# Entrepreneurs from Technology-Based Universities: An Empirical First Look

by David H. Hsu*, Edward B. Roberts** and Charles E. Eesley***

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**Abstract**

This paper provides an initial analysis of major patterns and trends in entrepreneurship among technology-based university alumni since the 1930s. We describe findings from two linked datasets joining MIT alumni with MIT founder information. The rate of forming new companies by MIT alumni has grown dramatically over seven decades. Women alumni have in more recent decades become entrepreneurs at a faster growth rate than men, but still constitute only 10% of new entrepreneurs. Alumni who are not U.S. citizens also are entering entrepreneurship at a faster pace than their American classmates, but still constitute only 15% of current entrants. The median age of first time entrepreneurs has gradually declined from about age 40 to about age 30. Our results also suggest that rather than examining stable individual traits, future research in this domain may wish to examine business and strategic environment factors.

*Wharton School, University of Pennsylvania, 2000 Steinberg-Dietrich Hall, Philadelphia PA 19104. dhsu@wharton.upenn.edu;
**MIT Sloan School of Management, 50 Memorial Drive, Cambridge MA 02142. eroberts@mit.edu;
*** MIT Sloan School of Management, 50 Memorial Drive, Cambridge MA 02142. eesley@mit.edu

## 1. Introduction

This paper provides an initial analysis of major patterns and trends in entrepreneurship among technology-based university alumni since the 1930s. The national innovative systems literature has stressed the role of universities in generating commercially important technical knowledge (Nelson, 1996). Various modes of diffusion to the private sector have been discussed in the literature. Such knowledge might enter the commercial realm when trained graduate students enter industry (Bozeman et al., 2001), professors consult to private entities (Powell et al., 1996), via conferences and interpersonal communication (Cohen et al., 2002), or when academically-published research possessing commercial implications enters the public domain (e.g., Agrawal and Henderson, 2002). In another strand of the literature (and of particular interest to researchers of entrepreneurial ventures), researchers have studied spin-off ventures started by university faculty and staff and commercialization of university-generated inventions via licensing to incumbent and start-up firms (e.g., Dahlstrand, 1997; DiGregorio and Shane, 2003; Roberts, 1991; Shane, 2002; Sine et al., 2003; Vohora et al., 2004). This type of activity has been particularly intense in recent years (Mowery et al., 2001). The phenomenon of start-up ventures emanating from research universities is quite an important one: 214 academic institutions accounted for a total of 450 new start-ups through technology licensing in fiscal year 2002, and since 1980 4,320 new companies have formed based on university technology licenses, with 2,741 still operating as of fiscal year 2002 [www.autm.net].[1]

Another way in which universities contribute to commercial activity via new venture creation is the attraction to an area and education of students (e.g., Robinson and Sexton, 1994). Increasingly, universities are seen as one of the keys to educating and attracting future

[1] The distribution of start-ups coming out of universities is quite uneven, however, with some universities generating both more numerous and more important commercial technologies into the private world than others. For example, in fiscal year 2003 MIT and Stanford each had 17 licensed technologies become the bases of new ventures, which is many more than the average number of start-ups per U.S. university licensing office (about two).

entrepreneurs as well as opening up new opportunities for firm creation. While recent literature on the "entrepreneurial university" or academic entrepreneurship has focused on faculty entrepreneurs and university spin-offs via those currently affiliated with the university (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. Formal study of technology-based entrepreneurship dates back to the 1960s (Roberts, 2004). Yet the contribution of universities to entrepreneurship via students and alumni[2] still needs much systematic analysis, particularly as related to changes over time.

For example, the Stanford website asserts that the university's "entrepreneurial spirit . . . has helped spawn an estimated 1,200 companies in high technology and other fields." [3] 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 5,000 companies, employing 1.1 million and with aggregate annual sales over $230 billion.[4] 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.

Clearly, 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. Disentangling the marginal impact of one life experience (albeit an important one,

[2] We use the term "alumni" throughout to include both male alumni and female alumnae.
[3] http://www.stanford.edu/home/stanford/facts/innovation.html
[4] http://entrepreneurship.mit.edu/mit_spinoffs.php

graduating from an institution of higher learning) from other experiences in contributing to the necessary skills and preferences for founding an entrepreneurial venture is a considerable challenge. 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 a technology and research-based university 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. We conclude with an assessment of areas for future research given our empirical findings.

The fact that the founders in our study are all graduates of the Massachusetts Institute of Technology (MIT) imposes some degree of uniformity on the sample of entrepreneurial ventures, which is attractive since entrepreneurs and new ventures 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 to better understand the changing nature of entrepreneurship among graduates of a prominent research university over a relatively long time span. The firms formed by the entrepreneurs in our dataset actually include a great deal of variation across both industry sectors (spanning service and manufacturing industries, with varying degrees of technological reliance) and venture sizes. The brief list cited above of some of the more prestigious companies founded suggests that studying these relatively homogeneous "types" of entrepreneurs emanating from MIT and comparable institutions who are responsible for considerable value in technology-based startups is an important undertaking. We leave the more ambitious project of estimating the

marginal impact of various institutional changes on entrepreneurial activity to future research, however.

At a minimum this dataset can be interpreted as providing insight into how the characteristics of founders and entrepreneurial ventures have changed over time for an interesting sample of firms. Prior work has recognized that "factors that drive changes in the rate of entrepreneurship are not likely to be manifest over short time periods" (Gartner and Shane, 1995), though few studies have examined long spans of such data. Using data over 70 years from the 1930s to the 2000s, we investigate changes in characteristics of individuals opting to start new ventures, as well as changes among entrepreneurs over the decades.

The remainder of the paper is organized as follows: section two reviews the prior literature on individuals and entrepreneurship, section three discusses the data and presents results on changes in the characteristics of those entering entrepreneurship over time. Section four presents some possible explanations for these trends. Section five discusses limitations in our data and methods, and a final section concludes.

## 2. Transition to Entrepreneurship

Entrepreneurship has been identified both in public discussion and the prior research literature as vital to economic growth. For example, 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 this reason, 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 between 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 results from the MIT dataset. Clearly, this literature covers a large terrain, but as we noted at the outset, the literature does not provide analysis over a long time span.

The first class of explanations for entering into entrepreneurship emphasize 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, 2005). A number of studies have suggests 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, in press). Empirical evidence supports this assertion (Bates, 1995; Roberts, 1991).

Ethnic and immigration status may also play a role in entrepreneurship. Entrepreneurship rates appear to be high among members of some immigrant communities, including Swedish technological entrepreneurs and recent Silicon Valley high-tech startups (Utterback et al., 1988; Saxenian, 1999; 2002). More generally, the decision to enter 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 (Bates, 1995; 2002). A second group of studies examines differential motivations for entering entrepreneurship according to gender. 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). Gender differences concerning entrepreneurship can be observed as early as high school. A survey of 1,000 students shows that girls are significantly less likely to want their own business (Kourilsky and Walstad, 1998). Further evidence that differences may begin before females have left home for college comes from results that the influence of parental self-employment runs primarily along gender lines (Dunn and Holtz-Eakin, 2000).

While marital status has no effect on the chances of a woman becoming self-employed, the more a husband earns from self-employment, the more likely his wife is to enter entrepreneurship (Caputo and Dolinsky, 1998). Several authors present evidence that the presence of children and the provision of child care by the husband increases self-employment among women (Boden, 1996; Caputo and Dolinsky, 1998). One study provides survey evidence that blocks to advancement within firms may induce women to go into business for themselves (Buttner and Moore, 1997).

A second class of explanations for transitioning into entrepreneurship has emphasized training and other experience. Exposure to entrepreneurial experience through household or personal experience increases the likelihood of entrepreneurship (Carroll and Mosakowski, 1987; Roberts, 1991; Sorensen, 2005). As well, the likelihood of entering self-employment increases with educational level (Dolinsky et al., 1993), though less at the doctoral level (Roberts, 1991). Certain career histories and experiences may lead some to become entrepreneurs while others remain employees. 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; Roberts, 1991) as important determinants of the likelihood to spin off new

ventures.

Recent studies have connected educational training with entrepreneurship, which appears to be a plausible explanation, as countries with a higher proportion of engineering college majors experience faster economic growth (Murphy et al., 1991).[5] Baumol (2004) suggests that the type of education appropriate for technical knowledge mastery may be significantly different than 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 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. The Lazear (2004) study does raise the question of whether it is the higher number of different roles that induces entrepreneurship by providing a necessary balance of skills/knowledge or by reducing 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) found 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., 2002). For example, Lee and Venkataraman (in press) propose a framework in which individuals' aspiration levels and their perceived valuation by the labor market interact to determine entry into entrepreneurial activity. Douglas and Shepherd (2000) create a more general model of this explanation by including

[5] The direction of causality may be reversed here, however: countries with faster growth may provide more engineering jobs and may support more engineering education.

attitudes toward risk-aversion, independence and work, showing that individuals decide whether to become an entrepreneur or an employee based on which provides greater utility.

Empirically supported differences have included the extent of counterfactual thinking and regret (Baron, 2000), general self-efficacy and regret (Markman et al., 2002), focus on controlling risk versus outcomes (McClelland, 1961; Sarasvathy et al., 1998), and optimism bias (Palich and Ray Bagby, 1995). Certain cognitive scripts associated with entrepreneurs have also been shown to be consistent across cultures (Mitchell et al., 2000). In addition Roberts (1991) found 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) demonstrated 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). This of course is counter to the observed "bubble phenomenon" wherein entrepreneurs spin-off rapidly when a new company experiences exciting growth!

