from graduation to the first entrepreneurial act is documented in Figs. 4 and 5. It is important to note that both of these figures are subject to a right time censoring issue in that some fraction of the declining age distribution will be revised as successively older alumni from a given graduation cohort decide to engage in entrepreneurship, which will of course raise the age distribution of that cohort. With this caveat, the combination of a declining time lag from graduation to forming a new venture among earlier graduates (who are unlikely to see large numbers of additional entrepreneurial entrants) and the declining median time lag to entrepreneurship among those founding firms since the 1980s both point to a declining age trend among first time entrepreneurs. A host of factors likely contribute to these trends, including the changing entrepreneurial environment discussed in Section 4.

This research therefore suggests that the impact of universities on industry not only occurs directly through the transfer of technical knowledge (Cohen et al., 2002), but also through the entrepreneurial activities of its alumni, increasingly soon after graduation and often years later. The bimodal age pattern suggests that theories of the link between university and industry may wish to take into account both academia's impact on transferring entrepreneurial know-how via training and facilitating new venture team formation (providing an important social context) and linkages to older alumni possibly through entrepreneurial networks (e.g., regional alumni clubs).

We see two areas for future research in this domain. First, what are the consequences of more youthful entrepreneurs from a business and public policy perspective? For example, how does the effect of less work experience at established companies trade off against new venture development via learning by doing? Second, the age distributions shown in Fig. 3 indicate not only that more individuals are becoming entrepreneurs at younger ages, but also that more persons are becoming entrepreneurs at older ages too, with a longer stretched out tail in the founder age curve. Among the following plausible explanations, which is the most salient?: (1) the growing tendency to work past a 65-year retirement target in the U.S. as a result of anti-age discrimination laws; (2) increasing life span and individuals' desire to stay gainfully employed and active; (3) declining corporate loyalties and increasingly unstable corporate employment policies that formerly had employees working for the same company until retirement; and/or (4) shifting types of entrepreneurship at older ages, e.g., through independent partnerships.

5.2. The gender imbalance among entrepreneurs

The growth of women entrepreneurs appears to mirror the number of women graduating from all levels at MIT (rising from just over 10 female graduates (1%) in the 1930s to 43% of undergraduates and 30% of the graduate student population in 2004–2005).[22] At the same time, women have lower hazard rates of entering entrepreneurship relative to their male counterparts (and the hazard-indicated gap appears to be growing larger over time).

Based on these findings, we highlight two potential areas for future research in this domain. First, a more systematic evaluation of the changing opportunity costs to entering entrepreneurship for women versus men would be useful. For example, the observed empirical pattern would not be surprising if the opportunity cost of an entrepreneurial career for women grew much faster than that for men over the time period. Such an analysis should also take into account the different types of firms likely to be started across gender lines. Second, while there has been increasing research on financial obstacles that differentially affect men and women (e.g., Hart et al., 2001), research on other potential impediments to female-founded venture initiation and growth would be welcome.

5.3. The increase in non-U.S. entrepreneurs

Figs. 1 and 9, amplified by Table 3, indicate the significant growth in both numbers of non-U.S. citizen MIT entrepreneurial alumni and the rate at which they exceed their U.S. classmates in becoming entrepreneurs. While there is variation among the non-U.S. citizen groups (European MIT alumni appear more entrepreneurial relative to U.S. alumni according to the estimates from Table 3), this area seems neglected in the research literature (Saxenian, 1999, 2002 are notable exceptions).

A number of explanations are plausible for these empirical patterns. For example, foreign individuals who travel to the U.S. for their education (especially to

[22] http://web.mit.edu/facts/enrollment.shtml (accessed 1 September 2005).

an elite university) are likely to be among the most entrepreneurial and financially well-off individuals in their home countries. If U.S. labor market options are not as open to immigrants relative to the American counterparts, immigrants may face lower opportunity costs to becoming entrepreneurs. Finally, some foreign graduate students would like to remain in the U.S. after graduation yet cannot due to expiring student visas. Under U.S. immigration law individuals wishing to start a new business can receive a non-immigrant visa as a "treaty investor" with no maximum period of stay.[23]

Students may also elect to return home to practice in their home environs the models of entrepreneurship they have observed in the U.S. For example, two of the three leading Internet firms in China, Sohu.com and Sina.com, were founded and led, respectively, by an MIT alumnus, Dr. Charles Zhang, and a Stanford alum, Ben Tsiang. In any case, future research would be welcome that provides empirical evidence related to the phenomenon of differing rates of entrepreneurship among foreign citizens and in foreign citizens as compared with U.S. citizens.