The financial capital of parents and, to a modest extent, the income of the potential entrepreneur (Bates, 1995; Dunn and Holtz-Eakin, 2000) has also been linked with entrepreneurship. 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 self-employment following an inheritance or gift (Blanchflower and Oswald, 1998). More generally, in a model of the supply of employees becoming entrepreneurs Hellmann (2003) shows that the munificence of funding for new ventures determines the rate of transition from employee to entrepreneur.

## 3. The MIT Data

We present a new dataset composed of 42,930 records of MIT alumni (the "alumni" data) responding to a 2003 survey of all living alumni. Of these alumni, 7,798 individuals indicated that they had founded at least one company. These individuals were then mailed another survey asking detailed questions about formation of their firms. 2,111 founder surveys (the "founder" data) were completed, representing a response rate of 27.1%. While the alumni data contains only basic demographic information on date of birth, country of citizenship, gender, major at MIT, highest attained degree and new venture founding history, the founder data contains more detailed information about firm formation. Our description of the data and data collection is relatively brief, as a confidentiality agreement we have in place with MIT prohibits us from describing the data in great detail. The present paper primarily makes use of the alumni data, while our companion paper on entrepreneurial firms relies mostly on the founder data. One of the key features of this interlinked dataset is its long time horizon in the cross section (1930-2001) that allows us to analyze trends over several decades.

### *3.1 What can be examined and what cannot?*

The advantage of the MIT alumni founder dataset in informing this debate is 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 see a wide range of 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 key 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 frequent long lag from graduation to first firm founding. Also, while there is a large amount of information on the founders, the number of matching variables on all alumni is more limited.

In regard to the personal characteristics of the entrepreneurial dataset that we now describe, we can analyze and report upon a number of characteristics. These include the overall temporal pattern of change in the number and intensity of founder experiences among these alumni. We can determine their ages when their first entrepreneurial acts occurred, and how long they delayed after graduation from MIT and/or other universities as well. The data permit separation by gender, enabling both analyses of patterns of entrepreneurship by gender and eventually detailed studies of differences between female and male entrepreneurs. Similarly, the data permit separation by country of citizenship, again enabling focus upon changes in temporal patterns and detailed studies of differences between non-U.S. and U.S. entrepreneurs within the dataset, even distinguishing by continent and country when the subsets are sufficiently large to permit those analyses. The educational data also include specification of the fields of study.

But we lack much 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. Perhaps of greater importance, we lack any information on cognitive characteristics of the entrepreneurs, any notion of opportunity costs they might have

perceived in becoming entrepreneurs, and perhaps most important we have no information on their motivations in starting these firms. These deficiencies constrain our areas of current analyses while providing good opportunities for future research direction.

*3.2 Founder characteristics*

*3.2.1 Overall growth in alumni entrepreneurial startups, including gender and non-U.S. information*

Figure 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, of whom a total of 747 reporting alumni started their first firms during the decade of the 1990s. Women founders begin to be visible in the 1950s and grow to about 10.1% of the sample by the '90s. 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. These data are normalized in Figure 2, which portray entrepreneurial intensity indices for the total of alumni as well as for the women and non-U.S. citizen subsets.[6] The entrepreneurial intensity index is simply defined as the number of foundings during that decade divided by the number of alumni in existence, summing all previous graduation decades. The normalized data also show significant growth overall but now the ratios begin to tell somewhat differing stories. Overall alumni entrepreneurial intensity develops rapidly through the decade of the 1980s, up to a rate of formation of 17 new first firms per 1000 living alumni, slightly turning down in the 1990s. The intensity of new

[6] 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.

entrepreneurial startup formation by women grows rapidly from 1950 on, up to about 10 per 1000 women alumnae, still 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, with the exception of the immediate post-World War II decade, to a rate of about 18 new companies being formed per 1000 alumni in the decade of the 1980s, with a slight turndown in the 1990s. In section 4.3 we provide data that indicate that most of the non-U.S. alumni entrepreneurs have been coming from Asia, Europe and Latin America, each continent in recent decades accounting for approximately 10% of the entire sample of MIT alumni first-time startups.

These results mirror those found by Gartner and Shane (1995), who find an acceleration of new venture foundings between 1957-1992, 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.

*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, on average, has multi-dimensional implications for entrepreneurship as previously being a mid-life career change to becoming an initial choice of a lifetime career. The differences in organizational work experience, network accumulation, wealth accumulation and family responsibility situation, among other changes, all strongly accompany this shift in the age of founding. The distribution of entrepreneurial ages at their times of first foundings also has changed over the past 40 years. Figure 3 shows the two frequency distributions of MIT alumni

entrepreneur ages for firms founded in the 1970s and 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). 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 entrepreneurs were under 30 years of age; during the 1970s that number grew to 31%; in the 1990s 36% of the founders were under 30. Prior to the '70s, 26% of the founders were over 40 years of age; during the 1970s 28% were older than 40; and in the 1990s 35% were older than 40.

The declining age over time is further evidenced by the drop shown in Figure 4 in the median lag from graduation until company founding that has occurred during the past several decades, moving from 10 years for MIT entrepreneur graduates of the 1980s to 6 years for those founding companies during the early 2000s. (Bachelor's 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.) This lag appears to be in even steeper decline if we show the data as a function of decade of graduation (Figure 5) rather than decade of founding (Figure 4). In Figure 5 the lag numbers for the more recent decades (dropping to as low as 4 years from graduation during the "bubble" years of the 1990s) are dramatically lowered by the fact that the decade means do not take into their calculation those firms that will be founded by classmates in later years, i.e. right-side censoring of the data. Note that the representative drop in 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 attainment (do remember that all are MIT alumni, but at different degree levels) shows relatively slow trends across the decades of new company formations of from almost 50% down to around 40% bachelor's degree recipients, a slight rise in percentage of master's degree holders to around 43%, with doctoral recipients gradually moving from around 10% toward 20 %. The significantly lower numbers of doctoral students becoming entrepreneurs lends some empirical credence to prior speculative literature on differences between education for breakthrough and education for incremental innovation (Baumol, 2004). It is possible that education appropriate for mastery of scientific knowledge and methods may impede heterodox thinking and imagination necessary for entrepreneurship. These numbers changed post-World War II 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 Figure 7 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 indeed right-side censored in that we do not know who of recent decade graduates will start first firms after 2001, the last date for which we have founding data. We also do not account for any differences in lag for SB, SM and PhD recipients in their paths toward entrepreneurship. But what interests us at this stage is the significant increase over time in the proportion of PhDs becoming entrepreneurs, essentially becoming the same by the present time as those receiving Masters degrees. Bachelor's degree recipients in sharp contrast decline in becoming entrepreneurs, at least in their early years post-degree. This is presumably explained in part due to the increased fraction of Bachelors graduates going on for advanced degrees. Fewer and fewer MIT SB degree holders enter the job market, including that for starting

new firms, with just their Bachelors degree.[7]

A final educational aspect is the general area of MIT study of these alumni entrepreneurs. In Figure 8 we show by decade of firm founding the percentage breakdown by general 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 Science, 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 indicate domination over most of the time studied of Engineering graduates as a large proportion of the overall MIT alumni entrepreneurs population, but declining in recent decades as the number of Science and Management graduates increase overall and simultaneously increase their participation in firm foundings.

In Figure 8 we show the normalized percentages of entrepreneurs by degree, 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. About twice the percentage of MIT engineering graduates as science alumni eventually become entrepreneurs. Management graduates overall seem to be as inclined proportionately to become entrepreneurs as MIT engineering grads. And, perhaps surprisingly, architecture alumni are proportionately the

[7] 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 2003-2005 (http://web.mit.edu/facts/graduation.shtml).

most entrepreneurial among graduates of all the MIT schools, no doubt reflecting a dominant "industry" structure of large numbers of small architectural practices, with relatively frequent changes in partnerships.

Table 1, panel B highlights some specifics of the educational backgrounds of the MIT alumni, showing for comparison the percent of all alumni founders by decade for only three MIT departments: electrical engineering and computer sciences (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 indications. 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 around 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*

Figures 1 and 2 show the dramatic increase in number and entrepreneurial intensity of those MIT alumni who had non-U.S. citizenships. These data are impressive but still understate the number whose country of origin is not the United States. Obviously many of the alumni have remained in the U.S. and had become U.S. citizens by the time they formed their first firm. Figure 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.

*3.3 Testing the founder characteristics' influence on firm formation*

From the information provided in section 3.2 it is clear 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 national origin. 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 in the previous year), and adjusts for the right-censoring of the data. In the regressions, subjects start being "at risk" of founding a firm at the time of their birth, 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). Reported coefficients represent 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. Since founding a firm is a relatively rare event in the overall data, and because we need the timing of events to conduct the hazard analysis, we construct a stratified random sample drawn from the larger alumni dataset. To construct the sample used in the multivariate regressions, we first selected all 1626 individuals known ex post to have founded a firm. We then matched these individuals in a five to one ratio with randomly-selected alumni who had not founded a firm as of 2003, 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.