5.4. Limitations

In interpreting the results from this study, it is useful to keep in mind three data-related issues: representativeness, response rates and self-reporting. The first issue is the extent to which inferences made from this dataset apply to entrepreneurship in general. The data for this study come from alumni of an important academic institution historically at the intersection of technology and commercialization. It is important to note that these are alumni and therefore the sample is not limited to those currently associated with MIT or to technology coming from MIT. While these individuals have all passed through MIT for a period of education, they have had diverse experiences before matriculation, while at MIT, and since graduation. Therefore, while there is no doubt that individuals in the sample are relatively homogeneous in some respects, they are quite different in others (as reflected in both the type of ventures they start as well as in their outcomes).

This paper therefore represents an exploratory analysis of the likelihood of MIT alumni to become entrepreneurs. The data are not suited to tackle some larger conceptual questions such as: the counterfactual career outcome of individuals had they not attended MIT, the impact of individuals who became entrepreneurs had they not attended MIT, the role of MIT in attracting and retaining entrepreneurs (and others) in the local Boston economy, and the social welfare implications of alternate career choices by MIT graduates.

We do not claim generalizability across the spectrum of entrepreneurial activity; however, we believe that the sample represents an interesting and important population of individuals over a significant time span. National samples of entrepreneurship may be more representative of entrepreneurship broadly defined, but probably not of technology-based entrepreneurship. Moreover, comparing national samples of entrepreneurship is challenging, as data sampling strategies vary depending on the subject matter of study (compare, for example studies of self-employment [e.g. Blau, 1987] and manufacturing [e.g., Dunne et al., 1988]). With these caveats in mind, we note that the percentage of individuals engaging in new firm creation is generally significantly higher in our sample relative to the 4–5% level often cited nationally (Dennis, 1997; Reynolds, 1994).

A second issue is possible response bias. For example, graduates who started a company but were unsuccessful may well not have reported these failed firms, either by omitting them from their responses or by not participating in the study at all. As an associated issue, the responses from non-U.S. alumni are likely to be somewhat less representative than their U.S.-based counterparts due both to potentially less complete contact records as well as perhaps fewer reminders to complete the survey. In addition, first and second generation U.S. citizens whose parents immigrated to this country are placed together with U.S. citizens whose families have a long history in the country, even though these two groups may exhibit behavioral differences with respect to entrepreneurial activity.

Finally, there is the issue of self-reporting. Older respondents, especially those who have started multiple companies, may display a memory bias in which some companies, possibly those which were relatively unsuccessful, are not reported. This may lead to the appearance that younger entrepreneurs are starting more (though less successful) firms on average. Similarly, if cultural attitudes toward entrepreneurship have indeed changed over the years, younger entrepreneurs may have been more likely to respond to the survey and to indicate that they had founded a firm. Older entrepreneurs may also have been less likely to respond to a university survey due to the sheer number of years since their

[23] This status is renewable indefinitely (http://www.expertlaw.com/library/immigration/e2_visas.html) (accessed 1 September 2005).

time as an MIT student if such alumni ties weaken over time.

While these limitations may provide reason for caution on making generalizations from the data, we believe that the trends reported are large enough that such bias is not significant. In addition, given the size of the dataset the sources of bias would have to be quite systematic to have had much impact.

5.5. University-related influences

Although we cannot statistically isolate the effect of the university experience upon its alumni entrepreneurial activity, a number of responses from the MIT alumni survey deserve comment. Table 6, panel A, tabulates the founder responses to the question of extent to which they were attracted to attend MIT by its entrepreneurial environment. That percentage generally rises dramatically for company founders over time. To be sure, these data need to be treated with healthy skepticism as an after-the-fact commentary, but nevertheless it presents the possibility of a self-reinforcing long-term feedback loop of entrepreneurship at MIT potentially attracting students who are more likely to become entrepreneurs, further enhancing the entrepreneurial environment over time.

Panel B of Table 6 provides many specific aspects of MIT that were seen as influencing the founders' later entrepreneurial actions. The perceived influences of other students and the overall "entrepreneurial network" at and about the institution seem to rise most dramatically over successive decades and in close relation to each other. In addition, we see claimed influences of several MIT organizations that were founded at different times over the 50-year period studied. Its Alumni Regional Clubs were the first MIT channel for communicating to alumni a series of educational seminars on starting a new company. Indeed, several survey respondents mentioned in their comments specific alumni seminars years ago which they remembered as having great influence upon them. These programs then led to the founding of the MIT Enterprise Forum in 1978, which over time spread worldwide in membership and activities, attracting participation from alumni of many classes and in recent years from current students also. The $50K Business Plan Competition and the MIT Entrepreneurship Center were both founded in the early 1990s, and have quickly become important in influencing founders. In a somewhat reassuring manner from a data reliability perspective, the MIT Venture Mentoring Service, which has grown dramatically in its brief 4-year history, is obviously too young to have affected many entrepreneurial foundings prior to 2003. These data serve as testimonials to the many dimensions of at least this specific university's role in encouraging and affecting entrepreneurship. The multiple sources of possible impact, and their degree of effect, might well be quite different at other research universities.

6. Conclusions

We present several facts about the entrepreneurial activity of MIT alumni on which to base future empirical and theoretical work related to technology-based entrepreneurship. Data were gathered from over 43,000 living alumni of the Massachusetts Institute of Technology, including more detailed information on over 2100 alumni who had identified themselves as founders of one or more companies during their lifetimes. Although some respondents started firms in the decades of the 1930s and 1940s, meaningful sample sizes began in the 1950s. Since that time we have witnessed a dramatic growth of the start-up phenomenon among MIT alumni. The sample of founders over this period became much younger in the time of their first entrepreneurial act, gradually included more women over the past 30 years (though women are not yet keeping pace with their male counterparts in their rate of entering entrepreneurship), and spread from just U.S. companies formed mostly by U.S. citizens to include firms being founded all over the world by citizens of many countries, all of whom are MIT alumni.

The increase in foundings over time is consistent with earlier findings (Blau, 1987; Gartner and Shane, 1995), though the percentage of individuals engaging in new firm creation is generally higher in our sample relative to the 4–5% level often cited nationally (Dennis, 1997; Reynolds, 1994). Lazear (2005) finds that among Stanford Graduate School of Business graduates, 6.6% of all employment periods are entrepreneurial ones. While he does not report time trends, 24% of these Stanford alumni founded a firm. This number is consistent with our finding in the MIT data (note that our data are university-wide).

At a broad level we interpret our results as suggesting that the volume of entrepreneurial activity responds to the business and entrepreneurial environment, and that differences in individual characteristics shape the transition to entrepreneurship, both within and across time periods. While the results at the individual level of analysis are intriguing and suggest avenues for further research (some of which are discussed in the prior section), we believe that efforts to better understand

the effects of various components of the entrepreneurial business environment on individuals' decisions to start new ventures would also be a very useful direction in this literature.

While prior research has emphasized a broad range of vehicles by which academic knowledge diffuses to the private sector (e.g., training graduate students who subsequently enter industry, professorial consulting, conferences and interpersonal communication, academic publications, university spin-offs, and university technology licensing), we raise the possible importance of another mechanism. Our results suggest that knowledge related to entrepreneurship may also be facilitated through intended and unintended consequences of research universities: encouraging individuals to become entrepreneurs, facilitating their social processes, enhancing their reputations (association with MIT), as well as training them to solve problems, all of which can become valuable inputs to new venture development. As one survey respondent stated: "I look at the MIT experience as training in problem solving. Business is a series of 'problem sets' that must be solved, so MIT is a key training ground."