Table 3 shows the results of four models: 3-1, graduation year and gender; 3-2, area of study at MIT; 3-3, geographic region of citizenship; and 3-4, a combined model with all the above factors included. Model 3-1 shows that later cohorts of graduating alumni experienced increased hazards (i.e., likelihood) of founding a firm by 2.2% per graduating year. As well, across the time span covered in the data, male alumni were almost twice as likely to found a firm relative to their female counterparts. Model 3-2 shows that, relative to natural science graduates, engineering, management and architecture (but not social science) graduates were more likely to start firms. Model 3-3 indicates that relative to U.S. citizen alumni, alumni hailing from Latin America and the Middle East were significantly more likely to be firm founders, while those coming from Asia had a lower hazard rate. Finally, model 3-4 simultaneously examines all the prior effects. While the graduation year, gender, and disciplinary background effects remain stable in their economic and statistical significance, the country of citizenship effects are modified somewhat. Latin American citizens had a 56% higher hazard of founding a firm relative to U.S. citizens (the Middle East result is no longer statistically significant), while Asian citizens were 37% less likely to start a firm relative to U.S. citizens. These basic results are robust to stratifying the baseline hazard according to disciplinary background (allowing engineering, management, social science, 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 or management 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. Non-U.S. alumni over time in general show the same general patterns as before. The graduation year effects disaggregated in this way suggest that later graduation years *within* cohorts has a negative or zero effect on the founding hazard, whereas the average graduation year effect across the entire time span is positive.

## 4. Why Have Things Changed?

### *4.1 Broad Changes Have Affected the Overall Extent of Entrepreneurship*

Figures 1 and 2 have shown the dramatic growth in overall entrepreneurial activity of MIT alumni over the past decades. Shifts in social trends at many levels likely influence the rate (and types) of entrepreneurs and new ventures created. Given the long lag from birth to first firm founding, the influences of many of these factors are likely to be missed by studies looking at short time spans. For example, long term shifts in the age distribution of a population may affect aggregate levels of entrepreneurship (Levesque and Minniti, in press). Explanations for the trends in Section 3 fall into four broad categories: (1) shifts in values, preferences and attitudes, (2) changes in the level of human and social capital added through attending a university, (3) shifts in science and technology, and (4) changes in government regulations or institutional and structural changes affecting the decision to enter entrepreneurship.

Attitudes regarding entrepreneurship as a career endeavor may be changing throughout society. Differences in the stigma associated with failure may impact levels of entrepreneurship across regions or over time (Landier, 2002). 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).

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).

Much of the overlap in the networks of scientists and technologists occurs through foundings, licensing, consulting and advising (Murray, 2002). Greater ties between universities and industry (Owen-Smith, 2003) have also been facilitated by a continuing wave of public research "center" creation beginning in the 1980s (Dietz and Bozeman, 2005). Students observe faculty and other students who become involved in commercial and entrepreneurial activities and this may have a social learning component, priming students to recognize and pursue entrepreneurial opportunities later in life. Indeed, previous studies have shown that social learning related to entrepreneurship takes place between faculty and co-authors (Stuart and Ding, 2005) as well as between graduate students and their advisors (Bercovitz and Feldman, 2004).

The contribution of universities to students' human and social capital has been largely neglected in the literature (for an exception, see Bozeman et al., 2001). However, it is relevant as scholars have demonstrated links between general human capital and entrepreneurial success as well as venture capital firm performance (Dimov and Shepherd, 2005; Gimeno et al., 1997).

Additionally, beneficial spillovers resulting from prior entrepreneurial activity in an area (including knowledge, supporting institutions, related firms, complementary services and prior precedent) are likely to make subsequent new venture creation more likely and more successful (Owen-Smith and Powell, 2004; Stuart and Sorenson, 2003). The large number of liquidity events in Silicon Valley and Massachusetts during the late 1990s may have increased these spillovers and altered the perceived (or actual) benefits and incentives to enter entrepreneurship.

*4.1.1 Rise of Institutionalized Venture Capital*

The rise and institutionalization of venture capital has been well documented in prior literature, beginning its history with the formation of American Research and Development in 1946 (Hsu and Kenney, 2005). 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 again in the late 1990s sharp increases occurred in the total amount of funds entering the venture capital industry (Kortum and Lerner, 2000; VentureOne, 2000).[8] In the years since 2000, following the burst of the tech bubble and September 11, 2001, the levels of investment have dropped.[9] While these trends have been demonstrated for the level of venture capital activity, less is known about trends in the relative importance and use by start-up firms of various sources of equity financing over time.

*4.1.2 Patent Reforms*

In addition to the munificence of the capital for new ventures, the likelihood of moving from traditional employment to entrepreneurship is enhanced by differences between firms in the assignment of intellectual property rights (IPR) to employees (Hellmann, 2003). If differences in the intellectual property (IP) environment between firms affect the likelihood of employee entrepreneurship, then differences over time in IP law and practices may affect rates of entrepreneurship as well. The impact of the patent system or of patent reforms on entrepreneurship has not been systematically studied.

As has been documented elsewhere (Gallini, 2002, and references therein), a series of policy changes starting in the 1980s extended and strengthened the relative protection that

[8] 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.
[9] National Venture Capital Association, http://www.nvca.org/ffax.html

patents provide.[10] Stronger IPR protection increases the returns to innovation via a decrease in the risk of expropriation (Gans and Stern, 2003). The creation of a "market for ideas" allows innovators to sell the results of their R&D to other firms even before these results are embodied in a product. This type of IP environment allows the formation of an upstream technology supplier sector, such as the proliferation of small biotech firms for the pharmaceutical industry.

A strengthened IP environment also increases the relative returns to competition with incumbents which could increase the likelihood of an innovator starting a new firm to commercialize an invention rather than licensing the invention to an incumbent. Regardless of whether stronger patents increase the benefits to entering entrepreneurship, changes in the perception that patents have become stronger or more important may have led more innovators to attempt to exploit their patents through new ventures.

On the other hand, Kortum and Lerner (1999) reject patent reforms as a primary explanation for the recent rise in patenting. If patent reforms have not caused the surge in patenting, then they may not have affected the rate of entrepreneurship. However, the Kortum and Lerner (1999) study does suggest another possible explanation in that improvements in the management of research increased innovation leading to higher levels of patenting. More innovation on the part of firms could have led to more innovations outside of the firm's core business which are a source of newly spawned entrepreneurial ventures (Gompers et al., 2005).

*4.1.3 New Technologies*

[10] In 1980, the *Diamond v. Chakrabarty* decision allowed the patenting of life forms and similar decisions by the U.S. Supreme Court extended patenting to software (1981, *Diamond v. Diehr*), financial services and business methods (*State Street Bank and Trust v. 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 percent during 1953-1978 to 90 percent 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. In 1984 the Hatch-Waxman Act also extended the length of patent protection for drugs.

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 biotech industry occurred physically and temporally alongside those developing the underlying science (Zucker et al., 1998; Murray, 2002).

If technological opportunities are behind the general increase in entrepreneurship, then we should see the increase concentrated in certain industries. Supporting this idea, but not shown in this paper, our data do show larger relative increases in new software and pharmaceutical, biotechnology and other medically-related firms formed by MIT alumni. Nonetheless, almost every industry area shows an increase in self-employment, including law and accounting. Kortum and Lerner (1999) also reject technological opportunities as an explanation for the surge in patenting. They show that while patenting in biotech and software has increased, technological opportunities alone do not explain the general increase in patenting.

Due to the widespread increase across industries our results do not support the idea that technological opportunities are a primary explanation for the significant increases in entrepreneurship. Indeed, we see the rise in entrepreneurship well before the emergence of biotechnology and even prior to the surge in software firms. Nevertheless, this paper is not meant to address this question in particular and further research into the link between technological opportunities and entrepreneurship is merited.

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. Radio, television,

and the internet could have altered the distribution of information, including information about entrepreneurial opportunities. However, we expect that alumni of MIT primarily take advantage of unique access to technological opportunities from the classroom and lab settings.

Many anecdotes exist of market research being done via internet searches, including research on potential competitors, which may make entrepreneurship easier or more difficult. Further, only recently have communities of entrepreneurs begun to organize via websites. Such a mechanism could bring together widely dispersed entrepreneurs with complementary skills and knowledge as we see with open source communities and innovation (von Hippel, 2005), but these are not yet reflected in the database we have analyzed.

*4.1.4 Macroeconomic Policies*

Changes in tax law or government macroeconomic policies may affect the level of entrepreneurship observed in a society. Blau (1987) explains the increase in self-employment in the early 1970s by changes in total factor productivity, increased taxes on higher income tax brackets, and changes in social security benefits. Higher marginal tax rates on those in the upper tax brackets appear to encourage entrepreneurship as do lower real interest rates and inflation rates (Blau, 1987; Gordon and Cullen, 2002).

Yet another possible explanation for some of the increase in entrepreneurship may be government regulatory policies. Between 1976 and 1990 a number of key industries were deregulated (Jensen, 1993). A study of the U.S. electric power industry shows that deregulation can cause the type of jolt in an industry that increases search processes and can result in a rapid increase in entrepreneurial activity (Sine and David, 2003).

*4.1.5 Statistical Evidence*

In an effort at adjudicating between the plausible explanations discussed, we present a statistical analysis. The unit of analysis is a year, and 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 capturing 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 the second half 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. Each of the independent variables is lagged by one year to account for adjustment times, though the results are largely insensitive to both contemporaneous specifications as well as lags of two and three years. Column 4-1 introduces a parsimonious regression, with *number of graduates* and *patents issued* as the sole right hand side variables. While *patents issued* can proxy for technological inputs or outputs (or both), the variable is positive and statistically significant, with an implied incidence rate ratio (IRR) of 1.023 (an additional 1000 patents awarded is associated with a 1.023x increase in the number of new ventures started). A second specification, column 4-2, examines the role of *venture capital disbursements* in the prior year. The estimated IRR of this variable, 1.062, is positive and statistically significant. 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). While the *GDP* and *NYSE* measures are estimated with statistically significant coefficients, their estimated economic importance is small. On the other hand, the dummy for *recessionary economy* is estimated with a positive and economically large coefficient (IRR=1.21) but is not statistically significant at the 10% level (though it is in the fully specified model, column 4-4). Putting all of these entrepreneurial environment effects together in the final column does not qualitatively change

the results discussed above. Furthermore, in all of the specifications in Table 5, the variable *number of graduates* is positive and statistically significant (which correlates with the passage of time, as the MIT graduating class has been increasing over time). 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. As well, there are a number of other shifts in the entrepreneurial environment which we are not able to statistically identify, for example the cluster of events at the end of the 1970s and beginning of the 1980s (such as the ERISA, Bayh-Dole Act, CAFC, etc. previously discussed).