Acknowledgements

We thank Paul Osterman, Woody Powell (the Editor), three anonymous reviewers, and participants of the MIT Innovation and Entrepreneurship seminar and of the Fall 2005 NBER Entrepreneurship Group Meeting for helpful comments. We acknowledge funding from the Mack Center for Technological Innovation at Wharton and the MIT Entrepreneurship Center.

Appendix A. Comparison of key demographic characteristics by survey

Variable	Responded to 2001 survey ($N = 43{,}668$)	Did not respond to 2001 survey ($N = 62{,}260$)	*t*-stat for equal means
Male	0.83	0.86	**10.11**
Engineering major	0.48	0.47	**−4.49**
Management major	0.16	0.15	**−5.75**
Science major	0.23	0.23	0.37
Social sciences major	0.05	0.06	**4.07**
Architecture major	0.06	0.08	**11.82**
Non-US citizen	0.81	0.82	**3.77**
North American (not US) citizen	0.13	0.11	**−4.14**
Latin American citizen	0.13	0.12	−1.44
Asian citizen	0.33	0.34	1.45
European citizen	0.30	0.26	**−5.08**
Middle Eastern citizen	0.05	0.08	**6.32**
African citizen	0.03	0.05	**6.25**
Variable	Responded to 2003 survey ($N = 2{,}111$)	Did not respond to 2003 survey ($N = 6{,}131$)	t-stat for equal means
Male	0.92	0.92	0.12
Engineering major	0.52	0.47	**−3.63**
Management major	0.17	0.21	**4.17**
Science major	0.17	0.18	1.09
Social sciences major	0.06	0.05	1.18
Architecture major	0.09	0.09	1.06
Non-US citizen	0.82	0.81	−1.36
North American (not US) citizen	0.17	0.14	−1.34
Latin American citizen	0.19	0.19	0.13
Asian citizen	0.22	0.24	0.73
European citizen	0.31	0.32	0.38
Middle Eastern citizen	0.08	0.07	−0.59
African citizen	0.04	0.04	0.17

Note: Bolded numbers indicate statistical significance at the 1% level.

References

Amit, R., Muller, E., Cockburn, I., 1995. Opportunity costs and entrepreneurial activity. Journal of Business Venturing 10 (2), 95–106.

Baron, J.N., Burton, M.D., Hannan, M.T., 1996. The road taken: the origins and evolution of employment systems in high-tech firms. Industrial and Corporate Change 5 (2), 239–275.

Baron, R.A., 2000. Counterfactual thinking and venture formation: the potential effects of thinking about "what might have been". Journal of Business Venturing 15 (1), 79–91.

Bates, T., 2002. Restricted access to markets characterizes women-owned businesses. Journal of Business Venturing 17 (4), 313–324.

Baumol, W.J., 2004. Education for innovation: entrepreneurial breakthroughs vs. corporate incremental improvements. NBER Working Paper Series No. 10578.

Blanchflower, D.G., Oswald, A.J., 1998. What makes an entrepreneur? Journal of Labor Economics 16 (1), 26–60.

Blau, D.M., 1987. A time-series analysis of self-employment in the United States. Journal of Political Economy 95 (3), 445–467.

Breslow, N.E., Lubin, J.H., Marek, P., Langholz, B., 1983. Multiplicative models and cohort analysis. Journal of the American Statistical Association 78, 1–12.

Buttner, H.E., Moore, D.P., 1997. Women's organizational exodus to entrepreneurship: self-reported motivations and correlates with success. Journal of Small Business Management 35 (1), 34–46.

Caputo, R.K., Dolinsky, A., 1998. Women's choice to pursue self-employment: the role of financial and human capital of household members. Journal of Small Business Management 36 (3), 8–17.

Carroll, G.R., Mosakowski, E., 1987. The career dynamics of self-employment. Administrative Science Quarterly 32 (4), 570–589.

Cohen, W., Goto, A., Nagata, A., Nelson, R., Walsh, J., 2002. R&D spillovers, patents and the incentives to innovate in Japan and the United States. Research Policy 31, 1349–1367.

Cox, D.R., 1972. Regression models and life tables. Journal of the Royal Statistical Society B 34, 187–220.

Dahlstrand, A.L., 1997. Growth and inventiveness in technology-based spin-off firms. Research Policy 26 (3), 331–344.

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

DeMartino, R., Barbato, R., 2003. Differences between women and men MBA entrepreneurs: exploring family flexibility and wealth creation as career motivators. Journal of Business Venturing 18 (6), 815–832.

Dennis, W.J., 1997. More than you think: an inclusive estimate of business entries. Journal of Business Venturing 12, 175–196.

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

Douglas, E.J., Shepherd, D.A., 2000. Entrepreneurship as a utility maximizing response. Journal of Business Venturing 15 (3), 231–251.

Dunn, T., Holtz-Eakin, D., 2000. Financial capital, human capital, and the transition to self-employment: evidence from intergenerational links. Journal of Labor Economics 18 (2), 282–305.

Dunne, T., Roberts, M., Samuelson, L., 1988. Patterns of firm entry and exit in U.S. manufacturing industries. Rand Journal of Economics 19, 495–515.

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

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

Evans, M.D.R., 1989. Immigrant entrepreneurship: effects of ethnic market size and isolated labor pool. American Sociological Review 54 (6), 950–962.

Evans, D.S., Leighton, L.S., 1989. Some empirical aspects of entrepreneurship. American Economic Review 79 (3), 519–535.

Gallini, N.T., 2002. The economics of patents: lessons from recent U.S. patent reform. Journal of Economic Perspectives 16 (2), 131–154.

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

Gartner, W.B., Shane, S.A., 1995. Measuring entrepreneurship over time. Journal of Business Venturing 10 (4), 283–301.

Gimeno, J., Folta, T.B., Cooper, A.C., Woo, C.Y., 1997. Survival of the fittest? Entrepreneurial human capital and the persistence of underperforming firms. Administrative Science Quarterly 42 (4), 750–783.

Gompers, P., Lerner, J., 1999. The Venture Capital Cycle. MIT Press, Cambridge, MA.

Gompers, P., Lerner, J., Scharfstein, D., 2005. Entrepreneurial spawning: public corporations and the genesis of new ventures 1986–1999. The Journal of Finance 60 (2), 577–614.

Hart, M.M., Greene, P., Brush, C., Saparito, P., 2001. Patterns of venture capital funding: is gender a factor. Venture Capital 3 (1), 63–83.

Hayek, F.A., 1945. The use of knowledge in society. American Economic Review 35 (4), 519–530.

Hellmann, T., in press. When do employees become entrepreneurs? Management Science.

Hsu, D.H., Kenney, M., 2005. Organizing venture capital: the rise and demise of American Research and Development Corporation 1946–1973. Industrial and Corporate Change 14, 579–616.

Iyigun, M.F., Owen, A.L., 1998. Risk, entrepreneurship and human-capital accumulation. American Economic Review 88 (2), 454–457.

Jaffe, A.B., 1989. Real effects of academic research. American Economic Review 79, 957–970.

Jensen, M.C., 1993. The modern industrial revolution, exit and the failure of internal control systems. Journal of Finance 48, 831–880.

Kortum, S., Lerner, J., 2000. Assessing the contribution of venture capital to innovation. Rand Journal of Economics 31 (4), 674–692.

Landier, A., 2005. Entrepreneurship and the stigma of failure. Available at SSRN: http://ssrn.com/abstract=850446.

Lazear, E.P., 2005. Entrepreneurship. Journal of Labor Economics 23, 649–680.

Lazear, E.P., 2004. Balanced skills and entrepreneurship. American Economic Review 94 (2), 208–211.

Levesque, M., Minniti, M., 2006. The effect of aging on entrepreneurial behavior. Journal of Business Venturing 21 (2), 177–194.