*4.2 The Increase in Women Entrepreneurs*

Figures 1 and 2 indicate the growth in numbers of women entrepreneurial alumni from MIT. Changes in access to higher education may provide an explanation of the trend (Dolinsky et al., 1993). Indeed, women's access to higher education has increased markedly over the years.[11] In particular, the number of women graduating from all levels at MIT has risen from just over 10 (1%) in the 1930s to 43% of undergraduates and 30% of the graduate population in 2004-5.[12] Larger fractions of women have also been moving into and remaining in the work force (Cotter et al., 2001). Women's increasingly important work roles have contributed to increases in their credibility as potential entrepreneurial founders, as well as their networks of colleagues and contacts (Andre, 1992; Lerner et al., 1997; Marini, 1989; Reskin, 1993).

Women have had less of an opportunity to accumulate the financial resources in savings needed to go into business for themselves (Boden and Nucci, 2000). On the other hand, lower wages for women mean that their opportunity costs for switching to entrepreneurship are lower than for men. One explanation for the apparent leveling off of the increase in women's

[11] According to the National Center for Education Statistics, women's enrollment in institutions of higher education surpassed that of men in 1979. http://nces.ed.gov/programs/digest/d03/tables/dt174.asp
[12] http://web.mit.edu/facts/enrollment.shtml

entrepreneurship in the 1990s is that increasing access to the workforce, to managerial positions, or more equal wages might be raising the previously quite low opportunity costs for women to enter entrepreneurship. However, lack of access to capital as compared to men is still a likely contributor to the persisting and large difference in the rates of entrepreneurship between men and women (Hart et al., 2001).

*4.3 The Increase in Non-U.S. Entrepreneurs*

Figures 1 and 2, amplified by Figures 11 and 12, indicate the significant growth in numbers of non-U.S. citizen MIT entrepreneurial alumni and the fact of their entrepreneurial intensity exceeding their U.S. classmates. As there is little prior research in the area, it is difficult to explain the high rate of entrepreneurship among foreign citizens or to explain its increase. One possible explanation is that individuals who choose (and are financially able) to travel to the U.S. for their education are among the most risk-taking and entrepreneurial individuals within their home countries. Once in the U.S. the high tuition for professional schools such as medicine and law makes graduate education in the sciences and engineering a more feasible choice. Immigrants to this country may face lower opportunity costs to becoming entrepreneurs than U.S. students who have attractive career options open to them. Finally, many 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 may receive a non-immigrant visa as a "treaty investor" with no maximum period of stay.[13] Of course, these motivations are all based entirely on speculation due to the lack of data available.

Indeed, the phenomenon may be as simple as the historic migration of millions of people from all over the world to the United States in search of the "golden land of opportunity", which for many is tantamount to being their own bosses by having their own companies. Those who

[13] This status is renewable indefinitely (http://www.expertlaw.com/library/immigration/e2_visas.html).

apply and get accepted to MIT may well be merely one subset of this broader population of opportunity seekers. Students may also elect to return home to practice in their home environs the models of entrepreneurship they have observed in the US. Anecdotally, two of the three leading internet firms in China, Sohu.com and Sina.com, have been founded and led, respectively, by an MIT alumnus, Dr. Charles Zhang, and a Stanford alum, Ben Tsiang.

*4.4 The Decline in Age of First-Time Entrepreneurs*

Table 1 (panel A) indicates that the median age of entrepreneurs beginning their first company went from about 40 years in the decade of the 1950s to about 30 years in the decade of the 1990s. We believe this primarily reflects the overall greater tendencies toward entrepreneurship that we discussed in section 3.1. The higher degree of acceptance of the legitimacy and desirability of starting and running your own firm and the especially significant shifts in attitudes prevalent at many universities (and in particular, in the case of our data, at MIT) have acted to encourage more entrepreneurship. And "the more" is accompanied by "the sooner". Such a change in starting age would of course be accompanied by the decline observed in the lag from graduation and beginning your first company.

## 5. Limitations of the Data and Methods

A reasonable question is how representative this sample is of 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. As a result, there is a great deal of heterogeneity in the types of ventures started and in their outcomes. Further, more universities have been creating technology transfer offices, following the lead of MIT and Stanford in this realm. To that extent, the data may offer a preview of what we may see in a world of increasing university attention to commercialization. It is clear, however, that there is variation among universities in importance to the various routes of commercializing knowledge. DiGregorio and Shane (2003), for example, examine factors leading to variance among universities in the creation of start-ups, including amount of research funding from industry, intellectual eminence and technology licensing office policies.

This sample provides a rich view of entrepreneurship through a unique and long-spanning data source. However, there are observable differences in response rates. Foreign citizens are more likely to have responded to the founder survey and we see a drop in the response rate of women from a high of 30% in the 1980s to around 20% in the more recent years. Given the large range of possible definitions of self-employment, one must also ask how important complete representativeness is weighed against analyzing an economically important population of firms and entrepreneurs.

As with any self-reported data, several limitations are worthy of mention. The first limitation is how to account for a possible bias in response. It may be that graduates who started a company but were unsuccessful did not report on these failed firms, either by omitting them from their responses or not participating in the study at all. This could be significant if many technology firms had failed but were not reported by respondents. As an associated issue, it is likely that the response rate from non-U.S. alumni are somewhat less representative than their U.S.-based counterparts due both to potentially less complete contact records, as well as fewer reminders in completing the survey. In addition, first and second generation U.S. citizens whose

parents immigrated to this country are lumped in with U.S. citizens whose families have a long history in the country. We therefore suspect that the foreign entrepreneurship phenomenon is currently understated.

Some special issues with longitudinal data should also be pointed out. 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 affiliation with MIT or because they are no longer living, therefore there may be some "left-censoring".

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, especially due to how relatively recent many of the trends appear.

## 6. Conclusions

Data were gathered from over 40,000 living alumni, including more detailed information on 2,100 alumni of the Massachusetts Institute of Technology who had identified themselves as founders of one or more companies during their lifetimes. Although a few respondents started firms in the decades of the 1930s and 1940s, meaningful sample clusters 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 at the time of their first

entrepreneurial act, gradually included more women over the past 30 years, 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.

At a broad level, we interpret our results as suggesting that individual characteristics such as age or gender are not as important in determining the transition to entrepreneurship as the business and entrepreneurial environment. Future efforts to better understand at a more detailed level the effects of various components of the entrepreneurial environment would therefore be especially welcome. This new dataset also allows the examination of founders and venture development (which is the subject of our companion paper) over a relatively long time period. At the individual level, we stress the heretofore neglected by-products of research universities as they relate to the entrepreneurial process: training individuals to problem solve and facilitating social processes and a reputation (association with MIT), all of which can become valuable inputs to 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."

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**Figure 1**

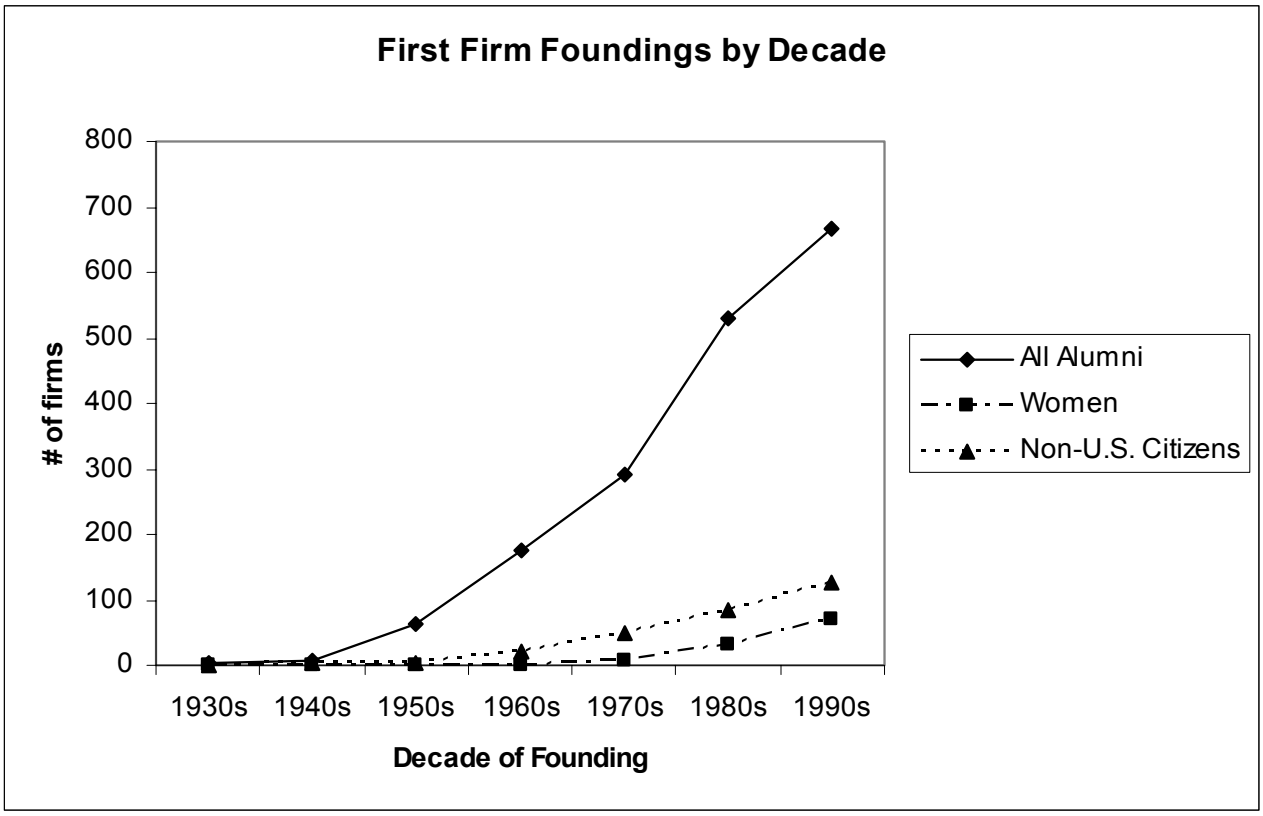
First Firm Foundings by Decade
800
700
600
500
400
300
200
100
0
# of firms
1930s
1940s
1950s
1960s
1970s
1980s
1990s
Decade of Founding
All Alumni
Women
Non-U.S. Citizens