McClelland, D.C., 1961. The Achieving Society. D. Van Nostrand Co., Princeton, NJ.

Mitchell, R.K., Smith, B., Seawright, K.W., Morse, E.A., 2000. Cross-cultural cognitions and the venture creation decision. Academy of Management Journal 43 (5), 974–993.

Mowery, D.C., Shane, S., 2002. Introduction to the special issue on university entrepreneurship and technology transfer. Management Science 48 (1), v–ix.

Murphy, K.M., Shleifer, A., Vishny, R.W., 1991. The allocation of talent: implications for growth. Quarterly Journal of Economics 106 (2), 503–530.

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

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

Oliver, A.L., 2004. Biotechnology entrepreneurial scientists and their collaborations. Research Policy 33 (4), 583–597.

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

Owen-Smith, J., Powell, W.W., 2004. Knowledge networks as channels and conduits: the effects of spillovers in the Boston biotechnology community. Organization Science 15 (1), 5–21.

Parhankangas, A., Arenius, P., 2003. From a corporate venture to an independent company: a base for a taxonomy for corporate spin-off firms. Research Policy 32 (3), 463–481.

Powell, W.W., Koput, K.W., Smith-Doerr, L., 1996. Interorganizational collaboration and the locus of innovation: networks of learning in biotechnology. Administrative Science Quarterly 41, 116–145.

Reynolds, P., 1994. Reducing barriers to understanding new firm gestation: prevalence and success of nascent entrepreneurs. Paper presented at the Academy of Management, Dallas, TX.

Roberts, E.B., 1991. Entrepreneurs in High Technology: Lessons from MIT and Beyond. Oxford University Press, New York, NY.

Roberts, E.B., 2004. A perspective on 50 years of the engineering management field. IEEE Transactions on Engineering Management 51 (4), 398–403.

Sarasvathy, D.K., Simon, H.A., Lave, L., 1998. Perceiving and managing business risks: differences between entrepreneurs and bankers. Journal of Economic Behavior and Organization 33 (2), 207–225.

Saxenian, A.L., 1999. Silicon Valley's New Immigrant Entrepreneurs. Public Policy Institute of California, San Francisco, CA.

Saxenian, A.L., 2002. Local and Global Networks of Immigrant Professionals in Silicon Valley. Public Policy Institute of California, San Francisco, CA.

Schumpeter, J.A., 1943. Capitalism Socialism and Democracy. Harper and Row, New York.

Shane, S., 1995. Is the independent entrepreneurial firm a valuable organizational form? Best paper proceedings of the Academy of Management 1985 Annual Meeting. Vancouver, BC 110–113.

Shane, S., 2000. Prior knowledge and the discovery of entrepreneurial opportunities. Organization Science 11 (4), 448–469.

Shane, S., Khurana, R., 2003. Bringing individuals back in: the effects of career experience on new firm founding. Industrial and Corporate Change 12 (3), 519–543.

Sine, W.D., David, R.J., 2003. Environmental jolts, institutional change, and the creation of entrepreneurial opportunity in the US electric power industry. Research Policy 32 (2), 185–207.

Sorensen, J.B., 2007. Closure vs. exposure: mechanisms in the intergenerational transmission of self-employment. Research in the Sociology of Organizations 25, 83–124.

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

Stuart, T., Sorenson, O., 2003. The geography of opportunity: spatial heterogeneity in founding rates and the performance of biotechnology firms. Research Policy 32 (2), 229–253.

Utterback, J.M., 1994. Mastering the Dynamics of Innovation. Harvard Business School Press, Cambridge, MA.

Utterback, J.M., Meyer, M., Roberts, E., Reitberger, G., 1988. Technology and industrial innovation in Sweden: a study of technology-based firms formed between 1965 and 1980. Research Policy 17 (1), 15–26.

VentureOne, I., 2000. Venture Edge. VentureOne Press, San Francisco.

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

von Hippel, E., 2005. Democratizing Innovation. MIT Press, Cambridge, MA.

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