**Figure 2**

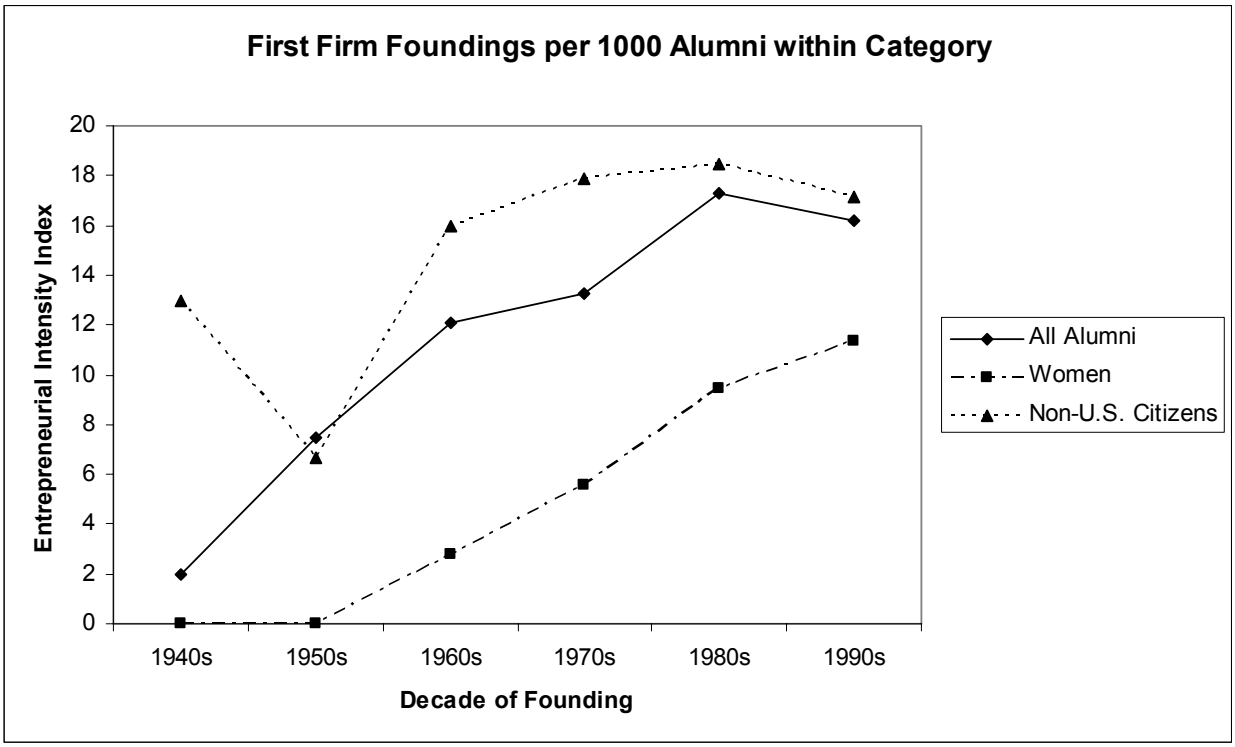
First Firm Foundings per 1000 Alumni within Category
Entrepreneurial Intensity Index
20
18
16
14
12
10
8
6
4
2
0
1940s
1950s
1960s
1970s
1980s
1990s
Decade of Founding
All Alumni
Women
Non-U.S. Citizens

**Figure 3**

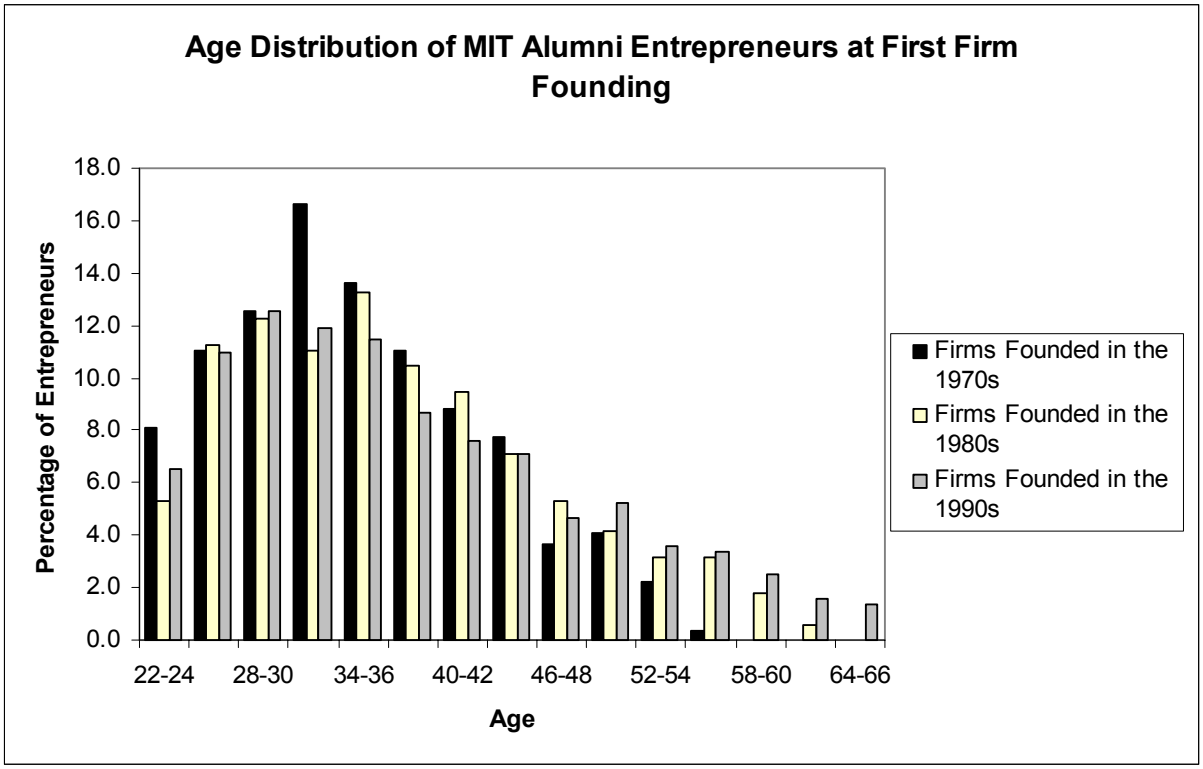
Age Distribution of MIT Alumni Entrepreneurs at First Firm Founding
Percentage of Entrepreneurs
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
22-24
28-30
34-36
40-42
46-48
52-54
58-60
64-66
Age
Firms Founded in the 1970s
Firms Founded in the 1980s
Firms Founded in the 1990s

**Figure 4**

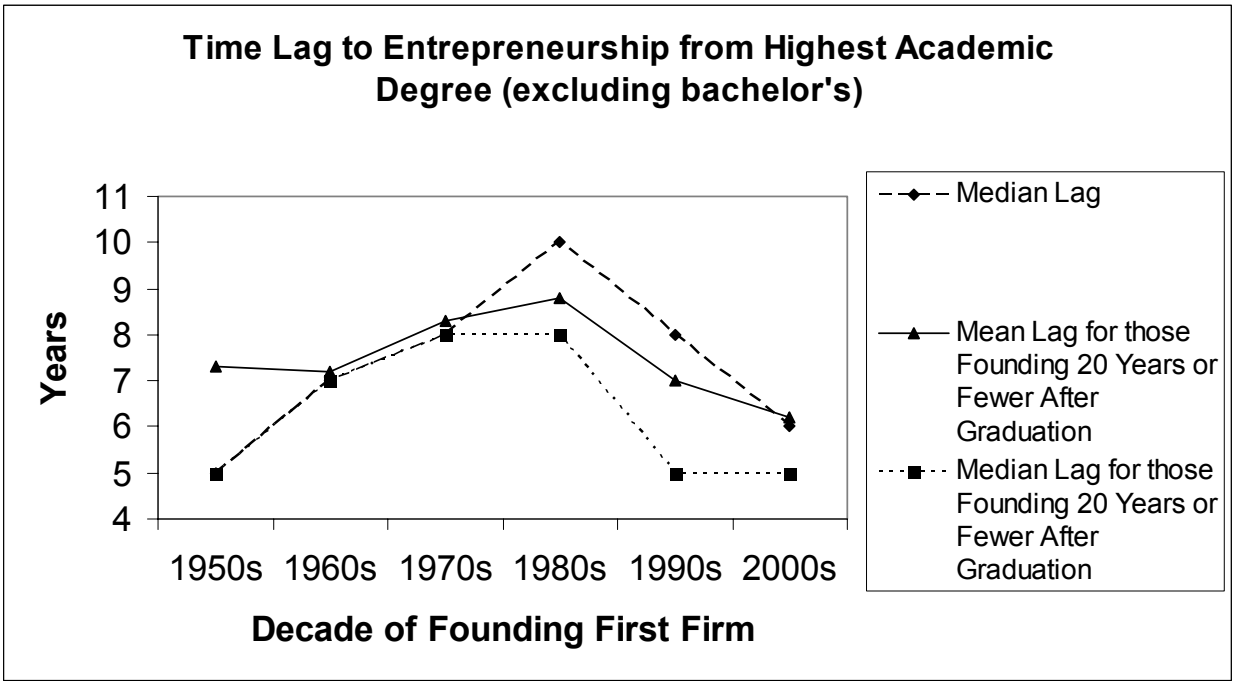
Time Lag to Entrepreneurship from Highest Academic Degree (excluding bachelor's)
Years
11
10
9
8
7
6
5
4
1950s
1960s
1970s
1980s
1990s
2000s
Decade of Founding First Firm
Median Lag
Mean Lag for those Founding 20 Years or Fewer After Graduation
Median Lag for those Founding 20 Years or Fewer After Graduation

**Figure 5**

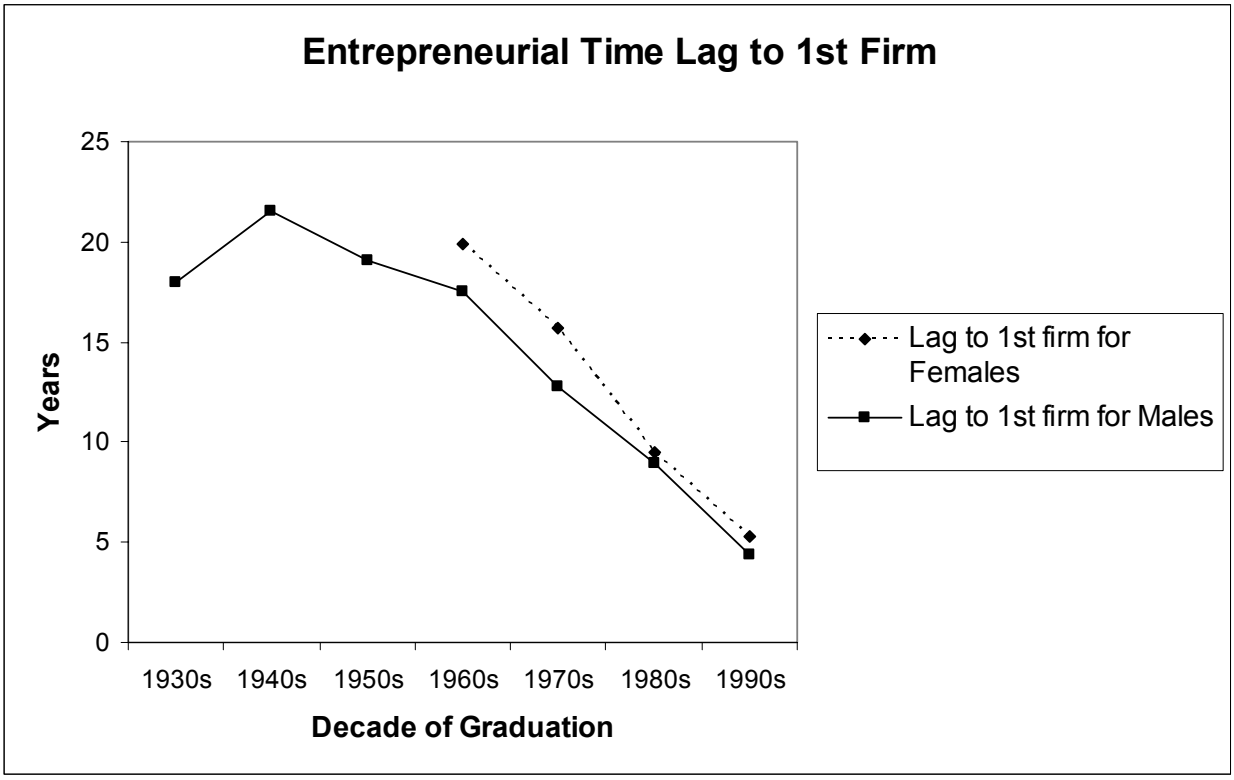
Entrepreneurial Time Lag to 1st Firm
25
20
15
10
5
0
Years
1930s
1940s
1950s
1960s
1970s
1980s
1990s
Decade of Graduation
Lag to 1st firm for Females
Lag to 1st firm for Males

**Figure 6**

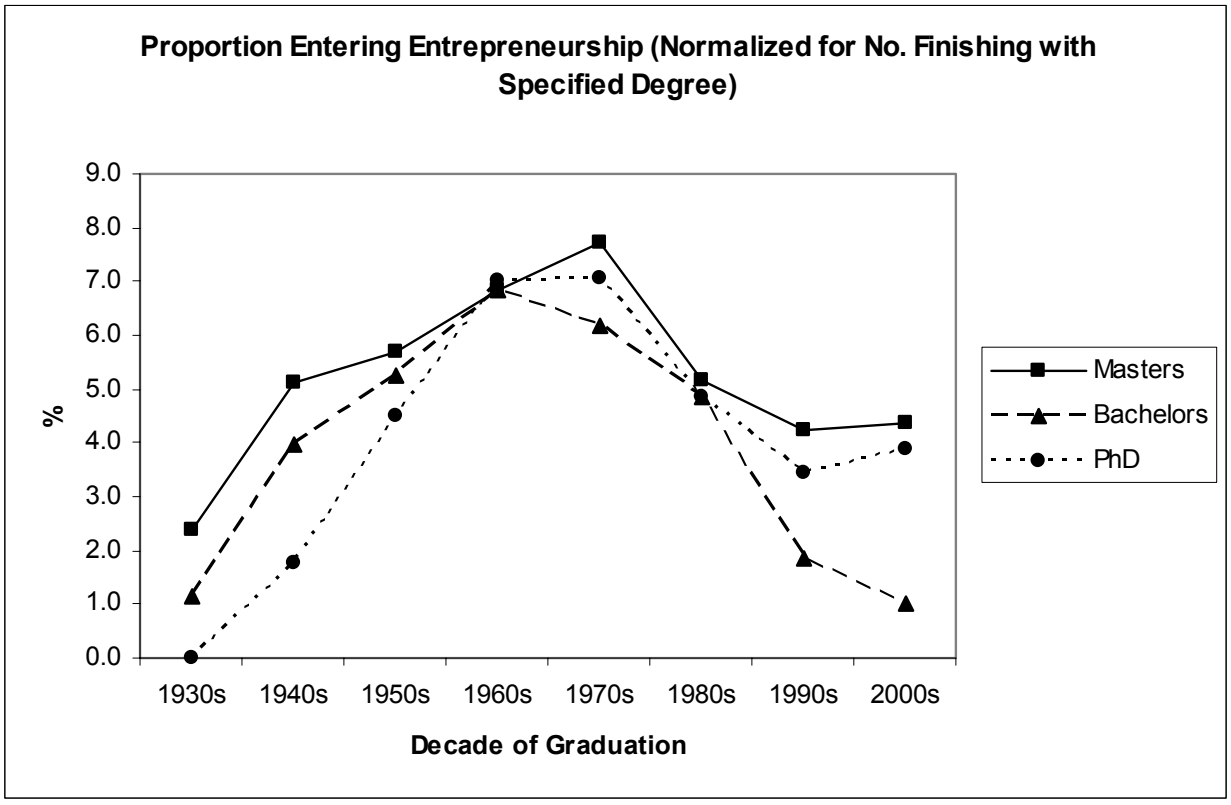
Proportion Entering Entrepreneurship (Normalized for No. Finishing with Specified Degree)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
%
1930s
1940s
1950s
1960s
1970s
1980s
1990s
2000s
Decade of Graduation
Masters
Bachelors
PhD

**Figure 7**

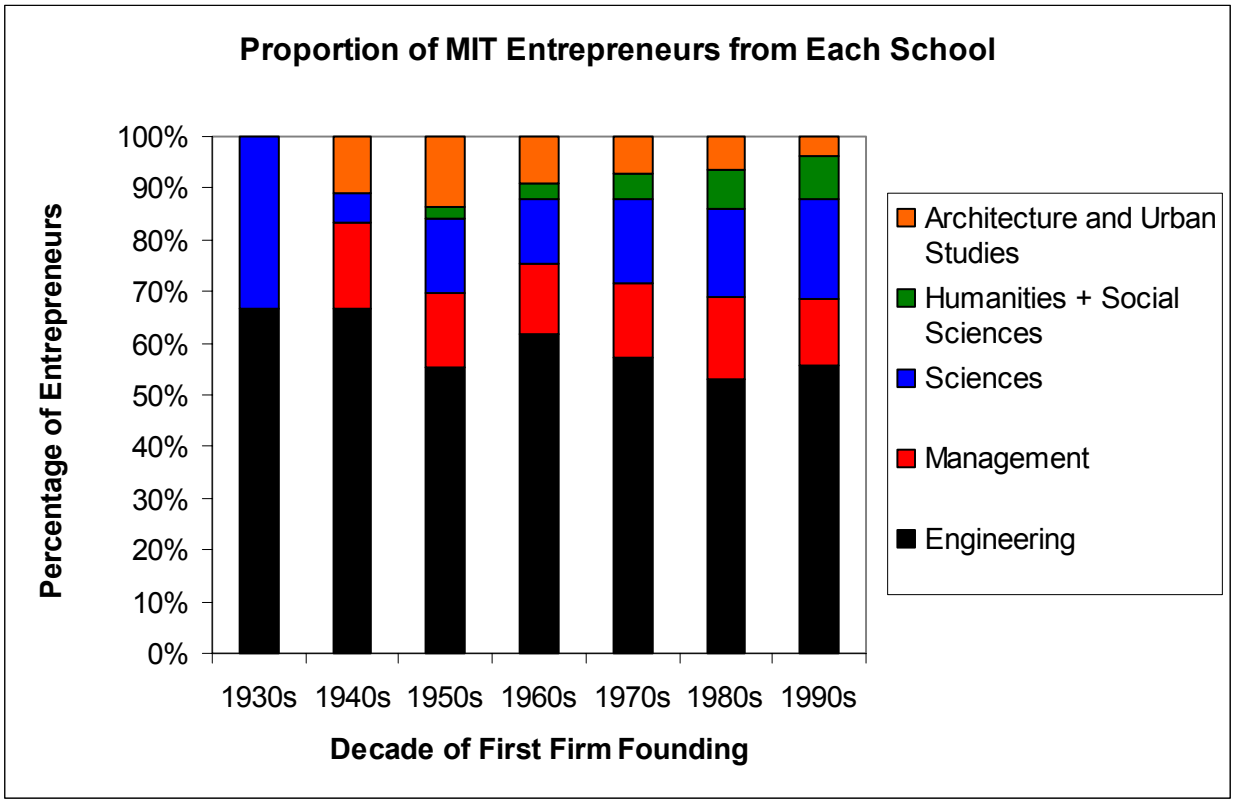
Proportion of MIT Entrepreneurs from Each School
Percentage of Entrepreneurs
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1930s
1940s
1950s
1960s
1970s
1980s
1990s
Decade of First Firm Founding
Architecture and Urban Studies
Humanities + Social Sciences
Sciences
Management
Engineering

**Figure 8**

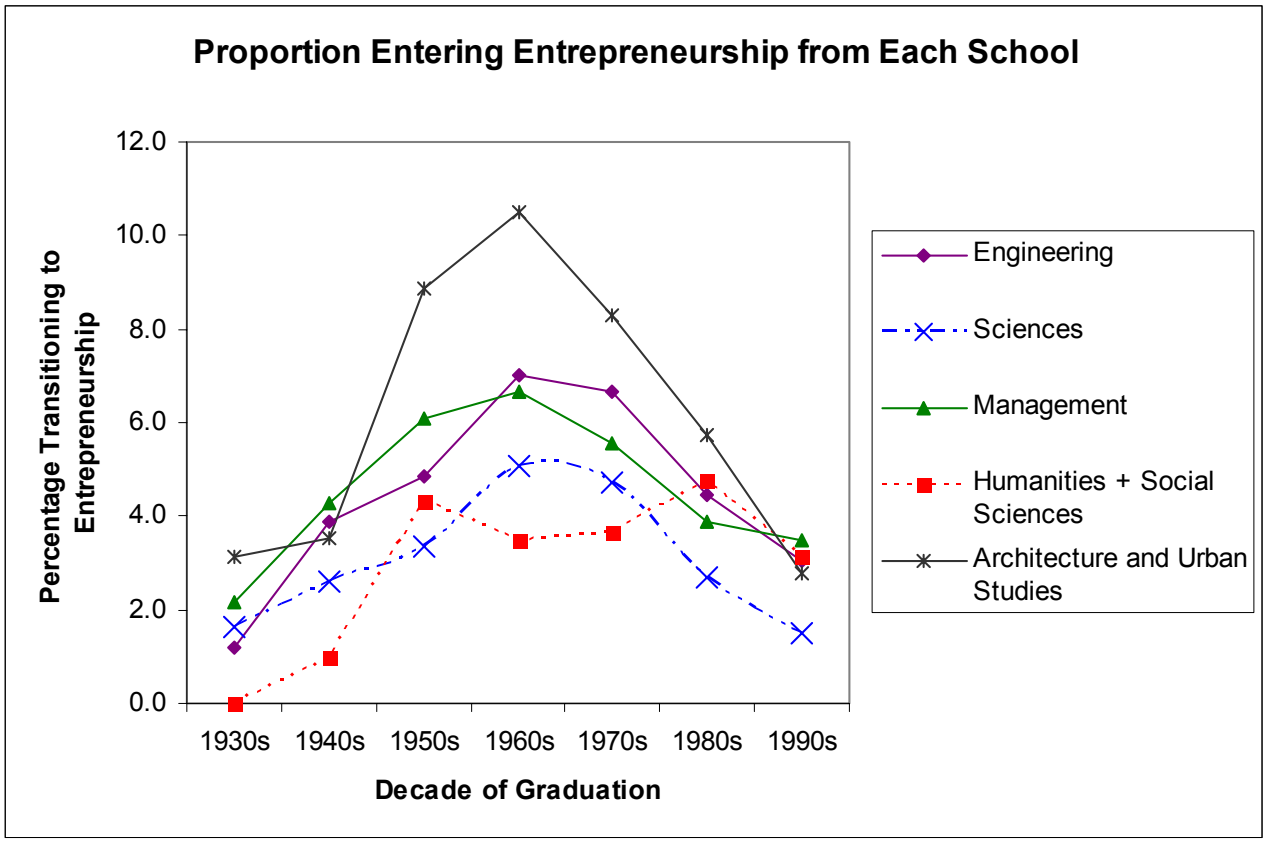
Proportion Entering Entrepreneurship from Each School
Percentage Transitioning to Entrepreneurship
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1930s
1940s
1950s
1960s
1970s
1980s
1990s
Decade of Graduation
Engineering
Sciences
Management
Humanities + Social Sciences
Architecture and Urban Studies

**Figure 9**

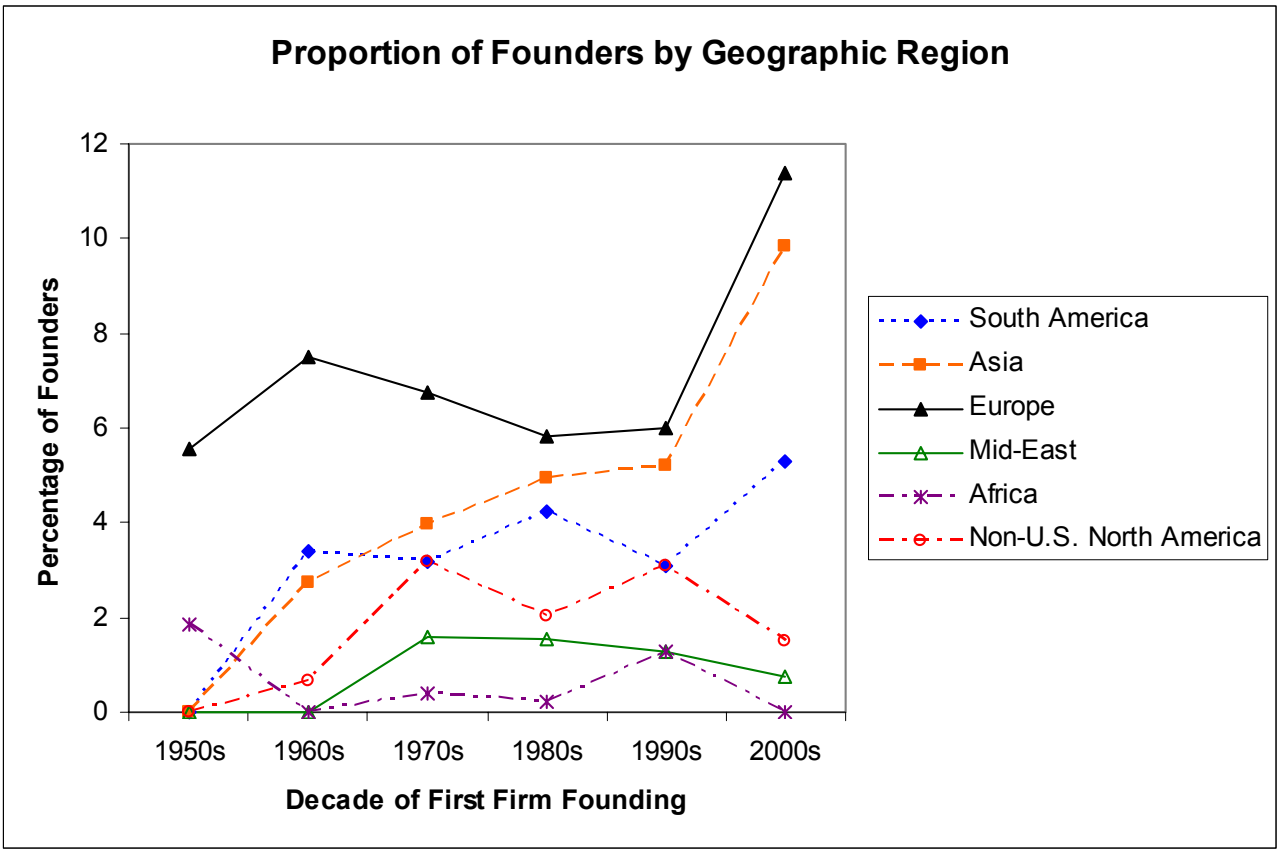
Proportion of Founders by Geographic Region
Percentage of Founders
12
10
8
6
4
2
0
1950s
1960s
1970s
1980s
1990s
2000s
Decade of First Firm Founding
South America
Asia
Europe
Mid-East
Africa
Non-U.S. North America

**Table 1**
**Trends in Graduates Becoming Entrepreneurs and Timing of the Transition to Entrepreneurship**

| **Panel A -** *Median Age at First Firm Founding* | | | | | | |
|---|---|---|---|---|---|---|
| **Decade of Graduation** | **1950s** | **1960s** | **1970s** | **1980s** | **1990s** | **2000s** |
| Overall | 40.5 | 39 | 35 | 32 | 28 | 30 |
| Non-U.S. Citizens | 38 | 35.5 | 36.5 | 32 | 29 | 30 |
| Women | 42 | 41 | 40 | 35 | 29 | 30.5 |
| | | | | | | |
| **Panel B -** *Proportion of Founders for Certain Academic Departments (%)* | | | | | | |
| **Decade of First Firm Founding** | **1950s** | **1960s** | **1970s** | **1980s** | **1990s** | **2000s** |
| EE & CS | 20.4 | 26.5 | 18.7 | 25.4 | 22.7 | 21.1 |
| Management | 16.7 | 14.3 | 13.5 | 13.8 | 15.8 | 11.3 |
| Life Sciences | 0.0 | 2.7 | 4.0 | 4.9 | 4.7 | 4.5 |
| | | | | | | |
| **Panel C** - *Proportion of Entrepreneurs by Final Degree (%)* | | | | | | |
| **Decade of First Firm Founding** | **1950s** | **1960s** | **1970s** | **1980s** | **1990s** | **2000s** |
| Doctorates | 10.4 | 20.0 | 18.4 | 14.9 | 18.5 | 18.9 |
| Masters | 36.4 | 36.0 | 40.3 | 38.4 | 56.2 | 67.6 |
| Bachelor's | 53.2 | 44.0 | 41.3 | 46.8 | 25.3 | 13.5 |

**Table 2**
**Summary Statistics and Variable Definitions**

| VARIABLE | DEFINITION | MEAN | SD |
|---|---|---|---|
| **Individual-level measures** | | | |
| *First start-up founded* | Year in which first firm was founded (considered censored if not observed by 2003) | 1985.49 | 12.26 |
| *Graduation year* | Year of MIT graduation | 1973.91 | 14.98 |
| *Male* | Dummy = 1 if the individual is male | 0.86 | 0.34 |
| *Academic major* | Set of dummies for academic major: engineering (54%), management (14%), social science (5%), architecture (3%), and natural science (the Excluded category) | | |
| *Country of origin* | Set of dummies for country of citizenship: Latin America (2%), Asia (7%), Europe (7%), Middle East (1%), Africa (1%) or North America (the excluded category) | | |
| **Year-level measures** | | | |
| *First firm foundings* | Number of first firms found | 25.53 | 25.94 |
| *Number of graduates (t-1)* | Number of individuals in the MIT graduating class in the prior year | 559.66 | 320.00 |
| *Patents issued (t-1)* | Number of U.S. patents issued in the prior year (‘000s) | 66.37 | 35.38 |
| *Venture capital disbursements (t-1)* | Total disbursements made by venture capital firms in the prior year ($M) | 3.99 | 13.88 |
| *Recessionary economy (t-1)* | Dummy = 1 if the U.S. economy was in recession in the prior year as determined by the NBER | 0.29 | 0.46 |
| *Gross domestic product (t-1)* | Gross domestic product of the U.S. economy in the prior year ($B) | 4053.54 | 2796.37 |
| *Inflation rate (t-1)* | Inflation rate of the U.S. economy in the prior year (%) | 3.34 | 4.12 |
| *NY stock exchange market cap. (t-1)* | Total market capitalization of the New Stock Exchange in the prior year ($) | 1.84e+9 | 3.14e+9 |

**Table 3**
**Entrepreneurship Cox Hazard Rate Regressions**
**(Individual level of analysis)**

| | Dependent Variable = *First start-up founded* (subjects start being at risk at year of birth)<br>Note: reported coefficients are hazard ratios | | | |
|---|---|---|---|---|
| Independent Variables | **(3-1)** | **(3-2)** | **(3-3)** | **(3-4)** |
| *Graduation year* | 1.022*** | | | 1.024*** |
| | (0.002) | | | (0.002) |
| *Male* | 1.980*** | | | 2.050*** |
| | (0.193) | | | (0.202) |
| *Engineering major* | | 1.495*** | | 1.543*** |
| | | (0.096) | | (0.100) |
| *Management major* | | 1.411*** | | 1.230** |
| | | (0.121) | | (0.106) |
| *Social science major* | | 1.129 | | 1.095 |
| | | (0.150) | | (0.146) |
| *Architecture major* | | 2.246*** | | 2.190*** |
| | | (0.240) | | (0.236) |
| *Latin American citizen* | | | 1.936*** | 1.547*** |
| | | | (0.271) | (0.219) |
| *Asian citizen* | | | 0.824* | 0.626*** |
| | | | (0.095) | (0.073) |
| *European citizen* | | | 1.025 | 0.915 |
| | | | (0.102) | (0.092) |
| *Middle Eastern citizen* | | | 1.781*** | 1.320 |
| | | | (0.412) | (0.306) |
| *African citizen* | | | 1.453 | 1.084 |
| | | | (0.440) | (0.329) |
| Log likelihood | -14592.44 | -14618.12 | -14656.67 | -14520.16 |
| Number of observations | 10,780 | 10,780 | 10,780 | 10,780 |

Note: 1,626 failures; 555,996 years at risk; ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

**Table 4**
**Entrepreneurship Cox Hazard Rate Regressions by Birth Cohort**
**(Individual level of analysis)**

| | Dependent Variable = *First start-up founded* (subjects start being at risk at year of birth)<br><br>Note: reported coefficients are hazard ratios | | | |
|---|---|---|---|---|
| | Birth year: 1912-1937 | Birth year: 1938-1948 | Birth year: 1949-1959 | Birth year: 1960-1979 |
| Independent Variables | **(4-1)** | **(4-2)** | **(4-3)** | **(4-4)** |
| *Graduation year* | 0.984** | 0.969*** | 0.970*** | 1.010 |
| | (0.007) | (0.009) | (0.009) | (0.010) |
| *Male* | 1.837 | 1.229 | 1.855*** | 3.038*** |
| | (0.933) | (0.290) | (0.302) | (0.455) |
| *Engineering major* | 1.329* | 1.573*** | 1.634*** | 1.275** |
| | (0.197) | (0.197) | (0.207) | (0.157) |
| *Management major* | 1.495** | 1.986*** | 1.757*** | 1.034 |
| | (0.294) | (0.332) | (0.305) | (0.177) |
| *Social science major* | 1.147 | 0.999 | 1.383 | 1.105 |
| | (0.393) | (0.288) | (0.314) | (0.280) |
| *Architecture major* | 3.553*** | 2.598*** | 3.134*** | 1.225 |
| | (0.706) | (0.685) | (0.578) | (0.328) |
| *Latin American citizen* | 2.157* | 3.165*** | 1.876*** | 0.901 |
| | (0.895) | (0.794) | (0.473) | (0.259) |
| *Asian citizen* | 0.632 | 1.255 | 0.609** | 0.613*** |
| | (0.321) | (0.318) | (0.131) | (0.110) |
| *European citizen* | 1.281 | 0.703 | 0.960 | 1.095 |
| | (0.261) | (0.176) | (0.197) | (0.189) |
| *Middle Eastern citizen* | 3.614* | # | 2.043** | 1.060 |
| | (2.588) | | (0.693) | (0.380) |
| *African citizen* | 1.344 | 0.384 | 0.615 | 1.612 |
| | (0.957) | (0.385) | (0.616) | (0.618) |
| Log likelihood | -2805.30 | -3131.14 | -3147.90 | -3390.09 |
| Number of observations | 2,540 | 2,706 | 2,695 | 2,839 |
| Failure events | 365 | 406 | 410 | 445 |
| Time at risk | 175,949 | 153,359 | 126,728 | 99,960 |

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% level, respectively. # denotes insufficient data for estimation.

**Table 5**
**First Firm Foundings Negative Binomial Regressions, 1930-2003**
**(Year level of analysis)**

| | Dependent Variable = *Number of First Firm Foundings* | | | |
|---|---|---|---|---|
| Independent Variables | **(5-1)** | **(5-2)** | **(5-3)** | **(5-4)** |
| *Number of graduates (t-1)* | 0.003*** | 0.004*** | 0.001** | 0.002*** |
| | (0.000) | (0.000) | (0.000) | (0.001) |
| *Patents issued (t-1)* | 0.002*** | | | 0.002*** |
| | (0.000) | | | (0.000) |
| *Venture capital disbursements (t-1)* | | 0.060*** | | 0.026*** |
| | | (0.013) | | (0.009) |
| *Recessionary economy (t-1)* | | | 0.188 | 0.275* |
| | | | (0.159) | (0.148) |
| *Gross domestic product (t-1)* | | | 6.26e-4*** | 4.32e-4*** |
| | | | (9.97e-5) | (9.98e-5) |
| *Inflation rate (t-1)* | | | -0.005 | -0.010 |
| | | | (0.023) | (0.022) |
| *NY stock exchange market cap. (t-1)* | | | 1.99e-10*** | -3.68e-10*** |
| | | | (6.19e-11) | (6.97e-11) |
| Constant | -0.886*** | 0.353 | -0.241** | -1.053*** |
| | (0.300) | (0.286) | (0.237) | (0.357) |
| Log likelihood | -247.51 | -266.35 | -234.43 | -226.01 |
| Number of observations | 72 | 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. # denotes insufficient data for estimation.